Restricted

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION
~~WASHINGTON 25, D. C.~~
Joplin, Missouri
September 18, 1953

all 4 copies to Op. Comm.

Operating Committee
Defense Minerals Exploration
Administration
Interior Building
Washington 25, D. C.

Re: DMEA-2299 Idm-E280
Inland Mining Corp.
Mena District, Ark.
Manganese

also rec'd extracts by F.T. of reports by final consultants

Dear Sirs:

We are sending you today under separate cover the original and three copies of a Final Report of the Field Team on the above referenced project.

This report was promised the Operating Committee in a telegram from the Executive Officer, Region VI to the Operating Committee, dated September 9, 1953.

You will note from the report that the Field Team recommends a Certificate of Discovery be issued by the Government covering the subject project.

Sincerely yours,

W. P. Williams

W. P. Williams
Executive Officer
DMEA Field Team, Region VI

WPW:jd

Return to Code 400-DMEA
Room 3538

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION
~~WASHINGTON 25, D. C.~~
Joplin, Missouri
September 18, 1953

Mr. W. T. Townsend
Assistant Treasurer
Inland Mining Corp.
1408 Life of America Building
Dallas, Texas

Re: DMEA-2299 Idm-E280
Inland Mining Corp.
Mena District, Ark.
Manganese

Dear Mr. Townsend:

We are returning to you herewith, by Registered U.S. Mail, the Metallurgical Report prepared for the Inland Mining Corp. by Morgan G. Huntington dated December 19, 1952. This report is entitled "West-Central Arkansas Ferromanganese Production Study".

In a covering letter dated June 26, 1953, you made this report available to the U. S. Government. Your letter gave express permission to make copies or to take excerpts from the Huntington Report.

I have completed my examination of the report and as requested in your letter will take the precaution that any material copied from the report will be marked "For Restricted Use of the United States Government Only."

Thank you for the use of this report.

Sincerely yours,

W. P. Williams
Executive Officer
DMEA Field Team, Region VI

WPW:jd
Enc.

cc - Operating Committee

DMEA Docket No. 2299 (Manganese)
Contract No. Idm-E280
Mena District, Polk County, Arkansas
Inland Mining Corporation
Life of America Building
Dallas, Texas

MORGAN G. HUNTINGTON
Mining and Metallurgical Engineer
Mineral Marketing Consultant
Washington, D. C.

4304 Yuma St., N. W.
December 19, 1952

Inland Mining Corporation
528 Republic Bank Building
Dallas, Texas

Gentlemen:

Herewith is a study of your manganese mining project in Western Arkansas which I have prepared at your request.

Respectfully submitted,

(Signed) Morgan G. Huntington
Morgan G. Huntington

MGH:ah

INNLAND MINING CORPORATION

WEST-CENTRAL ARKANSAS

FERROMANGANESE PRODUCTION STUDY

(Signed) Morgan G. Huntington
By: Morgan G. Huntington
Washington, D. C.
December, 1952

FOREWORD

For the past two years the writer has acted as technical advisor to the principals of the Inland Mining Corporation in connection with the exploration and development of the manganese deposits east of Mena, Arkansas. Emphasis has been placed upon the importance of concurrently securing abundant ore dressing and pyrometallurgical data pertinent to the material disclosed by excavating and by drilling. Five well known firms have been retained as ore dressing consultants. Most of such material is presented in the body of this report. Free use has been made of the voluminous information compiled by the United States Bureau of Mines.

The writer holds the opinion that the economic success of this project will hinge upon full integration of operating and the ultimate marketing of the manganese in its most valuable form. That is, the ore must be mined, beneficiated and smelted into the final finished product of commercial ferromanganese and sold directly to the western steel plants. Fortunately, the manganese ore, limestone, and natural blast furnace

fuel occur within a radius of a few miles. In no other area in the Nation is there such a fortuitous set of circumstances for the production of ferromanganese from domestic ores.

Ferro-grade manganese ore, along with iron ore, coal and limestone, is a large tonnage ingredient of steel. At least 11 pounds of metallic manganese is contained in each ton of steel produced. Up to the present time, we have imported more than 90 per cent of our manganese ore from Asia, Africa and South America.

During the past two decades, the price of manganese has increased four-fold and the demand has nearly doubled. It is now technically and economically feasible to produce ferromanganese from some of our domestic ores. At 13 cents a pound, manganese approaches the price range of lead, zinc and copper, which have been domestically produced for a hundred years.

The manganese deposits in west-central Arkansas have been known for half a century. These sedimentary rocks in which the manganese occurs have been mapped

by state and federal agencies and hundreds of manganese exposures are noted. This region is some six miles from north to south and forty miles from west to east and includes an area of more than two hundred square miles.

Although the host rocks are sporadically mineralized and the ore bodies of moderate size (50,000 to 200,000 tons), the geological inference is that the manganiferous material may amount in the aggregate to as much as one hundred million tons. Recent excavations and analysis by the Inland Mining Corporation indicate that a considerable part of this mineralized chert contains somewhat more than 4 per cent of metallic manganese.

This alone is not remarkable, since at least three other large low-grade deposits of manganese within continental United States are known to contain as much or more of the metal. However, the west-central Arkansas ores have several economic and technical advantages:

1. Ease of mining. Climatic conditions permit open-cut mining and transportation the year around.

2. The ore lends itself well to beneficiation by the cheapest and most nearly automatic of all ore dressing methods; i.e., heavy-media separation.

3. Local, naturally occurring furnace fuel and cheap, metallurgical limestone provide the means for low cost smelting of these beneficiated ores into commercial ferromanganese.

The writer is a student of thermodynamics and thermo-chemistry. The body of this report contains in detail all the pyrometallurgical calculations, economic as well as chemical, which are involved in the production of commercial ferromanganese from these Arkansas manganese ores.

INLAND MINING CORPORATION
West-Central Arkansas
Ferromanganese Production Study

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SUMMARY

The Inland Mining Corporation has been exploring the manganiferous novaculites of west-central Arkansas during the past 20 months. The major manganese mineralization begins 15 miles southeast of Mena and extends 35 miles farther east. Manganese occurrences are observed over an area of some 200 square miles.

The particular sedimentary bed to which the manganese mineralization is confined has been mapped by the United States Geological Survey. Scores of manganese exposures are noted by both the Survey and Bureau of Mines. The Arkansas State Geologists have also recorded data on the manganese mineralization of this region.

Although the existence of these west-central Arkansas manganese occurrences have long been known, they have never been successfully exploited. In fact, only in the light of modern metallurgical knowledge can these manganiferous beds be considered as of potential commercial importance.

The results of the exploration performed so far by Inland in this area indicate that the total quantity of manganiferous chert may run into the tens of millions of tons. The individual ore bodies, however, will probably prove to be on the order of fifty to two hundred thousand tons each, with many smaller deposits which may or may not be mineable for reasons of accessibility and/or grade.

The methods of mining will include both open-cut and underground mining, depending upon the depth and attitude of the mineralized portions of the beds. Like most mining operations of this physical charcter, at the outset, and for as long as economically possible, most of the ore will probably come from open cuts. An estimate of relative tonnages to be mined for the first five years is 80 per cent from open-cut and 20 per cent from underground. The grade of ore mined by the two methods is expected to be above four and six per cent of manganese, respectively.

8 x 4 = 32
2 x 6 = 12
10 44
Avg = 4.4

The west-central Arkansas manganese ores are amenable to concentration by heavy-media separation. It is thereby possible and practical to reject 60 to 80 per cent of the material mined at or near its

source. At the same time, more than 80 per cent of the original manganese is retained in the form of a 20 to 30 per cent intermediate product.

It is now feasible to smelt ferromanganese from ores less than half as rich as those currently specified. It is also possible to control the iron, phosphorus and copper content of the alloy by pyrometallurgical means. Such control has in the past been exercised entirely through rigid ore purchase specifications.

Utilising local semi-anthracite coal as fuel and the excellent limestone available for flux, it will be profitable to smelt the heavy-media concentrate into commercial ferromanganese.

INTRODUCTION

It is the purpose of this study to weigh the possibilities of obtaining a substantial production of ferromanganese from the west-central Arkansas manganiferous sediments. This involves the detailed consideration of two unusual pyrometallurgical problems.

The writer is drawing heavily upon the data gathered by four major steel companies in the successful smelting of ores chemically indentical to the Inland Corporation "intermediate concentrate."

Because the United States manganese problem is generally so poorly understood, an effort is made to describe briefly the function and the metallurgy of this element. The writer believes that ample data is now at hand to permit the complete conception of the thermo-chemistry and mechanics involved in the reduction of ferromanganese from ores containing more than 50 per cent of siliceous gangue.

The exploration of this manganiferous area is by no means complete. However, the results of the initial work by Inland indicate that new ore reserves

can be indicated by surface trenching and shallow drilling at a cost of less than ten cents a ton. The total possible tonnage which might be developed in this two hundred square-mile area is most certainly many times over that required to amortize the capital cost of the plant and equipment herein proposed.

MANGANESE IN THE STEEL INDUSTRY

Use of Manganese in Steel Manufacture:

About 90 per cent of the steel produced in the United States is refined in reverberatory furnaces by what is known as the basic open-hearth process. Approximately 25 per cent is circulating mill scrap, such as cropped ends of blooms, and the balance is pig iron produced by smelting iron ore. The remaining 10 per cent is produced by the acid Bessemer process, by electric arc furnaces and by acid open hearths.

Manganese is introduced into the steel making circuit in several ways.

1. As manganese content of the iron ore which may amount to more than 700,000 tons of metallic manganese annually.

2. As manganiferous ore and/or slags mixed with the iron ore charge in the blast furnace so that the resulting pig iron contains between one and two per cent of manganese. The exact amount varies with local practice.

3. As returning scrap melted in the open-hearth furnace. This purchased and circulating mill scrap contains about 0.55 per cent manganese.

4. Manganese is added in the form of ferro-manganese[1] either in the furnace or in the ladle immediately after tapping the finished steel from the open-hearth furnace. In this step, the actual consumption of metallic manganese ranged from 12 to 14 pounds per ton of ingot steel produced. It is this addition which provides most of the 0.5 to 0.7 per cent of manganese in all ingot steel.

About 75 per cent of the manganese contained in the pig iron and in the scrap is oxidized and enters the open-hearth slag. Most steel plants recharge about 45 per cent of their open-hearth slag into blast furnaces. The remaining 55 per cent of the manganese in open-hearth slags is a total metallic loss. This is really staggering since the total tonnage lost amount to some 600,000 to 700,000 tons of metallic manganese annually.

1/ Standard ferromanganese is 78-80 per cent manganese; however, certain steel plants use a lower manganese content. Most important is the manganese/phosphorus ratio which should not be less than 300 to 1.

Source of Ferro-Grade Manganese Ore:

Metallurgical-grade manganese ore from foreign sources is used in our steel industry in the amount of about 1½ million tons a year. Thus, more than 90 per cent of our total consumption is now transported across 4,000 miles of open sea. Without adequate stocks of imported ores or a dependable domestic source of manganese, we obviously face an untenable position in time of war.

Metallurgical-grade manganese ore, that is, those ores from which ferromanganese can be directly smelted, are now of the same strategic importance as iron ore itself. From the standpoint of national defense as well as for economic reasons, it seems desirable and reasonable to bend every effort to develop a commercial method for the production of ferromanganese from steel mill waste and from our ample low-grade manganiferous ores.

Function of Manganese in Finished Steel:

Many elements have been used with success in the deoxidation of steel. The crystal size and structure can be controlled with a variety of additions and physical treatments. However, no element other than manganese has been found which will serve to counteract the deleterious effect of sulphur on the rolling and forging properties of steel. Regardless of how pure the ore and how careful the metallurgist, since practically all fuels contain a substantial amount of sulphur, it is impractical commercially to produce finished steel with less than 3 to 4 hundredths per cent sulphur.

Importance of Manganese in Steel Production:

The addition of 12 to 14 pounds of metallic manganese in the form of ferromanganese is universally considered indispensable by steel metallurgists. Further, the present opinion of these metallurgists is, that in the absences of such manganese, no steel whatever can be made by any process, of any type, nor for any purpose.

If manganese were in ample supply, it could be used to replace perhaps half our requirements of scarce molybdenum, chrome and nickel in the production of alloy steels.

HISTORY

The waging of modern war is primarily a function of the metallurgical industries. Without substantial steel production, no nation could be regarded as a major world power.

The availability of iron ore, coking coal and limestone has dictated the economy of the steel industry. Equal in strategic importance is metallurgical grade manganese ore. It could be significant that the only industrial nation which is self-sufficient in this fourth large tonnage ingredient is Russia.

More than ninety per cent of the million and a-half tons of ferro-grade manganese ore annually required by the United States is shipped across the oceans. Some effort is currently being made to recover manganese from steel plant wastes. Should this under taking prove entirely successful, about half of our manganese must yet come from overseas or be produced from domestic sources.

The manganiferous sediments of west-central Arkansas have been known. As early as 1890, the

the Arkansas Geological Survey reported manganese in the area and the United States Geological Survey also published a report on the manganese minerals of the region. Bulletin No. 808 of the U. S. Geological Survey, published somewhat later, describes these mineralized beds in considerable detail. A photostat of Plate III of U.S.G.S. Bulletin 808 is included in this paper.

Several small scale attempts have been made to crush and concentrate the manganese minerals occurring in the novaculite. Little success has been achieved and the total production of marketable concentrate is probably not more than 20 or 30 carloads from the entire west-central region.

Unlike the Batesville area, the host rock does not weather rapidly enough to yield shipping grade nodules which may be sorted by hand. The novaculite is very hard and every bit must be drilled and blasted. Hence, west-central Arkansas has no such record of manganese production.

The Inland Mining Corporation has made the most serious attempt to explore this area. Much

geological detail of the manganiferous strata has been recently recorded as part of a Government financed exploration assistance program.

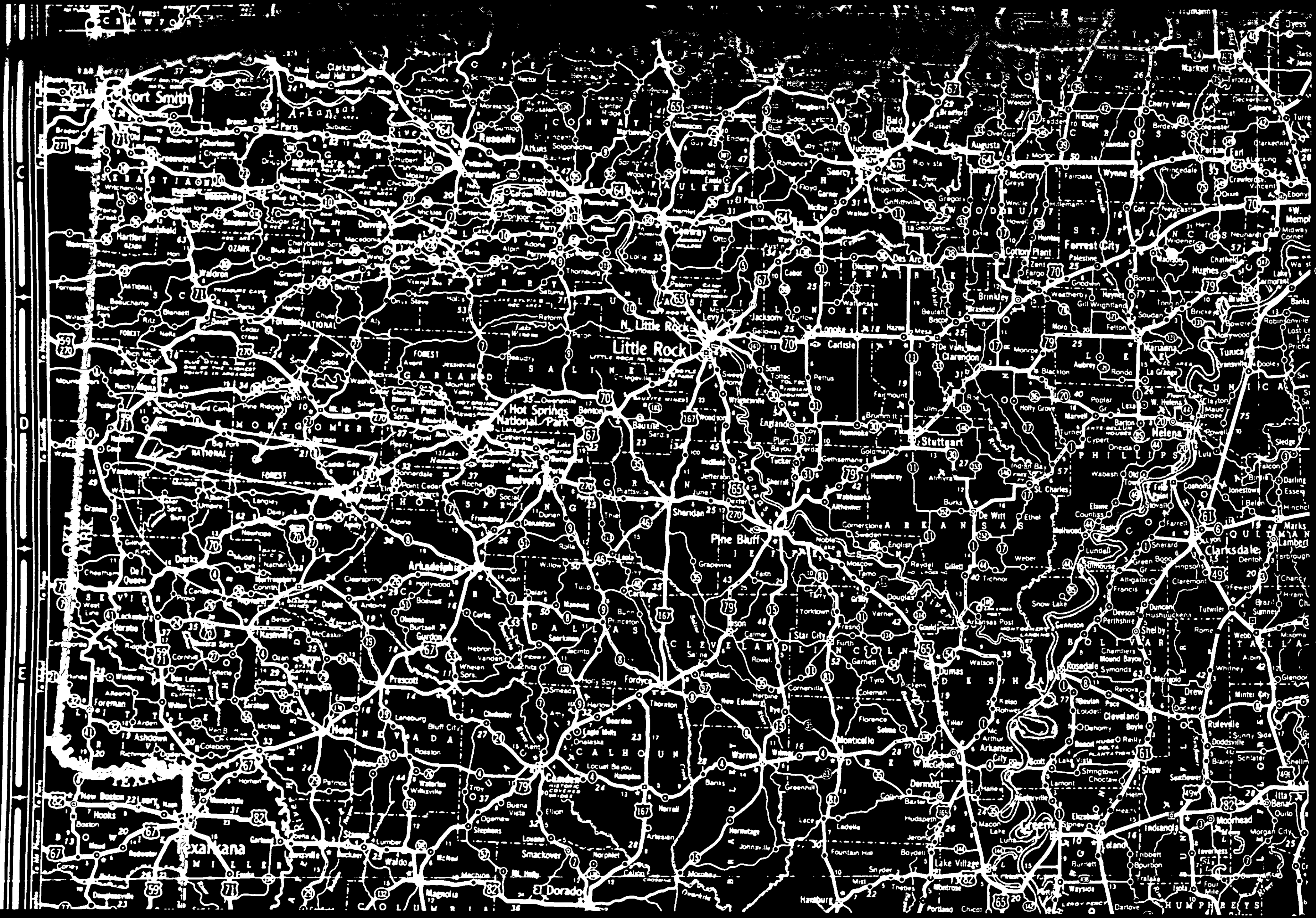
GENERAL INFORMATION

Location and Access:

The west-central Arkansas novaculite beds which exhibit manganese mineralization are exposed over a rectangular area some forty miles from east to west and about seven miles from north to south. The exposures extend from Mena in the west to beyond Caddo Gap in the east. Most of the outcrops appear in Montgomery and Poke counties, although they extend for a mile or so south into Pike County.

Mena has a population of about 7,000 and is a rail point on the Kansas City and Southern Railroad. Caddo Gap, on the eastern end of the area, is on the Missouri Pacific Railroad.

Several gravelled roads transverse the area and east-west access gnerally is good. The ridges, however, are steep-sided and are crossed by few roads running north and south.


Fort Smith
Arkansas River
Clarksville
Russellville
Conway
Searcy
Augusta
Wynne
Forrest City
Brinkley
Cotton Plant
Des Arc
Marianna
Helena
N. Little Rock
Little Rock
Jacksonville
Cabot
Beebe
Lonoke
Carlisle
Stuttgart
Clarendon
De Witt
St. Charles
Benton
Hot Springs National Park
Malvern
Arkadelphia
Sheridan
Pine Bluff
Fordyce
Camden
El Dorado
Magnolia
Hope
Prescott
Texarkana
Ashdown
Nashville
De Queen
Mena
Waldron
Booneville
Dardanelle
Morrilton
Danville
Star City
Monticello
Warren
Dumas
McGehee
Dermott
Lake Village
Arkansas City
Hamburg
Crossett
Clarksdale
Cleveland
Greenville
Leland
Indianola
Moorhead
Ruleville
Drew
Shelby
Rosedale
Tunica
Marks
Lambert
W. Memphis
Marked Tree
Dyess
Gurdon
Smackover
Malvern
Glenwood
Mount Ida
C

Topography:

The area of interest lies between 1500 and 2500 feet above sea level. The ridges and valleys run nearly east and west. Often, the valley walls are so steep as to be difficult to ascend on foot and nearly impossible on horseback.

Most of the valleys are too narrow for cultivation and, except for a few small, scattered farms, are heavily wooded. Small streams run the year around in many of the ravines.

The area is overgrown with dense underbrush and has a good deal of timber, which is mainly white and black oak, gum, and yellow pine.

Labor and Living Conditions:

Perhaps several hundred unskilled men could be hired locally. It would be necessary to build accommodations for skilled and supervisory employees.

The climate is mild and there is but little snowfall. Operations such as open-pit mining and truck hauling can be carried on the year around.

Power and Water:

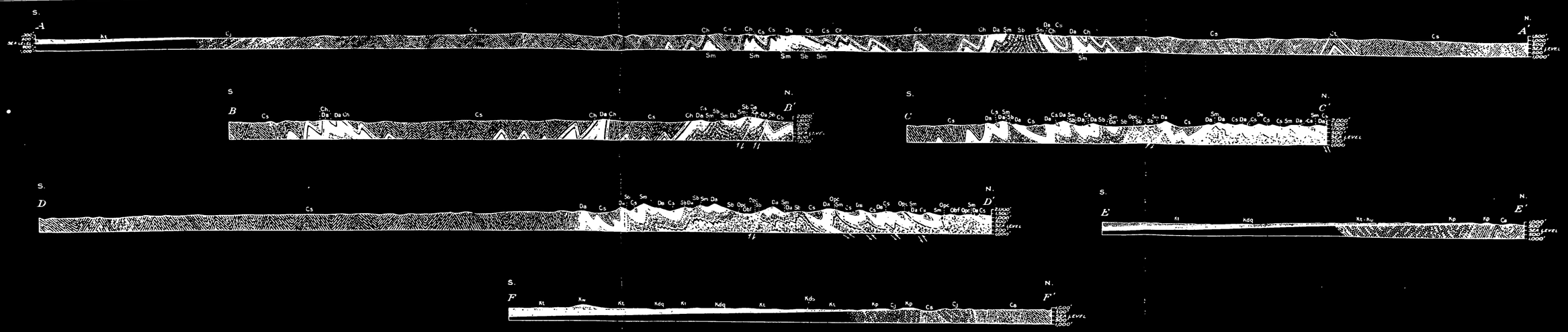
Electric power main transmission lines pass through Mena and DeQueen. Power lines could be extended into the manganiferous area at a cost of perhaps $3,500 a mile. Thirty miles would very likely be the maximum distance from existing power lines to any plant site now contemplated.

Water sufficient for metallurgical purposes can be developed from streams or wells.

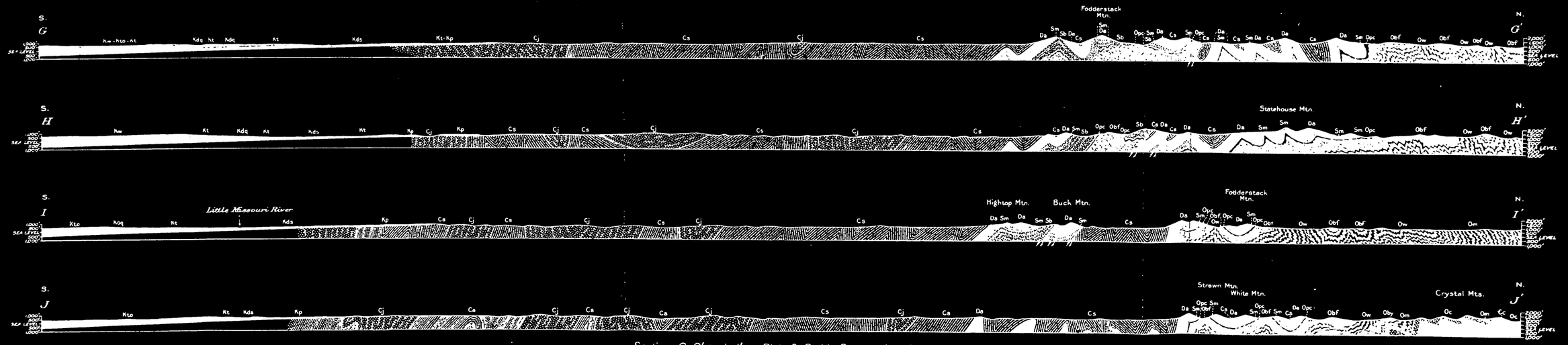
Property and Ownership:

Most of the land on which the manganiferous chert is exposed is held by the Federal Government. Except where an occasional agricultural or mineral patent has been secured, the mineral rights are open to location under Federal law.

The writer is advised that the Inland Mining Corporation now has under lease or holds by mineral location about one hundred lode claims. Each of these is 600 feet by 1500 feet and comprises 20.66 acres.



Sections A–A′ to F–F′ on Plate 3, De Queen quadrangle



Sections G–G′ to J–J′ on Plate 3, Caddo Gap quadrangle

Kto Tokio formation
Kw Woodbine formation
Kt Trinity formation
Kdq De Queen limestone member
Kds Dierks limestone lentil
Kp Pike gravel member
Ca Atoka formation
Cj Jackfork sandstone
Cs Stanley shale
Ch Hatton tuff lentil
-- Ct Bed of tuff

STRUCTURE SECTIONS ACROSS THE DE QUEEN AND CADDO GAP QUADRANGLES, ARKANSAS AND OKLAHOMA

For lines of sections see Plate 3

Scale $\frac{1}{125,000}$

1 0 1 2 3 4 5 MILES

EXPLANATION

CRETACEOUS CARBONIFEROUS DEVONIAN SILURIAN ORDOVICIAN CAMBRIAN

For detailed explanation of geologic formations see Plate 3

Da Arkansas novaculite
Sm Missouri Mountain slate
Sb Blaylock sandstone
Opc Polk Creek shale
Obf Bigfork chert
Ow Womble shale
Oby Blakely sandstone
Om Mazarn shale
Oc Crystal Mountain sandstone
Ꞓc Collier shale

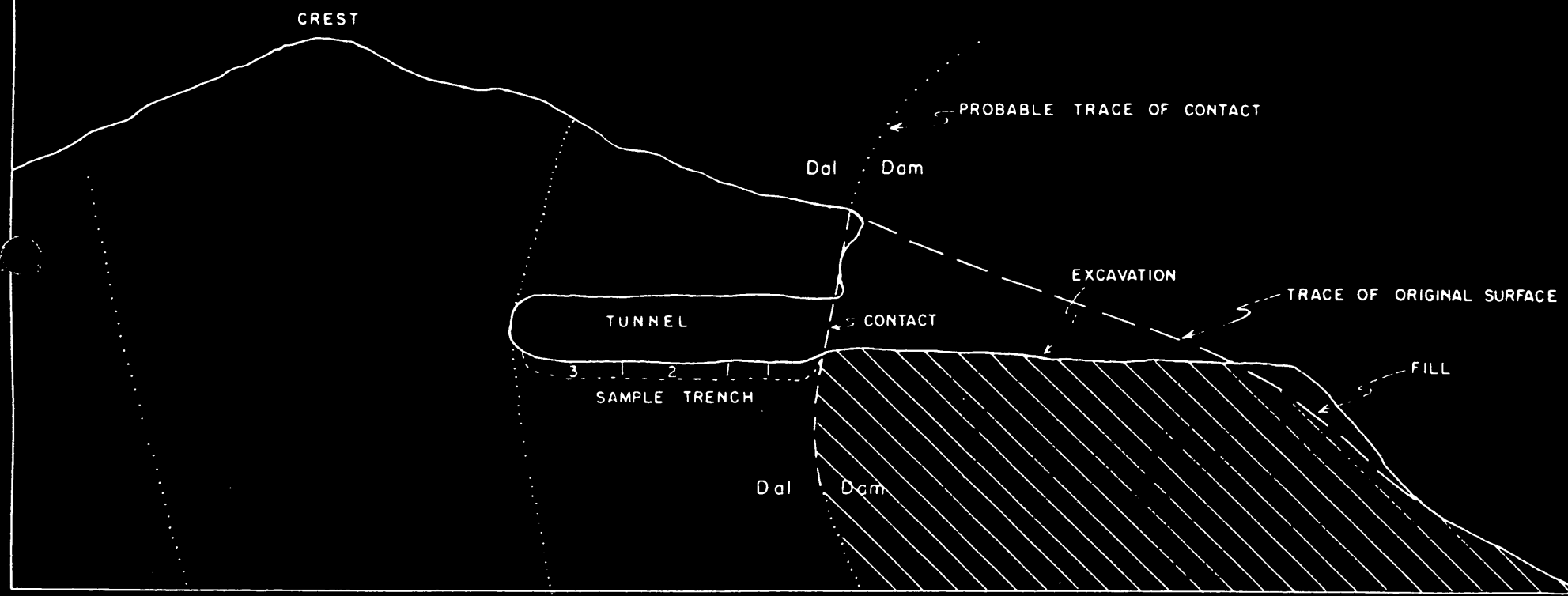
NOTE:
NUMBERS IN TRENCH IN TUNNEL
DENOTE SAMPLE INTERVALS

INLAND MINING CORP.
MENA, ARKANSAS

SKETCH OF TUNNEL ON NEW FIND GROUP OF CLAIMS ON
SEC 27 T3S R29W
POLK COUNTY ARKANSAS
SCALE 1" = 15'

D M E A PROJECT NO 2299
JUNE 30 1952
BY G A APPD R B.M.

CROSS SECTION A A' LOOKING N 55 W



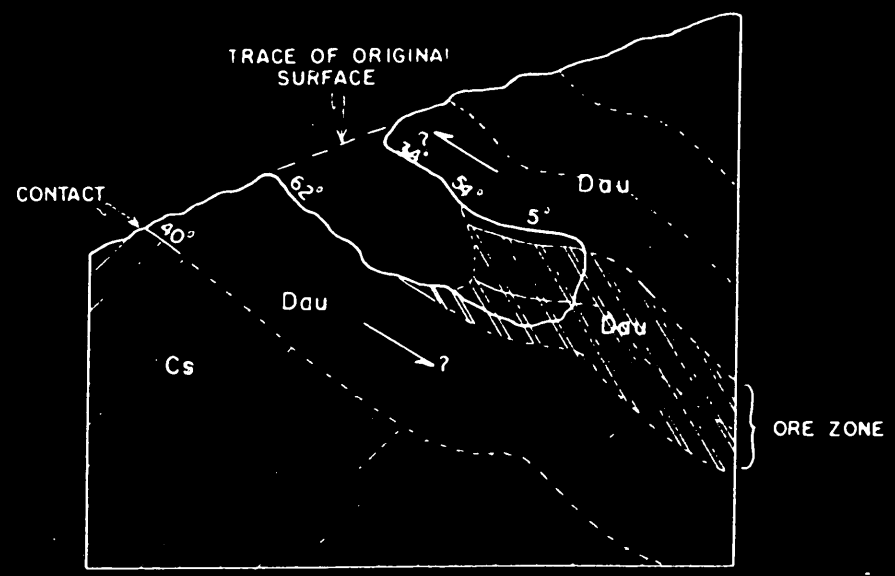
107 PLATE I

INLAND MINING CORP.
MENA, ARKANSAS

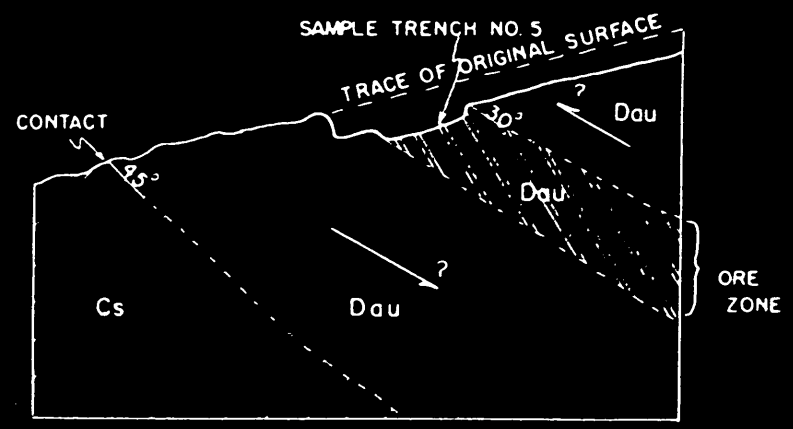
SKETCH- CROSS SECTIONS OF HURRICANE GROUP OF CLAIMS (Map No. 108) SEC 33 & 34 T3S R28W
POLK COUNTY, ARKANSAS
SCALE 1" = 20'

D.M.E.A. PROJECT NO. 2299
JUNE 30, 1952

BY B.A. APPD. R.B.M.



CROSS SECTION B B LOOKING S 71 W

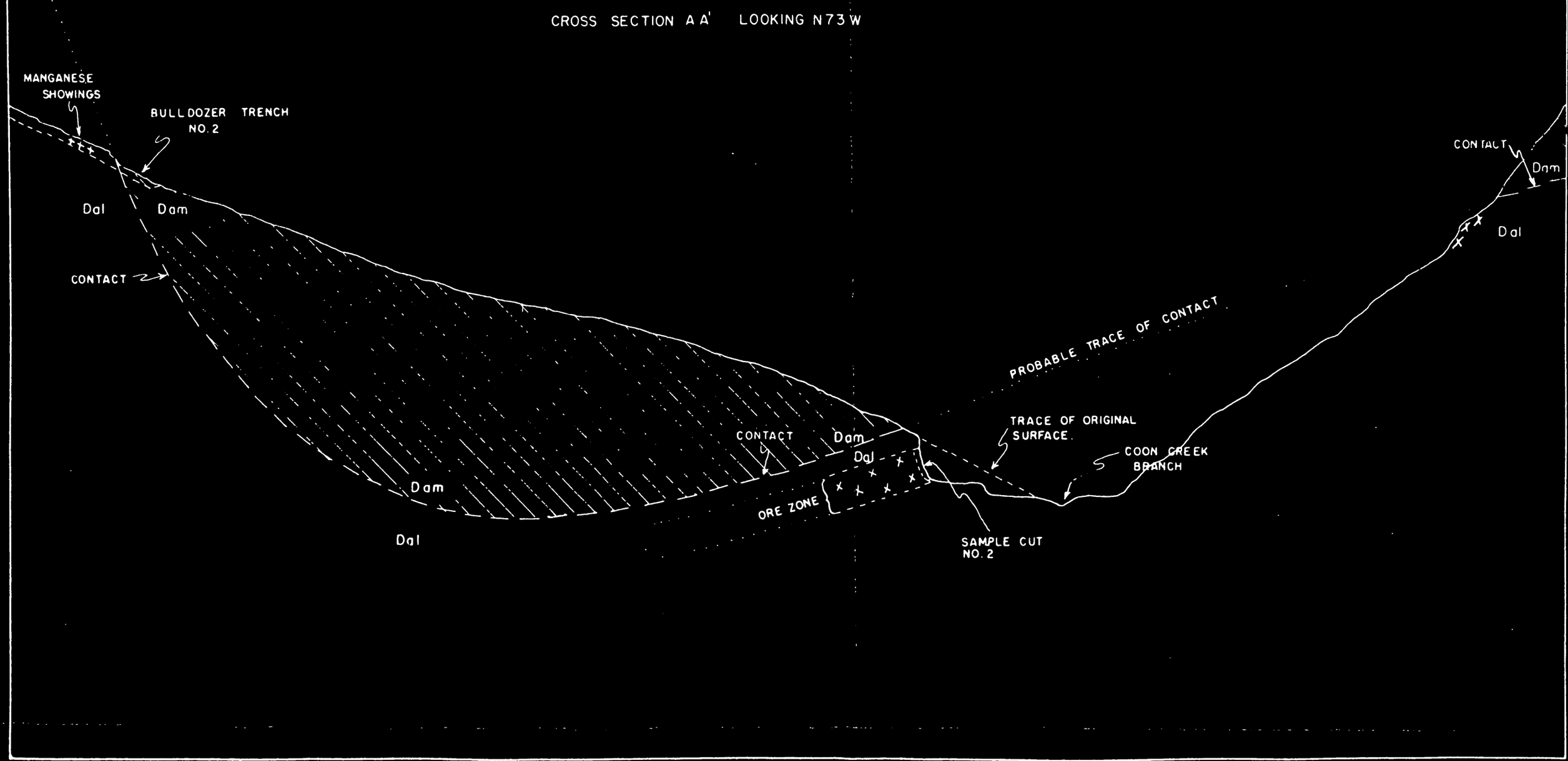


CROSS SECTION C C LOOKING N 44 E

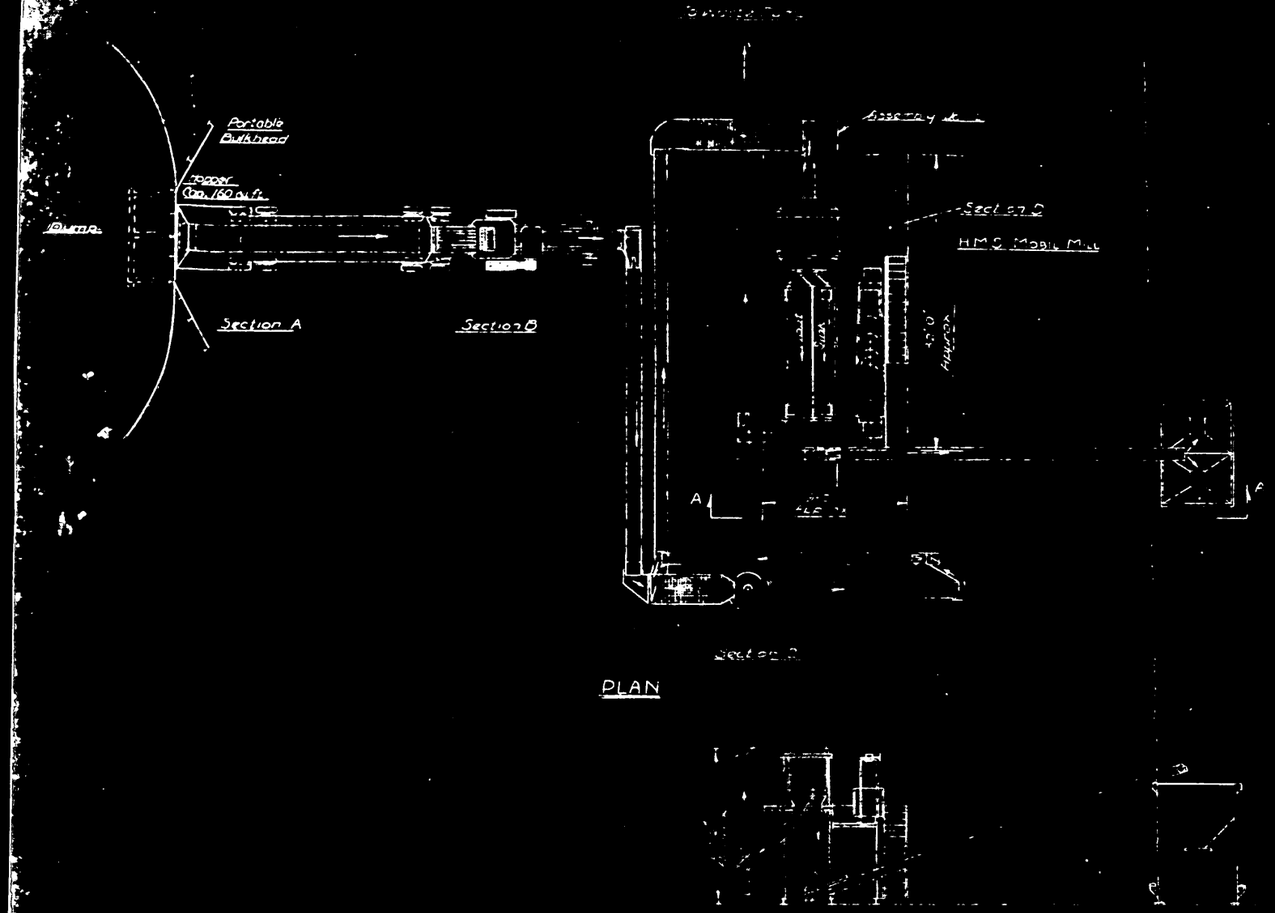
INLAND MINING CORP.
MENA, ARKANSAS

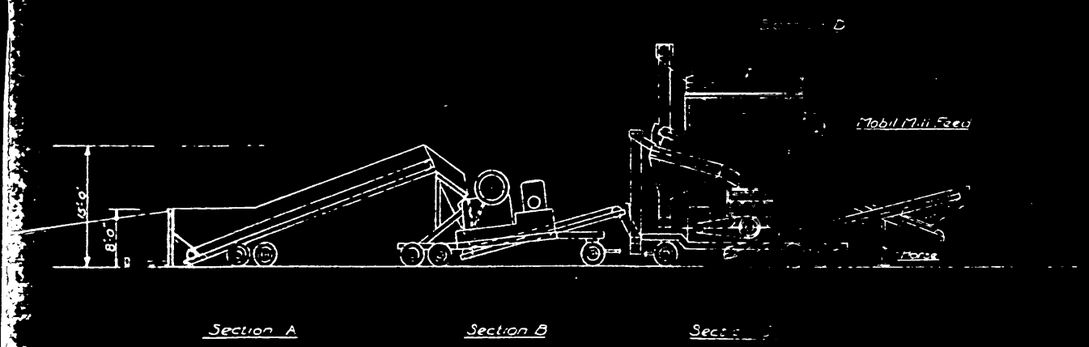
CROSS SECTION THROUGH EXCAVATION AND TRENCH ON COON CREEK GROUP OF CLAIMS (Map No. 109) SEC 13 AND 14 T4S R28W
POLK COUNTY, ARKANSAS
SCALE 1" = 60'

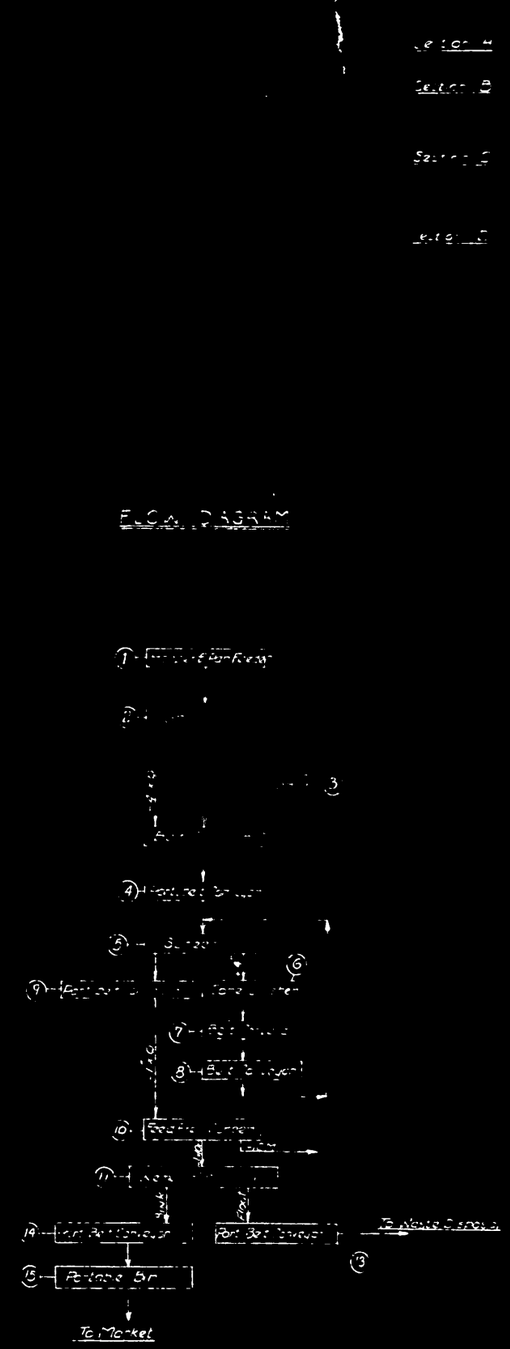
D.M.E.A. PROJECT NO. 2299
JUNE 30 1952
BY B.A. APPD. R.B.M.



109 - PLATE I







EQUIPMENT LIST

Item	No.	Description	HP	Size	Remarks
1	1	[illegible] Portable Bulkhead	31	42"×32'	Gas Engine
2	1	Grizzly Cantilever Type	-	3'×5½'	4" Openings
3	1	Crusher - Roll Jaw & Conveyor	92	24"×36"	Gas Engine
4	1	Belt Conveyor - Portable on Wheels or Skids	7½	24"×32'	
5	1	Screen Double Deck 2' Top 1' Bottom Cloth	7½	4'×12'	
6	1	Cone Crusher	64	3' Std.	Gas Engine
7	1	Belt Conveyor Screen Closure	5	18"×32'	
8	1	Belt Conveyor Screen Closure	5	18"×40'	
9	1	Belt Conveyor - Portable on Wheels or Skids	7½	18"×60'	
10	1	Feed Prep Screen Double Deck 5' Top 1' Bottom	10	4'×16'	
11		WEMCO Mobil Mill	60	3M Mod	8'-8' Drum
12	1	Pump - Vertical - Clean-up	5	2"	Not Shown
13	1	Belt Conveyor Waste Stacker - Portable	5	18"×80'	Floor
14	1	Belt Conveyor Portable on Wheels or Skids	5	18"×32'	Sump
15	1	Product Bin Portable	-	10'×14'	
16	1	Portable Generator Set - Diesel -		125 HP	Not Shown

NOTE

[illegible]

2 [illegible] Wheels or Skids may be substituted for pneumatic wheels

1 All Sections may be revolved to suit ground conditions

DWG No	DESCRIPTION	No.	DESCRIPTION
REFERENCES		NOTES	

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SAN FRANCISCO **WESTERN MACHINERY COMPANY** CALIFORNIA

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DATE	9-10-52	PORTABLE MANGANESE BENEFICIATION PLANT	SPECIAL ORDER
SCALE	NONE	30 TONS/HOUR H.M.S	
DRAWN	EM	FLOW DIAGRAM & GENERAL ARRANGEMENT	ISSUED SEP 11 1952
CHK'D		INLAND MINING CORP	
APPR.	A.J.S.	MENA ARKANSAS	LIST 10743

No.	DESCRIPTION OF REVISIONS	DATE

Many of the known manganese exposures are still open for location. Almost any of the manganiferous outcrops already located can now be leased or purchased for a few hundred dollars a claim, since there is now no commercial manganese production in the region.

THE ORE DEPOSITS

General Geology and Occurrence of the Deposits:

The United States Geological Survey (see photostats of Plates III and XV of U.S.G.S. Bulletin 808) has mapped the geology of west-central Arkansas on the DeQueen and Caddo Gap quadrangles. Most of the members typical of the paleozoic era are included in the sequence of the region. All have suffered compression from north and south. The longitudinal axes of the folding is hearly due east and west. At present, the maximum relief is about 1,000 feet.

The more rapid erosion of the folded, softer members has formed the narrow, often steep-sided ravines. The ridges are composed of the more resistant rocks, such as the novaculite members in which we are chiefly interested.

The Arkansas novaculite, or chert, is a light colored, hard sediment which has conchoidal or glass-like fracture. Where not mineralized with iron nor with manganese, this rock contains about 98 per cent of SiO_2.

The hardness and characteristic fracture of this rock are its most important features. That is, upon becoming over-stressed, this bed crushes into small, sharp fragments which are sufficiently strong to provide a high percentage of interstitial voids. The crushed portions of the novaculite beds thereby become the host of iron and manganese minerals which commonly migrate near the earth's surface in meteoric (oxygen-rich) waters. The grade of manganese ore encountered is, therefore, largely a function of the intensity or frequency of fracture of the novaculite.

No manganese mineralization of any importance has been observed outside of the Devonian novaculite. These beds are identified in U.S.G.S. Bulletin 808, Plate III by the symbol "Da". The reader's attention is directed to this geologic map. He will observe that the notations by the United States Geological Survey of manganese occurrences in the novaculite beds number nearly a hundred. The area to be explored for manganese is thus confined to the novaculite beds.

The work which has so far been done indicates that these beds can be rapidly prospected by bull-dozer trenches. Where manganese showings warrant,

jackhammer or churn drill holes can be drilled to establish tonnage and grade. The cost of such development is now estimated at about ten cents a ton of 5 per cent manganese material indicated.

Character of Ore:

These manganese minerals which fill interstices in the chert are hard, black oxides. Chemical analyses indicate that they are both pyrolusite, MnO_2 and manganite, MnO (OH). The absence of any barium in the samples so far assayed indicates that there is no psilomelane.

The mineral has a specific gravity of nearly five and a hardness of more than five on Mohs' scale. It has a conchoidal fracture and when fresh broken, the color is blue-black.

The chemical analysis of the mineral is 36 to 45 per cent of manganese, 2 to 3 per cent iron, less than 5 per cent silica plus alumina, 0.05 to 0.20 per cent phosphorus and only traces of lead, zinc, copper and sulphur.

Loss on ignition is 8 to 12 per cent. When fused with about 10 per cent of powdered coke, the resulting sinter, in most cases, comes up above 51 with controlled atmosphere, a nodule could be produced containing over 50 per cent of manganese.

The seams of manganese mineral in the fractured chert are from a knife blade in width to several inches. Numerous large "clay pockets" occur in the chert which contain chunks of mineral so large as to weigh several hundred pounds. However, except for the occasional large lump of pure mineral, the ore is a black and white breccia resembling pieces of highway paving which is composed of light-colored crushed rock cemented with asphalt.

Sampling and Assaying:

The sampling has been supervised by consulting geologist R. B. McElwain of Little Rock, Arkansas. The sample descriptions are taken from Mr. McElwain's periodic reports made to the writer and to the Defense Minerals Exploration Administration during the first half of 1952.

Although several hundred manganese exposures are known in the novaculite outcrops, only about twenty of these have been prospected by Inland. The choice has been primarily dictated by accessibility.

Three of the more promising manganese showings have been sampled, analyzed in complete detail and tested for amenability to beneficiation by heavy-media separation. These are:

1. The New Find group in Section 27, Township 3 South, Range 29 West.

2. The Hurricane Bill group in Section 34, Township 3 South, Range 28 West.

3. The Cooh Creek group in Sections 13 and 14, Township 4 South, Range 28 West. All three are in Polk County, Arkansas.

The following samples were taken from the higher grade sections of these three deposits for the purpose of obtaining complete quantitative information.

Excerpt from R. B. McElwaine
Monthly Report

Sample No. : HB #1

Date Taken: June 3, 1952

Location: Hurricane Bill claims 1 and 2 located in the east center of Section 33 and west center of Section 34, T.3S., R.28W., Polk County, Arkansas.

How Taken: Two channel samples were taken across the edge of the upturned ore bed which is about eight feet thick. The bed had been opened up by mining operations several years previously and the samples were taken in these old workings at points about 100 feet apart along the strike of the bed. The two channel samples were combined so as to make one representative sample of the area.

Weight of Original Sample: Seventy-five pounds.

Method of Splitting: The sample was crushed to minus one inch, coned, and quartered. Opposite quarters were combined and shipped for analysis. The remaining quarters were combined and saved for future reference.

Description of Ore: One channel sample was in fresh un-weathered rock. The hard, steel blue, manganese occurs as fracture fillings throughout the novaculite. The fractures have a normal thickness of 1/8" to 1/2" with numerous finer fractures and frequent heavier ones of one to two inches in thickness. The manganese in the thinner fractures contain considerable fine-grained silica, but in the coarser fractures the manganese appears to be fairly free of silica except along its contact with the rock.

The main ore bed is in the upper division of the Arkansas novaculite formation at a point about 12 to 15 feet stratigraphically below its contact with the Stanley Shale formation. This ore

bearing rock is more porous and softer than that from the lower division of the novaculite formation and is easier to drill and break than the latter. The ore from the first channel is from below the zone of oxidation and is clean and free of any apparent contaminating minerals including iron.

The second channel sample is comparable to the first one except that it is much closer to the original ground surface and contains some clay and considerable iron oxide along the fracture faces and in the more porous parts of the rock.

Sample No.: NF #1

Date Taken: June 6, 1952

Location: New Find mine located in south central part of Section 27, T.3S., R.29 W., Polk County, Ark.

How Taken: There is an old tunnel that penetrates the near vertical ore beds at a point about 20 feet below their surface outcrop. Several pieces of ore were picked at random from the wall of the tunnel to make up this sample. They are believed to be representative of one ten foot bed which contains the best ore of the 30 foot zone which is the thickness of the complete ore zone.

Weight of Original Sample: Sixty-five pounds.

Method of Splitting: The sample was crushed to minus one inch, coned, and quartered. Opposite quarters were combined and shipped for analysis. The remaining quarters were combined and saved for future reference.

Description of Ore: This ore is from the normal ore horizon at the top of the lower division of the Arkansas Novaculite formation. The rock is highly fractured and apparently somewhat altered so as to be more like the softer porous rock in the upper division than the hard dense type that is common to the lower division.

The manganese occurs as fracture filling and the fractures generally range from 1/8" to 1" in thickness. Part of the manganese is of the hard dense variety but the greater percentage of it is of the soft pyrolusite type. Most of the manganese appears to be free of the fine grained silica that is so common to most of the western Arkansas manganese occurrences.

The ore at point of sampling is practically free of clay and the only iron present appears to be fracture staining. No other minerals are observed to be present in visible quantities. The bulk of the manganese would probably be broken free of the rock if crushed to minus 1/2-inch.

Sample No.: CC #1

Date Taken: June 4, 1952

Location: Branch of Cook Creek in N.W.¼ of Section 13, T.4S., R.28W., Polk County, Arkansas.

How Taken: A ten foot ore bed lying in a horizontal position and with about six feet of rock overlying it has been mined so as to expose a vertical face of the ore bed along a distance of about seventy-five feet. At four intervals approximately ten feet apart along this exposure a channel was chipped out of the face across its vertical height and allowed to pile up at the base. As equal amount of material was taken from each pile and combined so as to form one composite sample.

Weight of Original Sample: Sixty pounds.

Method of Splitting: The sample was crushed to minus one inch, coned and quartered. Opposite quarters were combined and shipped for analysis. The remaining quarters were combined and saved for future reference.

Description of Ore: This sample is from the normal ore horizon at the top of the lower division of the Arkansas Novaculite formation. The rock is of the hard dense variety but is highly fractured and contains many large fractures which are filled with hard, high grade manganese.

This deposit appears to contain more large fractures that would produce more free ore with a minimum of curshing than any other deposit examined to date. There is also extensive fine fracturing filled with manganese.

Some iron oxide staining occurs at random throughout the exposure but no other minerals are present in visible quantities. The manganese itself is of the hard, dense, steel blue variety that breaks with a conchoidal fracture. It contains some fragments of novaculite but does not appear to have the usual intermixture of fine grained silica that is common to most of the western Arkansas ores.

Analyses Performed by
Bruce Williams Laboratories, Joplin, Mo.

Analysis on basis as received:

		HB#1	NF#1	CC#1
Moisture, dried to constant weight at 105° C.		0.14	0.18	0.11
Chemically combined Water	H_2O	2.81	3.85	4.06
Carbon Dioxide	CO_2	0.13	0.11	0.10
Calcium Oxide	CaO	0.10	0.15	0.08
Magnesium Oxide	MgO	0.12	0.23	0.17
Silica	SiO_2	75.80	64.59	62.50
Ferrous Oxide	FeO	0.03	0.02	0.03
Ferric Oxide	Fe_2O_3	4.72	1.72	3.00
Manganese Dioxide	MnO_2	12.72	23.09	21.33
Manganese Oxide	MnO	2.34	5.20	6.44
Barium Oxide	BaO	0.13	0.10	0.11
Alumina	Al_2O_3	0.48	0.16	1.44
Phosphorous Pentoxide	P_2O_5	0.20	0.22	0.25
Total Sulphur as Sulphur Trioxide	SO_3	0.10	0.13	0.12
Sodium Oxide	Na_2O	0.06	0.07	0.06
Potassium Oxide	K_2O	0.03	0.05	0.05
Zinc	Zn	*n.d.	n.d.	n.d.
Cobalt	Co	0.03	0.05	0.05
Nickel	Ni	0.02	0.03	0.04
Lead	Pb	n.d.	n.d.	n.d.
Copper	Cu	0.004	0.008	0.007
Difference and Undetermined		0.03	0.04	0.05
Total Manganese as Mn		9.85	18.62	18.47
Total Iron as Fe		3.32	1.22	2.12
Total Phosphorous calculated to P		0.09	0.10	0.11

*none detected.

The traces of copper, cobalt and nickel may be present as sulphides. Some of the manganese may be present as a silicate.

The following three metallurgical samples were taken to represent the ore as it would be broken in the process of mining. These samples were for evaluation as to metallic content of the ore deposits. The rejects were sent to the American Cyanamide Company ore dressing laboratories at Stamford, Connecticut and to the Dorr Company at West Port, Connecticut. The results of these tests are included in the METALLURGY section.

Sample Descriptions

Assay Results of Samples -- Bruce Williams Laboratories

Location	Trench No.	Sample No.	Length of Cut	Mn	Fe	P
New Find	1	1	10'	8.22	1.20	0.03
New Find	1	2	10'	2.83	1.20	0.03
New Find	1	3	10'	2.15	1.11	0.03
Hurricane Bill	1	1	6'	5.54	2.40	0.05
Hurricane Bill	1	2	6.5'	4.62	3.20	0.02
Hurricane Bill	2	1	7.5'	4.22	1.20	0.02
Hurricane Bill	2	2	8.5'	6.77	4.20	0.10
Hurricane Bill	3	1	7.5'	23.70	1.20	0.14
Hurricane Bill	4	1	9.5'	7.75	1.44	0.05
Hurricane Bill	5	1	9'	7.30	3.44	0.09
Coon Creek	1	1	6'	18.85	1.70	0.14
Coon Creek	1	2	6'	10.24	1.26	0.07
Coon Creek	2	1	6'	6.35	1.36	0.04
Coon Creek	2	2	6'	7.30	1.46	0.03
Coon Creek	3	1	6.5'	17.94	4.92	0.25
Coon Creek	3	2	6'	10.34	1.24	0.08

THE ORE RESERVES

In order to classify low grade manganiferous material as "ore", qualitative analysis is not sufficient. There must also have been demonstrated that the ore can, by some economical process, be concentrated or smelted into marketable form.

The New Find, Hurricane Bill and Coon Creek ores have been found to concentrate readily by means of heavy-media separation. This intermediate concentrate can be smelted into ferromanganese with good recovery.

The writer's estimate of manganese ore indicated by present trenching and visible outcrops is:

	Grade	Width	Tons
New Find	5.4% Mn	20 ft.	100,000
Hurricane Bill	8.00%Mn	10 ft.	120,000
Coon Creek	12.50%Mn	13 ft.	500,000

The reader is again referred to the Plate III of the U.S.G.S. Bulletin 808. The known manganese showings are marked by circles. Geologist McElwaine has expressed the opinion that one bulldozer crew could develop new ore in this region at the rate of at least 100,000 tons a month.

The reader's attention is also directed to the following list of land tracts upon which manganese exposures are found. It will be noted that the greater number of showings occur in Montgomery and Pike counties, although the Inland interests have so far been confined to Polk County.

Montgomery and Pike County
Manganese Occurrences:

Tract	Section	Township	Range
SW¼ of NW¼	13	4S	24W
NW¼ of SW¼	13	4S	24W
S ½ of NE¼	14	4S	24W
SE¼	14	4S	24W
N ½ of SE¼	19	4S	25W
N ½ of SW¼	19	4S	25W
S ½ of NE¼	19	4S	25W
S ½ of NW¼	19	4S	25W
S ½ of SW¼	13	4S	26W
NE¼	24	4S	26W
N ½ of NW¼	24	4S	26W
S ½ of NW¼	18	5S	23W
S ½ of NE¼	13	5S	24W
S ½ of SE¼	4	5S	24W
NW¼ of SE¼	4	5S	24W
SW¼	4	5S	24W
SW¼ of SE¼	32	4S	24W
SE¼ of SW¼	32	4S	24W
NW¼	5	5S	24W
N ½	6	5S	24W
N ½ of SE¼	1	5S	25W
S ½ of SW¼	9	5S	25W
S ½ of NE¼	9	5S	25W
SW¼ of SW¼	5	5S	25W
NW¼ of NW¼	8	5S	25W
SE¼ of SE¼	6	5S	25W
NE¼ of NE¼	7	5S	25W
S ½ of NE¼	3	5S	26W

Tract	Section	Township	Range
S ½ of NW¼	10	5S	26W
NE¼ of SW¼	11	5S	26W
NW¼ of SE¼	11	5S	26W
S ½ of NW¼	5	5S	26W
S ½ of NE¼	6	5S	26W
N ½ of SE¼	6	5S	26W
S ½ of NW¼	6	5S	26W
N ½ of SW¼	6	5S	26W
W ½ of NW¼	34	4S	26W
E ½ of NE¼	33	4S	26W
NW¼	28	4S	26W
N ½ of SW¼	17	4S	26W
SW¼ of NW¼	11	4S	27W
NW¼ of SW¼	11	4S	27W
S ½ of NE¼	10	4S	27W
S ½ of NW¼	26	4S	27W
S ½ of NE¼	27	4S	27W
NW¼	27	4S	27W
S ½ of SW¼	22	4S	27W
N½	28	4S	27W
N ½ of NE¼	29	4S	27W
N ½ of NW¼	29	4S	27W
N ½ of NE¼	30	4S	27W
N ½ of NW¼	30	4S	27W
S ½ of SW¼	19	4S	27W
N ½ of SE¼	18	4S	27W
N ½ of SW¼	18	4S	27W
N ½	17	4S	27W
S ½ of NW¼	16	4S	27W
N ½ of SW¼	16	4S	27W
S ½ of SW¼	32	3S	27W
N ½ of NW¼	5	4S	27W

Polk County Manganese Occurrences

Tract	Section	Township	Range
NW¼ *	13	4S	28W
NE¼	13	4S	28W
SE¼	13	4S	28W
SW¼	13	4S	28W
S ½ of SE¼	13	4S	28W
N ½ of NE¼	25	4S	28W
SE¼	14	4S	28W
NE¼	22	4S	28W
NW¼	18	4S	28W
NW¼	19	4S	28W
W ½ **	34	3S	28W
E ½ **	33	3S	28W
S ½ of NW¼	36	3S	29W
N ½ of NE¼	24	4S	29W
S ½ of NE¼	35	3S	29W
SW¼ ***	27	3S	29W
NE¼ of SW¼	15	4S	29W
N ½ of SW¼	8	4S	29W
S ½ of SW¼	13	4S	30W

Note: * Coon Creek
** Hurricane Bill
*** New Find

It appears a certainty to the writer that several million tons of ore could be quickly developed southeast of the Coon Creek area.

The total manganese metal indicated by recent work in eastern Polk County is estimated as follows:

	Grade		Tons	Amount of Manganese
New Find	5.4	x	100,000	540,000
Hurricane Bill	8.0	x	120,000	960,000
Coon Creek	12.5	x	500,000	6,250,000

Total indicated manganese ..... 7,750,000 units

CONSIDERATION OF PROBLEMS

Acquiring Prospecting and Mining Rights:

Practically all of the manganiferous novaculinte is on public domain. The mineral rights may be taken up as lode locations under Federal mining law.

All of the manganese exposures have, no doubt, been located and relocated many times. Probably much of the desirable ground now is actually open to location due to the most recent locator's failure to perform his last year's assessment work. However, most of the locators are local people who are willing to do business on a modest basis. The fact that no manganese undertaking here has been commercially successful has great bearing upon the asking price for these mineral claims.

Exploration and Development:

Inland Mining Corporation has already done sufficient exploration work on the manganiferous novaculites to permit an estimate of the development cost per ton of ore. This now appears to be about 10 cents a ton of ore discovered.

There are hundreds of known manganese exposures in the area. (See Plate III of U.S.G.S. Bulletin 808 and listing of land tracts under THE ORE RESERVES.) Practically no blind trenching need be done initially. Exploration may be confined to the evaluation of already discovered ore deposits. Each ore body need not necessarily be completely delimited by extensive drilling and tunneling since there are so many different exposures.

Sufficient tonnage may be assured by merely exposing one face on each deposit and assuming some moderate factor for continuation in depth along the dip of the stratum. For instance, if 100 feet should be considered a maximum reasonable figure, rather than 50 feet, only one-half the length of outcrop

need be exposed to set up the same ore reserve tonnage. Actually, this estimated depth factor will vary with the length and breadth of the outcrop exposed and will largely depend upon the judgment of the engineer in charge of the exploration program.

The equipment sufficient to carry on an adequate exploration program would consist of two large bulldozers, four portable compressors, four wagon drills with minor auxiliary tools. Should deeper holes be required for occasionsl testing, local water well churn drill rigs may be hired.

For the most part, exploration in this region will be largely clearing off of the naturally exposed outcrops for the purposes of taking samples and mapping.

Mining:

The attitude of the mineralized strata is often such that they may be strip-mined a considerable distance below the outcrop. The ratio of the thickness of overburden to that of the ore will determine the ultimate tonnage which can be won by open-pit methods.

The depth at which open-cut excavation must cease and underground mining be instituted is always a function of the thickness and attitude of the ore body. It costs ten or twelve times more to excavate one ton of material by underground methods than it does by open-cut. The ratio of overlying rock to the ore must generally be greater than about ten to one before abandoning open-cut methods.

The mineralization of the novaculites is sometimes thirty or forty feet in thickness. More often it is five to twenty feet thick. In cases where the ore dips flatly, a twenty-foot bed could conceivably be mined 200 feet below the original surface without resorting to underground mining.

If one were to begin mining at the outcrop of the bed where the overburden was nil and pursue the ore along its dip until the stripping ratio was ten to one, the average overburden removed would be five tons per ton of ore. The cost for each ton of ore mined in such case would be six times the unit cost per ton for open-cut mining.

The cost of open-cut excavation can be closely estimated while that of underground mining varies greatly. For the purpose of this report, only open-cut mining will be considered in detail, since for some time ample tonnage can no doubt be produced by the cheaper method.

The limiting factor in power shovel size as well as in the equipment is probably the over-all width of tread which could be accommodated on the usual mountain road. This is about ten feet in maximum width.

Heavy-duty one and one-half cubic yard rock shovels weighing 80,000 to 100,000 pounds are commonly mounted on ten-foot wide tracks. This is the

smallest and lightest shovel which should be put to such duty.

The greater part of the blasted overburden could be removed most rapidly and economically by large, rubber-tired, tractor-drawn scrapers.

Most of the blast hole drilling of 12 feet or deeper would be done with 6 to 9-inch churn drills made especially for this purpose. Holes for depths less than twelve feet would probably be drilled by compressed air wagon drills.

Explosives consumption would range from one-half pound per ton of rock broken on the higher banks to one pound per ton on the shallower faces.

No unusual problems of drilling and blasting are anticipated.

Hauling of broken ore from the pits to the several ore dressing plants is a much debated problem. The average distance would be somewhat less than one mile. Most of the roads would be of a temporary nature and difficult to maintain. Experience indicates

that whether done on contract or on company account, the over-all cost of this type of hauling from shovel to bin will amount to about 30 cents a ton-mile.

Ore Dressing:

Beginning in the fall of 1950, ore dressing research has been carried on for nearly two years. Five companies have been retained to perform tests on various samples of ore from this district. Among these are the Denver Equipment Company of Denver, Colorado, The Southwestern Engineering Company of Los Angeles, the Dorr Company, Westport, Connecticut and the American Cyanimid Company at Stamford, Connecticut.

The tests were many and the data is voluminous. All types of physical concentration tests known to the writer have been performed on this ore in order to determine the most economic means of beneficiating. These tests have included dry table concentrations, hindered settling, fixed and movable seive jigging, tabling, froth flotation, heavy-media sink-

continued after two reports of 10 pages and 20 pages

AMERICAN CYANAMID COMPANY
Mineral Dressing Laboratory

Investigation No. 242
Problem No. 812

August 5, 1952

Heavy-Media Seperation Tests on Samples of Manganese Ore from Mena, Arkansas Submitted by Inland Mining Corporation Dallas, Texas.

Introduction:

In May 1952, Mr. Morgan G. Huntington, consultant, visited the Mineral Dressing Laboratory and discussed with Mr. S. J. Swainson the possibility of up-grading some Arkansas manganese ore by Heavy-Media Separation. In a letter dated June 18, 1952 Mr. Cecil B. Chenoweth, Vice-president and General Manager, Inland Mining Corporation informed us that a sample had been shipped to the Mineral Dressing Laboratory.

Nine bags were received at the Mineral Dressing Laboratory on June 26, 1952, eight bags were received on June 27, 1952 and 19 bags were received on July 19, 1952. In a telephone conversation with Mr. Huntington on July 21, 1952, Mr. Swainson was requested to confine our testing to the latter shipment.

Object of Investigation:

We were asked to determine the possibilities of producing 25 % Mn concentrates from these samples by use of the Heavy-Media Separation Processes.

Summary and Conclusions:

Heavy-Media Separation tests on the composite of samples H. B. crushed to -2" and screened on 10 mesh and on the composite of samples C. C. crushed to -1" and screened on 10 mesh show that the desired grade of 25 % Mn was readily obtainable from ores as represented by the submitted samples.

Tests on the H. B. sample show that at specific gravity 2.80 approximately 75 % of the ore can be discarded as a float product which assays 2.89 % Mn, 1.72 % Fe and 0.04 % P. The sink product comprised 19.89 % of the ore and assayed 28.95 % Mn 3.54 % Fe, and 0.18 % P amounting to a recovery of 70.77 % of the Mn present in the sample.

Test 21, Sample C. C. indicates that at 2.70 specific gravity 59.53 % of the ore can be discarded in a float product assaying 2.67 % Mn, 0.95 % Fe and 0.028 % P. The corresponding sink product, comprising 29.63 % of the ore assays 33.90 % Mn, 3.01 % Fe, and 0.205 % P constituting a recovery of 78.26 % of the Mn present in the sample.

Preliminary Test Work:

Description of the Samples

On June 26, 1952 nine bags of ore designated NM-F and having a gross weight of 800 pounds were received at the Mineral Dressing Laboratory. On June 27, 1952 eight bags having a gross weight of 615 pounds and no sample designation were received. On the advice of Mr. Huntington no work was performed on these samples at the present time.

Nineteen bags having a gross weight of 1367 pounds were received at the Mineral Dressing Laboratory on July 19, 1952. This shipment comprised two samples whose sizes ran from 3" to fines and were marked as follows:

HB-1	M1	-2 bags	CC-1	M1	-2 bags
HB-1	M2	-2 bags	CC-1	M2	-2 bags
HB-2	M2	-1 bag	CC-2	M1	-1 bag
HB-3	M	-2 bags	CC-2	M2	-1 bag
HB-4	M	-1 bag	CC-3	M1	-2 bags
HB-5	M	-1 bag	CC-3	M2	-2 bags

We were instructed by Mr. Huntington to composite all the HB samples and to composite all the CC samples to form the second sample.

Preparation of the Samples for Testing

The nine bags marked HB were crushed to -2" and screened on 10 mesh. The -2" + 10 mesh fraction was thoroughly mixed and sacked into representative charges for testing. The -10 mesh fraction was mixed and sampled for analysis. This sample was designated HB Composite.

The ten bags marked CC were stage crushed to -1" and screened on 10 mesh. The -1" + 10 mesh fraction was mixed and sacked into representative test charges. The -10 mesh fraction was mixed, sampled and submitted for analysis.

Head Analyses

Representative head samples cut from the ores after crushing and before screening on 10 mesh were submitted for analysis of Mn, Fe, and P. Results of these analyses are presented in Table I.

Table I

Head Analyses

	HB Composite	CC Composite
Manganese	11.20 % Mn	12.96 % Mn
Iron	2.72 % Fe	2.18 % Fe
Phosphorus	0.095% P	0.11 % P

must be higher grade than average of operation

Qualitative Spectrographic Analysis:

Samples of the original ores were submitted for spectrographic analysis. The results of this analysis are presented in Table II.

Table II

Qualitative Spectrographic Analysis

Element	Range HB	Range CC	Element	Range HB	Range CC	Element	Range HB	Range CC	Element	Range HB	Range CC
Al	7	7	Co	5+	5+	Mn	8+	8+	Ag	X	X
Sb	X	X	Cu	6	6	Hg	<4	<4	Na	4+	4+
As	<4	<4	Ga	X	X	Mo	X	X	Sr	4	3
Ba	5	4+	Ge	X	X	Ni	5	5-	Ta	X	X
Be	3	2	Au	<4	<4	Nb	X	X	Sn	X	X
Bi	X	X	Fe	8	8	Pd	X	X	Ti	3	3
B	4	4	La	X	X	P	<5	<5	W	<5	<5
Cd	<4	<4	Pb	<4	<4	Pt	X	X	V	3	3
Ca	4	4	Li	X	X	K	<4	<4	Zn	5+	5
Cr	3	3	Mg	4+	4+	Si	8	8	Zr	4	4

The ranges for qualitative estimates are indicated as follows:

8 = 100 to 1.0 %
7 = 10 to 0.1 %
6 = 1.0 to 0.01 %
5 = 0.1 to 0.001 %

4 = 100 to 1.0 ppm.
3 = 10 to 0.1 ppm.
2 = 1.0 to 0.01 ppm.
1 = less than 0.1 ppm.

<and X = metal not detected

Test Work:

The Heavy-Media Separation tests were conducted in a 20 inch diameter cone equipped for continuous operation. This cone reproduces on a small scale the results which can be obtained in full-sized plants. A commercial plant can confidently be designed from the information obtained. The cone was fitted with slowly revolving sweeps that prevented any build up of the solid portion of the medium on the steep sides of the cone. The separating medium employed was finely ground ferrosilicon (15 % Si) suspended in water. This medium was adjusted to the desired overflow specific gravity; 3.00, then the sized, wetted and drained ore was fed at a rate of approximately 200 pounds per hour to the cone.

The ore as it was introduced to the cone was immediately separated in the medium into a light and a heavy fraction; the light material overflowed a weir, while the heavy fraction was discharged through an airlift.

The separated products with their accompanying medium were discharged upon a longitudinally divided vibrating screen dressed with 14 mesh woven wire cloth. The major portion of the medium drained from the separated products on the feed end of the screen into a sump and was returned continuously to the cone. As the products travelled along the screen they passed under water sprays which removed the medium that still adhered to these separated products.

The 100 pounds of cone feed from Sample HB was first separated at an overflow specific of 3.00. The float product of this test was then separated at an overflow specific gravity of 2.80. This float product was again separated at an overflow specific gravity of 2.70. On Sample CC the same procedure was adhered to using specific gravities of 3.00, 2.90, 2.80 and 2.70.

The products of the Heavy-Media Separation tests were then dried, weighed and prepared for analysis. The metallurgical results including assays, weight distributions and percentage recoveries of the pertinent components are presented in the tables that follow.

HEAVY MEDIA TEST

Table No. III

Test No. 11

Invest No. 242
Problem No. 812
Sample H. B. Composite

Product	Size	% Weight HMS Feed	% Weight Whole Ore	Assays % Mn	Assays % Fe	Assays % P	% Dist. Whole Ore Mn	% Dist. Whole Ore Fe	% Dist. Whole Ore P
Whole Ore			100.00	8.14	2.27	0.071	100.00	100.00	100.00
Total -10 M.			5.46	4.03	5.02	0.098	2.70	12.09	7.51
-2" + 10 M. HMS Feed		100.00	94.54	8.38	2.11	0.07	97.30	87.91	92.49
Sink 3.00		12.22	11.55	38.10	3.40	0.185	54.07	17.35	30.06
3.00 x 2.80		8.82	8.34	16.29	3.74	0.174	16.70	13.77	20.33
2.80 x 2.70		6.30	5.95	11.31	4.15	0.117	8.27	10.90	9.79
Float 2.70		72.66	68.70	2.16	1.51	0.033	18.26	45.89	32.31
-2" + 1" Feed	100.00	64.15	60.65	8.63	1.85	0.066	64.34	49.65	56.46
Sink 3.00	12.01	7.71	7.29	39.03	2.97	0.20	34.96	9.58	20.48
3.00 x 2.80	9.48	6.08	5.75	16.17	2.94	0.13	11.43	7.46	10.51
2.80 x 2.70	7.01	4.50	4.25	11.62	3.42	0.10	6.07	6.40	5.97
Float 2.70	71.50	45.86	43.36	2.23	1.37	0.032	11.88	26.21	19.50
-1" + 10 M. Feed	100.00	35.85	33.89	7.91	2.56	0.072	32.96	38.26	36.03
Sink 3.00	12.56	4.51	4.26	36.51	4.12	0.16	19.11	7.77	9.58
3.00 x 2.80	7.65	2.74	2.59	16.56	5.52	0.27	5.27	6.31	9.82
2.80 x 2.70	5.03	1.80	1.70	10.54	6.00	0.16	2.20	4.50	3.82
Float 2.70	74.76	26.80	25.34	2.05	1.76	0.036	6.38	19.68	12.81

Heavy Media Separatory Vessel: 20" diameter cone, outside airlift.

Medium Return: To all ports except bottom.

Feed Rate: ± 200 lbs./hr. Feed Size: -2" + 10 mesh.

Medium Type: Ferrosilicon

Medium Size: Grade 100

HEAVY MEDIA TEST

Table No. IV

Test No. 11

Invest No. 242
Problem No. 812
Sample H. B. Composite

RECAPITULATIONS

Product	Assays %				% Distribution		
	% Wt.	Mn	Fe	P	Mn	Fe	P
Whole Ore	100.00	8.14	2.27	0.071	100.00	100.00	100.00
Total -10 Mesh	5.46	4.03	5.02	0.098	2.70	12.09	7.51
-2" - 10 Mesh HMS Feed	94.54	8.38	2.11	0.07	97.30	87.91	92.49
Sink 3.00	11.55	38.10	3.40	0.185	54.07	17.35	30.06
Total Float 3.00	82.99	4.24	1.93	0.054	43.23	70.56	62.43
Total Sink 2.80	19.89	28.95	3.54	0.18	70.77	31.12	50.39
Total Float 2.80	74.65	2.89	1.72	0.04	26.53	56.79	42.10
Total Sink 2.70	25.84	24.89	3.68	0.166	79.04	42.02	60.18
Float 2.70	68.70	2.16	1.51	0.033	18.26	45.89	32.31

HEAVY MEDIA TEST

Table No. V

Test No. 21

Invest No. 242
Problem No. 812
Sample C. C. Composite

Product	% Wt.	Assays %			% Distribution		
		Mn	Fe	P	Mn	Fe	P
Whole Ore	100.00	12.84	1.83	0.091	100.00	100.00	100.00
Total -10 Mesh	10.83	11.11	3.40	0.126	9.37	20.17	14.96
-1" + 10 Mesh HMS Feed	89.17	13.05	1.63	0.087	90.63	79.83	85.04
Sink 3.00	20.05	41.15	2.89	0.21	64.26	31.73	46.24
Float 3.00 Sink 2.90	2.60	23.27	4.03	0.20	4.71	5.75	5.71
Float 2.90 Sink 2.80	2.93	19.98	3.36	0.21	4.56	5.37	6.75
Float 2.80 Sink 2.70	4.06	14.96	2.69	0.18	4.73	5.97	8.03
Float 2.70	59.53	2.67	0.95	0.028	12.37	31.01	18.31

Test Details:

Heavy Media Separator Vessel: 20" diameter cone, outside airlift

Medium Return: To all ports except bottom

Feed Rate: ± 200 lbs./hr. Feed Size: -1" + 10 Mesh

Medium Type: Ferrosilicon

Medium Size: Grade 100

HEAVY MEDIA TEST

Table No. VI

Test No. 21

Invest No. 242
Problem No. 812
Sample C. C. Composite

RECAPITULATIONS

Product	% Wt	Assays %			% Distribution		
		Mn	Fe	P	Mn	Fe	P
Whole Ore	100.00	12.84	1.83	0.091	100.00	100.00	100.00
Total -10 Mesh	10.83	11.11	3.40	0.126	9.37	20.17	14.96
-1" + 10 Mesh HMS Feed	89.17	13.05	1.63	0.087	90.63	79.83	85.04
Sink 3.00	20.05	41.15	2.89	0.21	64.26	31.73	46.24
Total Float 3.00	69.12	4.90	1.27	0.051	26.37	48.10	38.80
Total Sink 2.90	22.65	39.10	3.02	0.209	68.97	37.48	51.95
Total Float 2.90	66.52	4.18	1.16	0.045	21.66	42.35	33.09
Total Sink 2.80	25.58	36.91	3.06	0.209	73.53	42.85	58.70
Total Float 2.80	63.59	3.45	1.06	0.038	17.10	36.98	26.34
Total Sink 2.70	29.64	33.90	3.01	0.205	78.26	48.82	66.73
Float 2.70	59.53	2.67	0.95	0.028	12.37	31.01	18.31

AMERICAN CYANAMID COMPANY

(signed) R. C. Forbes
R. C. Forbes
Mineral Dressing Laboratory

EAB

242 - 812

AMERICAN CYANAMID COMPANY
Mineral Dressing Laboratory

Investigation No. 242
Problem No. 812

Heavy-Media Separation Tests on Additional Samples of Manganese Ore Submitted by Inland Mining Corporation, Mena, Arkansas.

Introduction:

This report is the second half of the report presented in August 1952, and covers test work on additional samples submitted by the subject company.

Object of Investigation:

In telephone conversation with Mr. S. J. Swainson on August 15, 1952, Mr. Morgan G. Huntington, Consultant, requested that we conduct Heavy-Media Separation tests at approximately 2.65 specific gravity on the two low grade manganese samples designated as Sample A and Sample NF-M. Mr. Huntington also requested Dutch State Mines Cyclone tests on the minus 10 mesh fraction of Sample C.C. on which Heavy-Media Separation tests were previously reported.

Summary and Conclusions:

Heavy-Media Separation tests on Composite A crushed to -1" and screened on 10 mesh were conducted at specific gravities of 2.67 and 2.62. The highest grade sink product was obtained at specific gravity 2.67 and assayed 7.05 % Mn. 12.75 % Fe and 0.49 % P in 40.84 % of the ore. The float 2.67 would comprise 50.85 % of the ore assaying 1.64 % Mn, 3.95 % Fe, and 0.134 % P. It is doubtful that a grade of 25 % Mn could be obtained on this sample by separating at a higher specific gravity.

Similar tests conducted on Composite NF-M resulted in a si product which amounted to 10.69 % of the ore which assayed 19.62 % Mn, 0.73 Fe and 0.13 % P.

Dutch State Mines Cyclone Separator tests on the minus 10 mesh fraction of Composite C.C. wet screened on 50 mesh resulted in excellent concentration of this size fraction, however this minus 10 mesh fraction constitutes only 10.83 % of the ore. Sink products were obtained which assayed over 40 % Mn in less than 20 % of the minus 10 mesh fraction. Results of these tests are presented in Tables VII, VIII, and IX.

Preliminary Test Work:

Preparation of the Sample for Heavy-Media Separation Testing.

Nine bags of ore marked "NF-M" were received at the Mineral Dressing Laboratory on June 26, 1952. The sample had a gross weight of 800 pounds and ranged in size from 4" to fines. On June 27, 1952 eight bags having a gross weight of 615 pounds were received at the Mineral Dressing Laboratory. These bags had no sample designation but we were later informed that these bags constituted Sample "A". This sample also ranged in size from 4" to fines. Both samples were prepared in the same manner.

The entire sample was crushed to -1" and screened on 10 mesh. The -1" +10 mesh fraction was thoroughly mixed by coning and sacked into representative charges for testing while the -10 mesh fraction was mixed and sampled for analysis.

Head Analyses.

The head analyses as calculated from the test products and the untreated -10 mesh are given in Table Ia.

Table Ia

Calculated Head Analyses

	Sample A	Sample NF-M
Manganese	4.15 % Mn	3.66 % Mn
Iron	7.98 % Fe	0.65 % Fe
Phosphorus	0.297 % P	0.028 % P

Qualitative Spectrographic Analysis.

Samples of the original -10 mesh materials were submitted for spectrographic analysis. The results of these analyses are presented in Table IIa.

Table IIa

Qualitative Spectrographic Analysis

El.	Range "A"	Range "NF-M"	El.	Range "A"	Range "NF-M"	EL.	Range "A"	Range "NF-M"	El.	Range "A"	Range "NF-M"
Al	6	7	Co	4	3	Mn	8	8	Ag	2	X
Sb	X	X	Cu	5+	4+	Hg	<4	<4	Na	4	5
As	<4	<4	Ga	X	X	Mo	3	X	Sr	3	4-
Ba	4-	4	Ge	X	X	Ni	5-	3	Ta	X	X
Be	3	X	Au	<4	<4	Nb	X	X	Sn	X	X
Bi	X	X	Fe	8	7+	Pd	X	X	Ti	4	5+
B	4-	5	La	X	X	P	5	<5	W	<5	<5
Cd	<4	<4	Pb	4	3	Pt	X	X	V	5	4
Ca	5	4+	Li	X	X	K	<4	<4	Zn	4	4-
Cr	3	4	Mg	5	7-	Si	8+	8+	Zr	4	4

The ranges for qualitative estimates are indicated as follows:

8 = 100 to 1.0 %	4 = 100 to 1.0 ppm.
7 = 10 to 0.1 %	3 = 10 to 0.1 ppm.
6 = 1.0 to 0.01 %	2 = 1.0 to 0.01 ppm.
5 = 0.1 to 0.001 %	1 = less than 0.1 ppm.

< and X = metal not detected

Test Work:

Heavy-Media Separation.

The Heavy-Media Separation tests were conducted in a 20 inch diameter cone equipped for continuous operation. This cone reproduces on a small scale the results which can be obtained in full-sized plants. A commercial plant can confidently be designed from the information obtained. The cone was fitted with slowly revolving sweeps that prevented any build up of the solid portion of the medium on the steep sides of the cone. The separating medium employed was a mixture of finely ground ferrosilicon (15 % Si) and magnetite suspended in water. This medium was adjusted to the desired overflow specific gravity; 2.67, then the sized, wetted and drained ore was fed at a rate of approximately 200 pounds per hour to the cone.

The ore as it was introduced to the cone was immediately separated in the medium into a light and a heavy fraction; the light material overflow a weir, while the heavy fraction was discharged through a 2 inch airlift.

The separated products with their accompanying medium were discharged upon a longitudinally divided vibrating screen dressed with 14 mesh woven wire cloth. The major portion of the medium drained from the separated products on the feed end of the screen into a sump and was returned continuously to the cone. As the products travelled along the screen they passed under water sprays which removed the medium that still adhered to these separated products.

The 50 pounds of cone feed was first separated at an overflow specific gravity of 2.67. The float product of this test was then separated at an overflow specific gravity of 2.62.

The products of the Heavy-Media Separation tests were then dried, weighed and prepared for analysis. The metallurgical results including assays, weight distributions and percentage recoveries of the pertinent components are presented in the tables that follow.

HEAVY MEDIA TEST

Table No. IIIa

Test No. 31

Invest No. 242
Problem No. 812
Sample A Composite

Product	% Wt	Assays %			%Distribution		
		Mn	Fe	P	Mn	Fe	P
Whole Ore	100.00	4.15	7.98	0.297	100.00	100.00	100.00
10 Mesh	8.31	5.25	9.21	0.345	10.51	9.58	9.66
-1" +10 Mesh HMS Feed	91.69	4.05	7.87	0.292	89.49	90.42	90.34
Sink 2.67	40.84	7.05	12.75	0.49	69.39	65.24	67.45
Float 2.67 Sink 2.62	7.49	3.90	7.68	0.27	7.03	7.21	6.81
Float 2.62	43.36	1.25	3.31	0.11	13.07	17.97	16.08

Test Details:

Heavy Media Separatory Vessel: 20 inch diameter cone, outside airlift

Medium Return: To all ports except bottom

Feed Rate: ± 200 lbs./hour Feed Size: -1" - 10 mesh

Medium Type: Ferrosilicon plus magnetite (75 % - 25 %)

Medium Size: 65 % -325 mesh

HEAVY MEDIA TEST

Table No. IVa

Test 31

Invest No. 242
Problem No. 812
Sample A Composite

Recapitulation

Product	% Wt.	Assays %			%Distribution		
		Mn	Fe	P	Mn	Fe	P
Whole Ore	100.00	4.15	7.98	0.297	100.00	100.00	100.00
-10 Mesh	8.31	5.25	9.21	0.345	10.51	9.58	9.66
-1" + 10 Mesh HMS Feed	91.69	4.05	7.87	0.292	89.49	90.42	90.34
Sink 2.67	40.84	7.05	12.75	0.49	69.39	65.24	67.45
Total Float 2.67	50.85	1.64	3.95	0.134	20.10	25.18	22.89
Total Sink 2.62	48.33	6.56	11.96	0.456	76.42	72.45	74.89
Float 2.62	43.36	1.25	3.31	0.11	13.07	17.97	16.08

Test Details:

Heavy Media Separatory Vessel: 20 inch diameter cone, outside airlift.

Medium Return: To all ports except bottom

Feed Rage: ±200 lbs./hour. Feed Size: -1" +10 mesh

Medium Type: Ferrosilicon plus magnetite (75 % - 25 %)

Medium Size: 65 % -325 mesh

HEAVY MEDIA TEST

Table No. Va

Test No. 41

Invest No. 242
Problem No. 812
Sample NF-M Composite

Recapitulation

Product	% Wt.	Assays % Mn	Assays % Fe	Assays % P	%Distribution Mn	%Distribution Fe	%Distribution P
Whole Ore	100.00	3.66	0.65	0.028	100.00	100.00	100.00
-10 Mesh	18.32	2.10	0.93	0.026	10.51	26.15	17.19
-1" +10 Mesh HMS Feed	81.68	4.01	0.59	0.029	89.49	73.85	82.81
Sink 2.67	10.69	19.62	0.73	0.13	57.25	12.00	49.07
Float 2.67 Sink 2.62	2.78	11.08	0.73	0.074	8.41	3.08	7.27
Float 2.62	68.21	1.28	0.56	0.011	23.83	58.77	26.47

Test Details:

Heavy Media Separatory Vessel: 20 inch diameter cone, outside airlift

Medium Return: To all ports except bottom

Feed Rate: ±200 lbs./hour. Feed Size: -1" -10 Mesh

Medium Type: Ferrosilicon plus magnetite (75 % . 25 %)

Medium Size: 65% -325 mesh

HEAVY MEDIA TEST

Table No. VIa

Test No. 41

Invest No. 242
Problem No. 812
Sample NF-M Composite

Recapitulation

Product	% Wt	Assays % Mn	Fe	P	%Distribution Mn	Fe	P
Whole Ore	100.00	3.66	0.65	0.028	100.00	100.00	100.00
-10 Mesh	18.32	2.10	0.93	0.026	10.51	26.15	17.19
-1" +10 Mesh HMS Feed	81.68	4.01	0.59	0.029	89.49	73.85	82.81
Sink 2.67	10.69	19.62	0.73	0.13	57.25	12.00	49.07
Total Float 2.67	70.99	1.66	0.57	0.013	32.24	61.85	33.74
Total Sink 2.62	13.47	17.85	0.73	0.118	65.66	15.08	56.34
Float 2.62	68.21	1.28	0.56	0.011	23.83	58.77	26.47

Test Details:

Heavy Media Separatory Vessel: 20 inch diameter cone, outside airlift

Medium Return: To all ports except bottom

Feed Rate: ±200 lbs./hour. Feed Size -1" +10 mesh.

Medium Type: Ferrosilicon plus magnetite (75 % . 25 %)

Medium Size: 65 % -325 mesh

float separation, and Dutch State Mines Cyclone process.

It has been determined that ferrosilicon suspension in water effects the lowest cost separation of mineral from gangue and maintains the highest recovery of valuable mineral. Known as "heavy-media separation", of as "sink-float", this process is the most nearly automatic of all ore dressing methods. Copies of reports by the American Cyanamid Company which describe tests performed on these ores are included in this section.

The minus 8- or 10-mesh fraction representing about ten per cent of the original ore is not amenable to treatment by sink-float. This fine material can be concentrated on fixed sieve jigs with very good recovery, as has been demonstrated by the Dorr Company.

The fines from higher grade ores could probably be directly re-combined without seriously lowering the grade of concentrate, thus adding about 10 per cent over-all recovery and somewhat simplifying the ore dressing set-up.

It is possible to obtain semi-protable crushing machinery and heavy-media separation units. (See portable plant flow sheet.) Employing such equipment, it is practical to immediately reject as barren waste about three-quarters of the material mined. This separation would take place at or very near the site of excavation. The concentrate would represent one-quarter or less of the ore mined and contain 75 to 90 per cent of the total manganese. The average grade of this beneficiated product is expected to have the following approximate analysis:

Manganese	26.50 per cent
Iron	3.85 per cent
Phosphorus	0.19 Per cent
Copper	0.02 per cent
Cobalt	0.08 per cent
Nickel	0.07 per cent
Silica	47.50 per cent
Total Water	5.50 per cent
Balance, less than	0.80 per cent

Transportation of Concentrate:

The selection of smelter location will determine the maximum trucking distance from the several heavy-media plants. An estimate may be made, however, by assuming the smelter will be placed in the geometric center of a mineable area 24 miles long and six miles wide. The maximum haul would be 12 miles and the average about seven. "Off-the-highway" equipment can be obtained which will perform dependably at less than 10 cents a ton-mile.

This wide, heavy hauling equipment would be confined to unpaved roads and would travel on county roads only by special permission. No doubt, an agreement can be reached with the County Commissioners for such permission. The large tonnage waste from the proposed ore dressing plants would provide the finest road metal for maintenance of the raod surface.

Storage and Mixing of Ores:

In order to provide ample storage, thorough mixing and convenient and inexpensive reclamation of ore, many ferrous and non-ferrous plants have adopted a system of bedding. This consists of forming a pile or "bed" which is long in proportion to its width and heighth. The bed is accumulated on a concrete floor from an overhead conveyor belt. This overhead belt is unloaded by a belt tripper moving forward and backward at a constant speed. Thus, each lot of ore received is distributed over the length of the bed in a uniform manner. The important result of such bedding is the fact that the pile will have exactly the same cross-sectional analysis from one end to the other, except for a small portion of the extreme ends.

Reclaiming such a pile is undertaken end-wise with the complete assurance that the chemical analysis of each day's ore will be exactly the same during the life of the pile.

Provision would be made for two such beds. One would be accumulated from the several ore dressing

Units while at the same time the other would provide a uniform feed to the furnace. The size of each bed should be sufficient to supply the smelter for a number of days.

Material to be Smelted:

The beneficiated ore as reclaimed from the bedding system is expected to have the following approximate analysis.

	As Metal	As Oxide
Manganese	26.50 %	40.10 %
Iron	3.85 %	5.50 %
Cobalt	0.08 %	.10 %
Copper	0.02 %	.025%
Nickel	0.07 %	.09 %
Phosphorus	0.19 %	.42 %
Silica		47.50 %
Total H_2O		5.50 %
Balance, less than		.80 %

Availability of Fuel and Flux:

Semi-anthracite is available in quantity from Arkansas mines. The analysis of such fuel is expected to be, on a dry basis.

At least	72.0 per cent	fixed carbon
Less than	18.0 per cent	volatile matter
Less than	8.5 per cent	ash
About	1.5 per cent	sulphur

The price delivered at the smelter is expected to be less than $10 a ton or about one-half the price of coke.

There is available from the St. Clair Limestone Company of Sallisaw, Oklahoma, an ample supply of 2-inch limestone to meet the following specifications:

$CaCO_3$	more than	98.0 per cent
SiO_2	less than	1.0 per cent
Phosphorus	less than	0.10 per cent

The estimated price is less than $5.00 a ton delivered to the plant.

Pyrometallurgical Problems:

More than 90 per cent of our ferromanganese is at present produced in ten pig iron type blast furnaces. These blast furnaces are not equipped to recover all the finely divided manganese carried in the furnace gases. A rather low (2700° - 2900° F.) hearth temperature is therefore maintained to prevent the high metal losses due to volatilization. At the same time, the furnace slag contains six to ten per cent of manganese, because of this hearth temperature.

Metal losses in the slag are held to a minimum by specifying the manganese ores which give the lowest slag to metal ratio. At present, only those ore are acceptable which generate about 1,500 pounds of slag per ton of ferromanganese. Obviously, with ferromanganese slag containing up to 10 per cent of manganese, metal losses would increase sharply if the slag-metal ratio were allowed to rise.

For the past quarter century, about 84 per cent of the total manganese charged into the furnace

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Re. 22,063

UNITED STATES PATENT OFFICE

22,063

BLAST FURNACE TREATMENT OF LOW GRADE MANGANESE-IRON ORE

Percy H. Royster, Montclair, N. J.

No Drawing. Original No. 2,265,863, dated December 9, 1941, Serial No. 234,847, October 13, 1938. Application for reissue January 3, 1942, Serial No. 425,579

7 Claims. (Cl. 75—31)

This invention relates to the pyrometallurgy of oxidic ores containing substantial amounts both of iron and of manganese, as opposed to ordinary iron ore containing only a few percent (e. g., 3% or less) of manganese compounds, and is concerned with the provision of an improved method of smelting oxidic manganese-iron ore in the blast furnace for the production of a metal and of an artificial manganese ore low in iron.

In my copending application for U. S. Letters Patent Serial No. 234,848 filed October 13, 1938, there is described a process of working up ores of the above description, said process consisting essentially in a blast furnace treatment of the ore with solid fuel, the process being characterized by the employment of (1) a fuel-to-ore ratio materially lower than is conventional in blast furnace practice, and (2) a highly preheated blast (e. g., an air blast at above 1800° F.), the total heat supplied to the charge (from combustion of the fuel plus sensible heat derived from the blast) being adjusted to and maintained at a value sufficient to discharge as liquid products the resulting reduced metal (e. g., pig iron) and the resulting artificial ore (slag) but insufficient to bring about metallization of the greater part of the manganese content of the starting material. The metal may contain a minor amount of manganese. The slag (or "artificial manganese ore") product may contain larger amounts of SiO_2 and Al_2O_3 than the usual grades of manganese ore, a small amount of FeO and the greater part of the manganese of the starting material.

Satisfactory operation of that process under blast furnace conditions can be realized economically with high blast temperatures provided the ore-to-fuel ratio is increased in the charge until the hearth temperature is reduced to the unusually low range 2000° F. to 2370° F. Even at 2420° F. I have found in actual practice that I can produce metal with as low as 1.75% Mn, i. e., a metallization of 5.3% of the manganese in the charge and a retention in the slag of about 94.7% of the charged manganese.

By the expression "hearth temperature" I mean the algebraic average of the temperatures observed with an optical pyrometer (corrected for emissivity) sighted on the emergent streams of metal and slag at "cast" and "flush," respectively.

The inventive object of the above described process is the provision of thermal and chemical conditions in a blast furnace hearth favoring the selective reduction of iron oxide.

The present invention has the same practical objectives as has the invention of the aforesaid copending patent application. Thus, it is an object of the present invention to provide conditions of blast furnace operation which shall effect the selective reduction of iron from an oxidic manganese-iron ore so as to produce a metal and a slag of such relative contents of MnO and FeO as to amount to an "artificial manganese ore."

According to the improved process of the present invention, however, I treat oxidic manganese-iron ore in a blast furnace under non-equilibrium or "upset" conditions of operation by impairing the intensity of reduction in the hearth and by so altering the chemical, physical and metallurgical conditions of usual practice that the effectiveness of the blast furnace hearth, ordinarily such a strongly reducing agent, is depreciated. The present process may be characterized as a blast furnace operation purposefully carried out under conditions inimical to the attainment of thermodynamic equilibrium. That is to say, I so limit the time, the degree of chemical contact, and the distribution of heat and of materials, that the free energy of reduction in the furnace hearth is diminished, to the end that the FeO content of the slag emerging from the furnace is higher than would result from attainment of thermodynamic equilibrium.

In effecting notable departure from equilibrium conditions I may employ one, or another, or a combination of two or more, of the following measures:

1. Overburdening the furnace by the maintenance of too high an ore to fuel ratio;
2. Non-uniformly distributing the charge on the stock line;
3. Maintaining too short a stock column;
4. Using poor coke;
5. Maintaining the slag level in the hearth higher than customary;
6. Causing the "oxidizing zone" or zone of coke combustion to cover a larger fraction of the furnace hearth area than is customary;
7. Operating with a charge which yields a slag low in CaO and MgO but high in iron and/or manganese;
8. Increasing the moisture content of the blast above normal.

A fuller explanation of these measures follows:

1. Overburdening is most frequently and readily indicated by the appearance of a "scouring slag"—i. e., a black slag relatively high in FeO—and by the concurrent production of pig iron of

poor analysis, low in silicon and high in sulphur. In conventional blast furnace practice overburdening and the consequent occurrence of scouring slag is avoided but may inadvertently occur. In the present process, however, I may purposefully overburden in order to produce a slag intentionally high in FeO, in order to maintain the desired departure from equilibrium conditions.

2. Non-uniform distribution of ore and fuel on the stock line causes the charge to descend in an irregular manner, permits the ascending gas stream to channel, and results in the injection into the bosh, tuyère zone and hearth of incompletely treated ore, thereby adversely affecting the reduction efficiency of the hearth. In conventional blast furnace practice non-uniform distribution of ore and fuel on the stock line is avoided: in the present process, however, I may purposefully and desirably impair the reduction efficiency of the hearth in this manner.

3. Allowing the level of the charge to descend too low in the furnace shaft reduces the length of the path of travel of the ore and fuel and, concurrently, the period of time within which the charge remains in chemical and thermal contact with the hot reducing gas ascending through the furnace. Thereby, the furnace is prevented in part from exercising its normal metallurgical effect as a strong reducing means, and "raw ore" (i. e., incompletely reduced iron oxide) arrives in the slag bath, "upsetting" the furnace operation as indicated by the appearance of one, two or three percent of FeO in the slag. While this would not, of course, be economically desirable in conventional blast furnace practice, I may purposefully effect this measure in order to control hearth conditions.

4. Charging coke of poor combustibility—due to (*a*) low porosity, (*b*) improper coking, (*c*) high ash content, (*d*) defective cell structure or (*e*) abnormal graphitization of carbon—likewise has an adverse effect on reduction. With reduced coke combustibility, the fraction of the furnace hearth area in which the oxidizing gases O_2, CO_2 and H_2O exist is increased and the FeO content of the slag is elevated above its equilibrium value and above that value sought in conventional blast furnace practice.

5. The effect of carrying the slag bath high in the hearth so that its surface is held in chemically reactive contact with the oxidizing gases existing in the combustion zones adjacent to the tuyères is to decrease the intensity of reduction in the hearth and to increase retention of the manganese in the slag. This measure includes, in the extreme case, carrying the upper surface of the slag bath in contact with, or even above, the tuyère level, so as positively to effect bubbling of air through the liquid slag. Metallurgically, I am here carrying out, to some extent, a Bessemerizing process in the neighborhood of the tuyères and pneumatically oxidizing the manganese content of the metal and concurrently raising the FeO content of the slag above its equilibrium value.

6. By increasing the jet velocity of the air blast through the tuyères sufficiently, I have found that I can cause (*a*) lumps of coke to be blown bodily away from the immediate vicinity of the blast entrance and (*b*) the oxidizing zone to extend farther than usual into the furnace, thereby subjecting an enhanced fraction of the hearth contents to oxidation.

7. There are two important physical characteristics of a blast furnace slag which affect the furnace operation, (*a*) its viscosity and (*b*) its "wetting" property toward coke.

When the slag viscosity is too high, the slag does not flow freely through the bosh and into the hearth and this sluggishness of slag flow causes an accumulation of incombustible material in the combustion zone. As a result, the oxidizing zone contiguous to the tuyères extends to cover an enlarged fraction of the hearth, the intensity of reduction there is increased, and the FeO in the slag is maintained at the desired concentration.

Apart from viscosity considerations, slags containing substantial amounts of iron and manganese and relatively small amounts of CaO and MgO show an adhesion for coke carbon.

Basic or even slightly acid slags do not "wet" coke carbon to any material extent but slags low in lime and magnesia and carrying a considerable amount of manganese silicates have a tendency to adhere to coke carbon. That is to say, they form liquid films which "wet" the coke and impair its combustibility. In the present process it is desirable to operate the furnace with a charge which yields a type of slag which will effect a certain amount of "coke wetting."

8. Increasing the water content of the blast above normal moisture content, i. e., operating with a wetted blast, is a powerful means of impairing the intensity of hearth reduction. Introduction of water, e. g., as a liquid spray or as live steam, in controlled amount, into the blast, is easily effected in practice, and functions in a manner counter to that of a dried blast.

The present invention is defined specifically as a blast furnace operation wherein a substantial departure from equilibrium conditions is enforced. I have found that it is possible to effect the desired departure from equilibrium by employing suitably a variety of operating factors, inimicable to thermodynamic equilibrium, such as the eight measures above listed.

Each of the several measures above described, either alone or in combination, when used under proper control, is directed to the one end of limiting the fundamentally high intensity of reduction that exists in the hearth of a normally operated blast furnace, for the express purpose of effecting a departure from equilibrium which results in suppression of manganese metallization and enhancement of the FeO content of the slag. Adoption of any one of the eight measures enumerated above or others of like effect, makes possible raising the FeO content of the slag above equilibrium value (i. e., a fraction of one per cent at usual blast temperatures), up to, say, one, two, or more, per cent.

The process of the present invention makes possible the maintenance of a higher FeO value in the slag than thermodynamic equilibrium requires, i. e., the maintenance of non-equilibrium conditions. By thus maintaining a high FeO value in the slag I depress the Mn content of the pig iron and hence effect satisfactory retention of MnO in the slag even when operating with such relatively high slag, metal and hearth temperatures as are normal in conventional blast furnace practice.

The objectives of the present invention can, in general, be realized with blast temperatures as low as 1000° F. However, with slag temperatures as high as 2730° F., and with blast temperatures

below 1000° F., a relatively high ratio of fuel to ore is required in order to keep the furnace in operation. Although I do not wish to limit the process of the present invention to any minimum blast temperature, in the sense that I am able to make the process operate with cold blast, I have found that the economy of the process and the operation of the furnace are greatly improved by employment of relatively high blast temperatures. For economical reasons, I prefer to use blast temperatures above 1800° F. In fact, I have found that with blast temperatures in excess of 2000° F., e. g., from 2200° to 2600° F., it is practically impossible to produce furnace difficulties by an indiscretion in the carrying out of the process since the slag produced is quite fluid at 2300° F. and the freezing point of the metal produced is below 2200° F.

No special skill or experience is required for the carrying out of this process. With any given oxidic manganese-iron ore, coke, burden and furnace, and with high blast temperature available, the furnace can be put into operation according to conventional blast furnace principles. Analysis of Mn in the metal and of FeO in the slag should be taken, and likewise optical pyrometer readings of the temperatures of the slag at flush and the metal at cast. If the temperature of the slag at flush is too high (e. g., above 2600 F.), and if Mn in the metal is high (e. g., 4 or 5%), indicating an undesired loss of Mn from the slag, and conjugately if the FeO content of the slag is lower than the limit established for the required Mn-to-Fe ratio needed for "ferro" production (e. g., above 3 or 4%), the reducing conditions of the hearth are obviously too intense and one or more of the several special measures, above described, for increasing the FeO content of the slag is or are practiced, and prompt analysis of the FeO content of the slag made at each flush. As the FeO is increased and the Mn content of the pig iron depressed, the economy of the process can be used as criterion for determining the optimum FeO content. The maximum value of FeO in the slag is fixed by the ratio of MnO to FeO in it, in order that the slag shall have the "artificial manganese ore" characteristics above mentioned and be within the "ferro" limit (i. e., capable of smelting, in a subsequent operation, to ferromanganese). The ratio of Mn to Fe in the slag should not be less than 8 to 1, for 80% ferromanganese and, in general, should be 12 or 14 to 1. On the other hand, the minimum limit of FeO in the slag will depend upon the maximum tolerance of manganese in the metal. As a general observation, it may be stated that the Mn in the metal may desirably be held between 0.5% to 1.0% as a lower limit and 3.5% to 4.0% as an upper limit, and the MnO retained in the slag may desirably amount at least to 70% of the total manganese content of the ore and preferably should amount to from 85% to 95% thereof.

The following specific examples are added to the foregoing description by way of illustration only. The invention is not limited to the specific conditions enumerated therein, except as may be indicated in the appended claims.

I may employ a blast furnace of usual design, 86′ tall from iron notch to lip ring of the bell, with a charge column measuring 72′ vertically from the center line of the tuyères to the normal stock line; the furnace has a heath diameter of 14′6″, a bosh diameter of 19′0″, a bosh angle of 76°, and a stock line diameter of 12′6″. The active volume of the charge column (between tuyère plane and stock line) is 14,850 cu. ft. Each 20-minute round of 28,000 lbs. of ore and 7175 lbs. of coke occupies a volume of 436 cu. ft., and forms a layer on the stock line 43″ thick (average). The average time of passage of the charge through the furnace, herein called "time of passage," is 10 hours 30 minutes. The stock line descends at an average rate of 2.15 inches per minute. The furnace is provided with a "McKee top," with rotating distributor, which device may be adjusted to rotate on a predetermined schedule. In conventional practice this device is so adjusted as to provide for uniform distribution of the charge ingredients on the stock line (i. e., "peripheral symmetry" of charge).

I charge into this blast furnace, at 20-minute intervals, rounds or charges consisting of 28,000 lbs. of oxidic manganese-iron ore and 7175 lbs. of coke, and no limestone. Analyses of the ore and coke charged are:

6,350 lbs./ton Ore		1,568 lbs./ton Coke	
Fe	33.00	Moisture	1.50
Mn	11.56	Volatile matter	1.20
P	0.205	Ash	4.50
SiO_2	8.1	Fixed carbon	92.80
Al_2O_3	2.15	S	0.45
CaO	0.73	Fe	0.78
MgO	0.34	SiO_2	2.19
CO_2	0.41	Al_2O_3	1.06
Combined H_2O	7.89	CaO	0.28
Moisture	14.50	Nitrogen	0.35

I blow this furnace of 16,680 cu. ft. with air preheated to 1900° F. In this operation I produce daily 318 long tons of pig iron and 240 long tons of slag. The metal analyzes: Si, 0.25%; S, 0.07; P, .59; Mn, 2.20; C, 3.85; Fe, 93.04. The slag analyzes: SiO_2, 31.40%; Al_2O_3, 9.05; CaO, 2.96; MgO, 1.25; FeO, 3.50; MnO, 51.66; S, 0.31; P_2O_5, less than 0.03. The temperature of the emergent metal was 2700° F., and that of the slag was 2780° F.

At the hearth temperature realized in the above illustrative example, had there been a reasonable approach to thermodynamic equilibrium, the FeO of the slag would have been much lower (less than 1%, for example) and the manganese in the metal would have been four or five per cent.

I was able to produce the above described results, which represented a marked departure from equilibrium results, by a variety of means. For example, in one mode of carrying out the process of the invention I effect non-uniform distribution of the stock on the stock line. I have found that this may be done, using a furnace provided with the type of top above described, by imparting to the charge ingredients a selected asymmetry or peripheral non-uniformity through appropriate predetermined adjustment of the schedule of the distributor. Thus, for example, the distributor may be so rotated as to deposit 17,000 lbs. of the total ore of one round in the first hemicircle and only 1,000 lbs. of ore in the second hemicircle. Coke deposition, in accordance with this example, is similarly affected, 2872 lbs. thereof being deposited in the first hemicircle and 4303 lbs. thereof being deposited in the second hemicircle. Thus, the ratio of ore to coke in the first hemicircle of the stock line is 5.92 to 1, whereas it is only 2.55 to 1 in the second hemi-

circle, although the total ore (28,000 lbs.) and the total coke (7175 lbs.) have the ratio 3.90 to 1.

By the above distribution I have, in effect, overburdened the first hemicircle of the furnace and "underburdened" the second half. If all of the iron in that portion of the charge lying in the first half were metallized, it would mean that only 1025 lbs. of coke had been consumed per ton of pig iron produced. However, this half of the furnace, under the conditions described, is not able to metallize all of the iron therein because of the under-fueling, and the melted ore runs into the hearth with from 10 to 12% of FeO remaining unreduced. Simultaneously, in the second half of the furnace, where coke is in great excess, iron is metallized with a consumption of 2400 lbs. of coke per ton of metal produced. This latter, under the conditions described, is a semi-spiegel showing from 8 to 10% Mn and Si in excess of 1%. The slag flowing into the hearth on this same side has a very low content of FeO.

As the metals from the respective halves of the furnace flow into the hearth they commingle and diffuse, yielding a metal bath indicating 4 to 5% Mn.

In like manner, the slag (substantially free from FeO) from second side, commingles with the oxidizing, "high-iron," scouring slag from the first half, and by admixture and diffusion yields a slag containing from 5 to 6% FeO.

Chemical reaction between the FeO of the slag and Mn of the metal takes place according to Equation 1, and although heat is generated by the exothermic reaction, tending to elevate metal and slag temperatures and thereby to lower the FeO content of the slag, I have found that opportunity is not afforded for the two liquids to attain thermodynamic equilibrium and thus that the desired objective is effected.

In an alternative procedure, while employing conventional symmetrical distribution at the stock line, I impair the reduction efficiency of the hearth by dropping the stock line a considerable distance below the level conventionally adhered to. For example, by protraction of the interval of each round to 30 minutes (instead of 20 minutes) the level of the top of the stock line is caused to move down in the furnace 0.7'' per minute. By maintaining this retarded charging schedule for 12 hours, I drop the stock line 42', after which event charging at 20 minute intervals is resumed. With this low stock line (30', as opposed to the former 72'), the average time of passage is decreased from 10 hours 30 minutes to about 5 hours. This shortening of the charge column is sufficient to cause injection of "raw ore" into the furnace hearth, thereby diminishing the normally high intensity of reduction of the hearth and insuring the desired retention in the slag of most of the Mn content of the oxidic manganese-iron ore in non-metallized form and the production of metal containing Mn less than 4%.

Because of the variables encountered (e. g., the reducibility, porosity, density, composition, moisture content, etc., of the particular ore, especially the "combined water," the clay content, and the "caking" or agglomerating characteristics of the ore, the characteristics of the fuel, etc.) no quantitative formula for shortening the "time of passage" can be laid down. However, one skilled in the art may, by analyses of the metal and slag, and observation of the slag and metal temperatures, readily determine the optimum stock line level for any "new" or previously untried oxidic manganese-iron ore and thereafter proceed in accordance with the above principle. It may be remarked here that observance of this embodiment of the invention makes possible a material shortening of the stack of a furnace to be built for carrying out this process, thereby effecting a saving in the cost of the furnace per se, and a lowering of the pressure required to blow the wind into the furnace (i. e., further savings in investment and operating costs in the engine room).

As a third alternative procedure, I maintain conventional symmetrical distribution on the stock line, maintain the level of the stock line at 72' above the tuyères, but upset the charge column descent by employing an asymmetrical tuyère system. Thus, in the case of an existing blast furnace provided with 8 symmetrically arranged tuyères each 4'' in diameter, total tuyère cross-sectional area 0.695 sq. ft., I replace the tuyères on the first hemicircle with tuyères 4⅜'' in diameter and on the second hemicircle with tuyères 3¼'' in diameter. The new tuyères have the same total area as the replaced tuyères, but two-thirds of the wind is now blown in at the first hemicircle and only one-third thereof at the second hemicircle. This causes the rate of coke consumption in the first hemicircle to be doubled, and the rate of descent of the stock column in that half proceeds twice as fast as in the other half. Accordingly, the stock line, even though the charge had been deposited in a uniform manner at the stock line, is caused to "dip" or become inclined to such an extent that when the average level has descended about 10' the plane of the round is inclined about 35° from the horizontal. The end result of this operation is the same as that flowing from asymmetrical distribution (first example above) and as that flowing from dropping the stock line (second example above).

The inventive objective may, I have found, be reached, with better all-around results, with more opportunity for nice control and with less liability to error due to the "personal equation," by combining the features (1) a moderate drop in stock line level (15' to 20'), and (2) a limited asymmetry of stock distribution on the stock line (e. g., 5% excess of ore on one side over that on the other side, and 5% excess of coke on the latter over that on the former), with (3) the employment of tuyères of 4¼'' diameter on one side of the furnace and tuyères of 3¾'' diameter on the other side. These individually less drastic measures combine desirably to bring about injection of suitable amounts of FeO into the hearth with consequent diminution of the intensity of reduction in the latter and the promotion of a slag containing by far the greater part of the manganese of the charge in non-metallized form.

In cooperation with any one or more of the above illustrated measures, (e. g., in cooperation with the combination described immediately above) I may and preferably do employ the measure of oxidizing the slag directly with the blast. I control the average upper level of the slag bath, preferably through the agency of a plurality of cinder notches, with associated coolers and monkeys, located at differing distances below the tuyère level, so that the same is in close proximity to the blast entrance. Thus, I may place the topmost cinder notch within 24'', or less, of the center line of the tuyères, and dis-

pose one or, preferably, more cinder notches at spaced intervals therebeneath.

It has been shown that, with run-of-the-oven coke, oxygen gas is found as far as 16" to 20" from the blast entrance, and that CO_2, in an amount giving a ratio of CO_2 to CO as great as 0.25 to 1 (which amount, at hearth temperature, is oxidizing in the reaction $Fe+CO_2=FeO+CO$) as far as 26" to 30" inwardly from the tuyère nose. Hence, by carrying the slag bath upper surface within 26" to 30" from the tuyère the former is directly subjected to gases containing a sufficient proportion of CO_2 to CO to oxidize some of the iron to FeO. When I carry the slag level within 16" to 20" from the tuyère the slag encounters gases containing CO_2 and O_2, which gases can and do oxidize some of the FeO to Fe_3O_4, thereby further enhancing the oxidizing intensity of the slag.

Considerable decrease in intensity of reduction in the furnace hearth may be effected by treating some or all of the coke of the charge as follows: The coke, as formed, is quenched in an aqueous slurry of clay or other incombustible inert mineral matter, the relative amount of such mineral matter being adjusted so that the coke when dried carries a thin coating of the mineral matter. I have found that such coatings inhibit prompt combustion of the coke in the latter's arrival in the tuyère zone, and hence diminish reduction intensity.

The use of coke in large lamps serves to extend the dimensions of the combustion zone and therefore to diminish the intensity of reduction in the furnace hearth. The linear dimensions of the combustion zone are almost directly proportional to the linear dimensions of the coke lumps.

An equally effective means of extending the dimensions of the combustion zone is the employment of higher jet velocities of the incoming air. I have found that when the jet velocity of the tuyère is increased to an extent such that lumps of coke are blown away from the tuyère nose the intensity of hearth reduction is measurably reduced. Thus, with 2100 cu. ft./min. of air (measured at 60° F. and 30" Hg.) blown through each of the eight 4" tuyères, at 1900° F. hot blast and 14 lbs. gauge pressure in the hearth, the velocity of the wind, at the tuyère nose, is about 950 ft./sec., and its hydrodynamic impact pressure is 3.3 lbs./sq. in. At this very considerable pressure the blast forces back the lumps of coke and tends to produce a so-called "gassy tuyère." Substitution of 3½" tuyères for the 4" tuyères makes possible raising the jet impact pressure to 5.65 lbs./in., and desirably extends the combustion. Employment of such high jet velocities is limited by consideration of blowing equipment available, of power consumption, etc.

Perhaps the most convenient and positive of all the methods listed above for limiting the free energy of reduction in the hearth, and the one which is most easily controlled, is the introduction of added moisture into the blast. In the above operation I prefer to reduce the burden to 26,800 lbs. of ore and 7175 lbs. of coke, per round, to hold the blast temperature at 1900° F., and to introduce 102 lbs. of steam per minute into the hot blast main. This represents about 20 boiler horse power, and is an insignificant demand on the boiler room. I prefer to jet this moisture as boiler steam into the hot blast main at a point near the stove end, in order to permit diffusion of air and steam before the blast reaches the bustle pipe. The wetted blast here contains 11% by volume of H_2O, consumes 3.3% of the carbon being burned at the tuyères, and absorbs heat equivalent to one hundred degrees of hot blast. That is to say, the introduction of 11% of H_2O vapor into the blast is the thermal equivalent of lowering the blast temperature 100° F. Its operating advantage lies in the ease and speed with which its effect can be controlled.

With the flow of steam into the hot blast main controlled by a valve, I can sight an optical pyrometer down the tuyère, open the steam valve, and the added moisture arrives at the tuyère nose within 1/20 of a second of the time of valve opening; the moisture completes its reaction with hot carbon in the tuyère zone within ½ second, being converted into CO and H_2, and the complete effect of the steam can be observed with substantially no delay.

A further operating advantage accrues from providing individual steam connections to the goose necks, or blow pipes, of the tuyères, and introducing 12 lbs. of steam per minute into each tuyère for predetermined periods of time. Thereby the degree of control possible over intensity of reduction may be considerably enhanced.

I claim:

1. Process which comprises charging oxidic manganese-iron ore and solid fuel into a blast furnace; blasting the charge with preheated air; maintaining the upper surface of the resulting slag bath at a level within the zone of direct influence of the oxidizing constituents of the blast, whereby the normal reduction intensity of the furnace hearth is lessened and a molten slag containing some FeO and at least 70% of the total manganese content of the ore in non-metallized form and a molten pig iron product are produced; and tapping off the slag and the molten pig iron product.

2. Process for the simultaneous production of pig iron and a slag containing oxide of manganese and oxide of iron in a ratio of at least 8 to 1 from an oxidic manganese-iron ore containing said oxides in a lesser ratio, which comprises charging manganese iron ore and solid fuel into a blast furnace; adjusting the components of the charge to yield a strongly "acid" slag high in silicates; blasting the charge with preheated air; and maintaining the upper surface of the resulting slag bath at a level within the zone of direct influence of the oxidizing constituents of the blast, whereby the normal reduction intensity of the furnace hearth is lessened and a molten slag containing some FeO and at least 70% of the total manganese content of the ore in non-metallized form and a molten pig iron product are produced.

3. Process which comprises charging oxidic manganese-iron ore and solid fuel into a blast furnace in a non-uniform manner such that the proportion of ore to fuel in the several locations in a horizontal plane in the shaft of the furnace differs materially from the average ratio of ore to fuel in said horizontal plane, and non-uniform flow of gases upwardly through the shaft and non-uniform descent of the charge are brought about, and blasting the charge with preheated air; whereby the normal reduction intensity of the furnace hearth is lessened and a molten slag containing some FeO and at least 70% of the total manganese content of the ore

in non-metallized form and a molten pig iron product are produced.

4. In the process of producing molten pig iron and a molten slag by heating oxidic manganese-iron ore with solid fuel, the improvement which comprises blasting a charge of the ore and fuel in a blast furnace with preheated air admitted into the furnace charge as a high velocity jet having a jet velocity in excess of 700 feet per second, whereby the normal reduction intensity of the furnace hearth is lessened and a molten slag containing some FeO and at least 70% of the total manganese content of the ore in non-metallized form and a molten pig iron product are produced.

5. In the process of producing molten pig iron and a molten slag rich in manganese compounds by heating oxidic manganese-iron ore with solid fuel, the improvement which comprises establishing and maintaining in the shaft of a blast furnace a charge column consisting essentially of a mixture of the ore and the fuel, blasting the charge with preheated air, and maintaining the charge column so short that raw ore from the charge is injected into the fluid bath of the furnace hearth.

6. Process which comprises charging oxidic manganese-iron ore and solid fuel into a blast furnace; blasting the charge with preheated air; maintaining the upper surface of the resulting slag bath at a level within the zone of direct influence of the oxidizing constituents of the blast, whereby the normal reduction intensity of the furnace hearth is lessened and a molten slag containing more than 1% FeO and a molten pig iron product are produced; and tapping off the slag and the molten pig iron product.

7. In the process of smelting oxidic manganese-iron ores in the blast furnace the improvement which comprises blowing a preponderance of the total blast through the tuyères of one side of the furnace, whereby non-uniform descent of the charge is effected.

PERCY H. ROYSTER.

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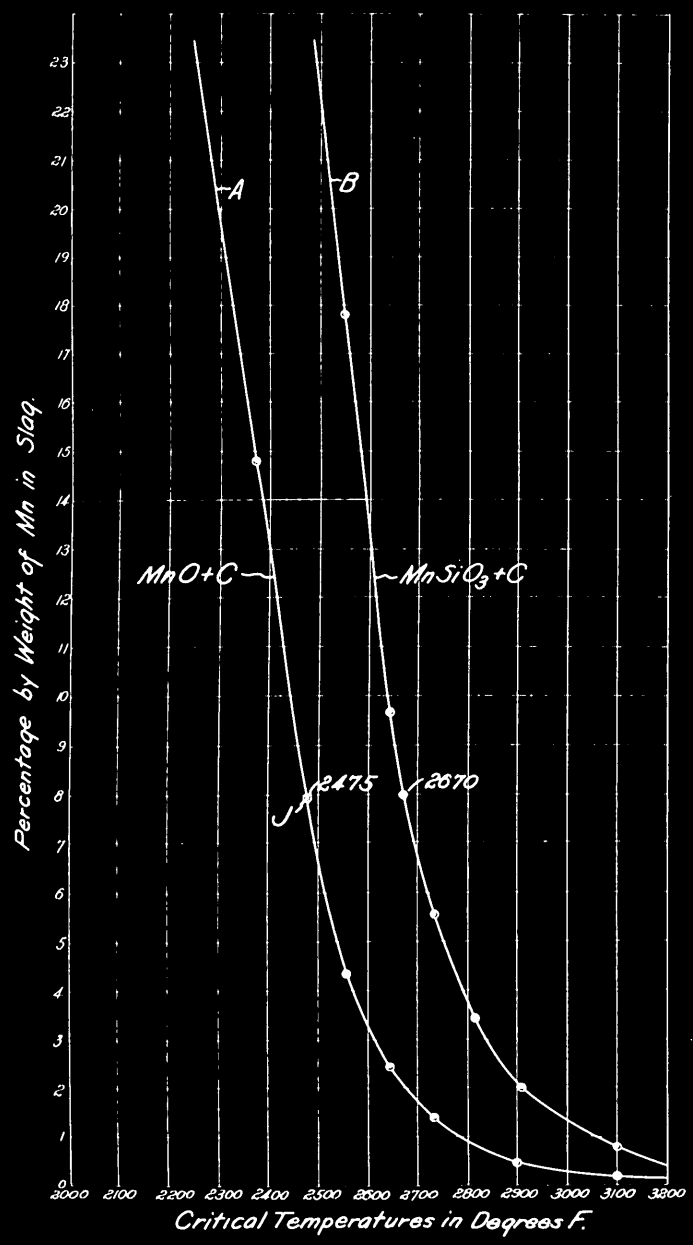
PROCESS FOR REDUCING MANGANESE ORES

Filed March 9, 1939



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PROCESS FOR REDUCING MANGANESE ORES

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3 Claims. (Cl. 75—131)

This invention relates to the pyrometallurgy of a compound or complex ore (hereinafter referred to as "mixed ore") containing an oxygen compound of iron and at least one oxygen compound of at least one other metal more difficultly reducible than the oxygen compound of iron but less difficultly reducible than an oxygen compound of silicon (e. g., less difficultly reducible than SiO_2). The invention is concerned with an improved process of smelting such "mixed ore" whereby to produce a ferrous alloy product having a relatively high content of said "other metal." The improved process has particular applicability to the production, from low grade manganese-iron ore (by "low grade" here being meant an ore containing a larger ratio of iron to said "other metal" than is desired to be present in the alloy product, and usually containing a substantial amount of gangue) of ferro-manganese of at least 40% grade, and iron.

The invention is concerned, also, with novel steps of the complete process.

In accordance with the general process of the present invention I subject the aforesaid "mixed ore" to a preliminary metallurgical treatment, by which treatment a substantial (e. g., major) portion of the iron content of the ore is reduced and separated out as a molten primary metal and a major portion,—or substantially all,—of the content of the other metal is incorporated in non-metallized form in a primary slag, whereupon said primary slag, in the second step of the process, is smelted to produce a secondary slag of low metal content and a secondary metal containing the greater part of the charge's content of said other metal. Thus, I may, in the second step, smelt in the blast furnace a prefused material resulting from a prior treatment of a mixed ore, by which treatment a major or at least substantial portion of the iron content of the mixed ore had been differentially or selectively smelted and separated, as liquid metal, from the concurrently produced liquid slag containing in non-metallized form the major portion of the content of "other metal" of the original ore. Differently expressed, I may subject the mixed ore to differential or selective reduction of a major portion of the iron content thereof in a blast furnace operation, thereby producing a slag having a materially lower ratio of iron to "other metal" than had the original mixed ore, and thereafter metallize the "other metal" (and also the residual iron content) in a smelting operation.

In carrying out the complete process according to the preferred embodiment thereof, in the preliminary metallurgical treatment I charge the mixed ore and solid carbonaceous fuel (e. g., coke) into a blast furnace, blow the charge with a preheated air blast, and maintain in the furnace conditions favorable to effect metallization of the major part of the iron content of the ore while retaining in the molten slag most of the content of the other metal in the form of an oxidic compound. In carrying out the second step I blow the charge with an air blast maintained at a temperature of 1,200° F., or higher, so as to provide in the furnace hearth a sufficient amount of heat of high availability for reduction not only of the residual oxygen compound of iron but also of the more difficultly reducible oxygen compound present in the slag being treated.

In applying the just described two-step blast furnace process to the production of ferro-manganese from a manganese-iron ore containing more than one-eighth as much iron as manganese, I charge the ore and solid carbonaceous fuel, without essential flux addition, into a blast furnace, blow the charge with a preheated blast while limiting the free energy of reduction in the hearth to an amount insufficient to metallize a major portion of the manganese content of the ore but sufficient to metallize the major portion of the iron content of the ore; I separate the resulting molten pig iron (which contains practically all of whatever phosphorus was contained in the ore) and the resulting slag; thereupon, in the second step of the process, I charge this slag as a burden, a basic fluxing agent and solid carbonaceous fuel (e. g., coke) into the same or another blast furnace, and blow the charge with a highly preheated blast,—preferably an air blast heated to a temperature of at least 1,800° F. The products resulting from this latter blast furnace treatment are (1) a ferro-manganese alloy, and (2) a final slag.

The preliminary treatment may be carried out in any one of a plurality of ways. Thus, (I) I may so operate that equilibrium conditions, or a close approximation thereof, obtain in the furnace hearth, in which event I use a highly preheated air blast and adjust the supply of solid carbonaceous fuel, with respect to the sensible heat of the blast, so that the total heat supply is insufficient to metallize the major portion of the manganese but is sufficient to keep liquid the contents of the hearth and to effect metallization of a major or at least substantial amount of the iron contained in the mixed ore.

The concept denominated "I" above will now be described in greater particularity in the immediately following paragraphs:

In carrying out this phase of the process of the invention I may for example charge into the blast furnace Cuyuna ore (or other manganese-iron ore) and coke, with no essential flux addi-

tion, in a ratio of ore to coke such that less than 1,800 pounds of coke are employed per long ton of pig iron produced, and blast the charge with air preheated sufficiently to prevent freezing in the furnace hearth. For this I have found that a blast temperature of 1,800° F. or above is desirable. The adjustment between the ore to coke ratio and the blast temperature preferably is so maintained that the total heat (i. e., the sum of the heat supplied by combustion of the coke plus the sensible heat of the blast) is low relative to the usual thermal requirements of the blast furnace as customarily operated, whereby the temperature of metal and slag are kept low, the temperature of reduction is kept low, and the amount of free energy available for the reaction $MnO+C=Mn+CO$ is small. I have found that by observing these conditions I am able to convert a major portion of the iron in the charge to metal, while only reducing a minor amount of the manganese oxide of the ore to a lower state of oxidation than MnO, the major amount of the total manganese of the ore entering the furnace being removed therefrom in the molten slag. This balance as between heat supplied by the blast and heat supplied by combustion of the fuel is so maintained, by observance of the measures above described, that less than 25% of the manganese content of the ore (preferably, less than 10% of the manganese content of the ore) is converted to manganese metal in this furnacing operation and so that a slag containing above 20% of MnO is obtained.

The slag product is one having an unusually high content of manganese oxide: It is, in effect, an artificial manganese ore whose low iron content is the result of the beneficiation of a manganese-iron ore in a blast furnace by "selective reduction." As a manganese ore, its manganese content may be moderate and its contents of silica and of alumina may be higher than are usually encountered in high grade manganese ores normally used for ferro-manganese production. Nevertheless, I have found that such slags can be employed, in a commercially feasible process, for the production of ferro-manganese of acceptable analysis.

The following example illustrates one mode of carrying out phase "I" of the process of the invention:

EXAMPLE 1

I charge into a blast furnace of approved design, having an 18 foot hearth diameter and a 22 foot bosh diameter, at twenty minute intervals, rounds or charges consisting of 29,180 pounds of Cuyuna ore, 7,175 pounds of coke, and no limestone. The analyses of the ore and coke as charged are:

6,350 lbs./ton Ore:		1,568 lbs./ton Coke:	
Fe	33.00	Moisture	1.50
Mn	11.56	Volatile matter	1.20
P	0.205	Ash	4.50
SiO_2	8.1	Fixed carbon	92.80
Al_2O_3	2.15	S	0.45
CaO	0.73	Fe	0.78
MgO	0.34	SiO_2	2.19
CO_2	0.41	Al_2O_3	1.06
Combined H_2O	7.89	CaO	0.28
Moisture	14.50	Nitrogen	0.35

I blow this furnace with 16,680 cubic feet per minute of air (measured at 60° F., 30 inches Hg pressure, 60% humidity) preheated to 1,900° F. In this operation I produce daily 330 long tons (of 2,240 lbs.) of pig iron and 250 long tons of slag. The analysis of the metal made is:

Pig iron

Si	0.18
S	0.08
P	0.59
Mn	1.75
C	3.92
Fe	93.48

and the slag analysis is:

SiO_2	31.70
Al_2O_3	9.20
CaO	3.00
MgO	1.27
FeO	2.00
MnO	52.64
S	0.32
P_2O_5 less than	0.03
Mn	41.00
Fe	1.55
P	0.015

In this operation the furnace is supplied with so little total heat, from the combustion of fuel plus the sensible heat of the preheated blast, that the slag is tapped from the furnace at the temperature of 1,350° C. (2,462° F.) and below, the metal of 1,300° C. (2,372° F.) and below.

Expressed in molar concentrations, the above slag composition is three-fourths manganese silicate containing 63.85 molar percent manganese ortho-silicate (tephroite) and 11.67 molar percent manganese meta-silicate (rhodonite) combined with 10.3% anorthite ($CaAl_2Si_2O_8$) and with smaller impurities of ferrous silicate ($FeSiO_3$), 5.32%, spinel ($MgAl_2O_4$), 6.02%, manganese sulphide (MnS), 1.92%, and aluminate ($MgAl_2O_4$), 0.92%.

I have found that in the ternary system rhodonite-tephroite-anorthite, the mixed silicates not only remain fluid at temperatures below 1,150° C., but their viscosities are low enough at these low temperatures to permit them to be used without flux in the hearth as blast furnace slags.

In this illustrated example, 41% of the total heat supply to the furnace appears in the form of sensible heat of the hot blast. In my process the heat of the blast functions as an essential factor in the operation and not as in prior blast furnace operations as a minor economy effecting the salvage of otherwise wasted heat. In all cases, I prefer that at least 35% to 40% of the total heat supply shall be furnished by the hot blast.

This blast furnace operation differs from any operation with which I am familiar in that:

(1) The ratio of manganese-iron ore to coke is in excess of any previous practice;

(2) There is no necessity for putting limestone or other flux into the charge;

(3) The blast temperature is higher than has been used heretofore;

(4) The temperature of the slag is lower than in any previous blast furnace practice;

(5) The slag is higher in MnO than any heretofore manufactured metallurgical slag;

(6) The CaO, MgO, and the ratio

$$\frac{CaO+MgO}{SiO_2+Al_2O_3}$$

or "basicity," is lower than has ever been produced in blast furnace practice.

The primary chemical requirements in carrying out my process are (1) to reduce a large portion of the iron, keeping the FeO content of the slag low, and (2) to reduce a very small portion of the manganese, keeping the Mn content of the metal low. Under conditions of thermodynamic equilibrium, the attainment of both these objectives can be realized only when the temperature of reaction is low. In the reaction

$$FeO+Mn=Fe+MnO \quad (1)$$

the change in free energy F is given by the equation

$$-RT\log_e(Fe)(MnO)/(FeO)(Mn)=\Delta H-T\Delta S \quad (2)$$

where T is the absolute temperature of equilibrium (degrees Kelvin), $\log_e$ the natural logarithm, ΔH the change in "total heat" or enthalpy (calories per mol) and ΔS the change in entropy (entropy units, E. U. per mol).

It can be shown from the recent publications of Kelley (Bureau of Mines Bulletins No. 350, 1932, No. 374, 1934, No. 407, 1935, and No. 393, 1936) that ΔS for Equation 1 has the value—1.687 E. U./mol. and ΔH the value of 25,640 calories/mol. Hence in the case of any slag and metal held in contact long enough for equilibrium to be reached, the values of (Fe), (Mn), (FeO) and (MnO) can be calculated from the equation

$$\mathrm{Log}_{10}(Fe)(Mn)/(FeO)(Mn)=5{,}604/T-0.369 \quad (3)$$

Equation 3, although not in agreement with the 1920 experiments of Christianson & Hunter, has been verified experimentally and is believed to represent the chemistry of the reaction.

In the illustrated furnace operations given above, the molar concentration of FeO and MnO in the slag are (FeO) =0.01867 and (MnO) =0.500. In the accompanying metal (Fe) =0.812 and (Mn) =0.01552. The temperature T for equilibrium in this system calculated from Equation 3 is 1,596° K. or 1,323° C. The temperature of the effluent slag is 1,350° C. (or 2,462° F.), the metal 1,300° C. (or 2,372° F.), and the mean,—which approximates the temperature of the surface of contact between metal and slag,—is 1,325° C. (or 2,417° F.).

Chemically, the results at the low hearth temperature described in the specific example are satisfactory. The ratio of Mn-to-Fe in the slag is very high,—26.6 to 1. Of the Mn charged into the furnace, 94.69% is retained in the slag to be used in a second step for conversion to ferro-manganese.

In practical furnace operation it is frequently convenient to provide means for controlling variations which may arise from furnace irregularities. For this purpose, a reserve of a hundred or more degrees of "blast heat" is desirable. For example, the 1,900° F. hot blast temperature quoted in the above illustration refers to the average temperature employed. In practice I prefer to provide myself with blast heating equipment capable of providing, as circumstances may require, a considerable temperature reserve, and for heating the blast to these unusual temperatures I may and preferably do employ the blast heating equipment described in my U. S. Reissue Patent No. 19,757, reissued November 12, 1935, which equipment, when constructed with such refractory materials as now are available on the market, is capable of delivering hot blast at temperatures as high as 2,400° F., or even 2,600° F.

It may be said that in carrying out this preliminary or beneficiation step I operate the furnace with a "cold bottom" by coke starvation, and keep the furnace "alive" by means of a highly overheated blast. I have found that a highly heated blast operates as an important "intensity factor" in the total heat of the furnace, by which expression I mean that the temperature level at which the heat of the blast is available is as important as is the total heat. I have also found that the stability of any furnace operations with such hot blast, even with low fuel consumption is superior to operations with lower blast temperature and higher fuel consumption.

As the temperature of the hot blast is raised closer to the temperatures of slag and metal fluidity the hazard of the hearth freezing is largely avoided, and it can be seen that when the blast temperature is raised as high as 2,100° F. the metal and slag will remain fluid even in the temporary absence of any carbonaceous fuel whatever. I have found that if the blast temperature is 1,800°–1,900° F., this 300° or 200° F. approach to the temperature of slag fluidity is sufficient to assure satisfactory operation in practice.

Or (II), I may so operate the blast furnace in this first or beneficiation step that a substantial departure from equilibrium conditions in the furnace hearth is maintained. I have found that it is possible to effect the desired departure from thermodynamic equilibrium by employing suitably any one, or a combination of two or more, of a variety of operating factors each of which is inimical to thermodynamic equilibrium, such as the eight measures following:

A. Overburdening the furnace by the maintenance of too high an ore to fuel ratio;

B. Non-uniformly distributing the charge on the stock line;

C. Maintaining too short a stock column;

D. Using poor coke;

E. Maintaining the slag level in the hearth higher than customary;

F. Causing the "oxidizing zone" or zone of coke combustion to cover a larger fraction of the furnace hearth area than is customary;

G. Operating with a charge which yields a slag low in CaO and MgO but high in iron and/or manganese;

H. Increasing the moisture content of the blast above normal.

A fuller explanation of these measures follows:

1. Overburdening is most frequently and readily indicated by the appearance of a "scouring slag,"—i. e., a black slag relatively high in FeO,—and by the concurrent production of pig iron of poor analysis, low in silicon and high in sulphur. In conventional blast furnace practice overburdening and the consequent occurrence of scouring slag is avoided but may inadvertently occur. In the present process, however, I may purposefully overburden in order to produce a slag intentionally high in FeO, in order to maintain the desired departure from equilibrium conditions.

2. Non-uniform distribution of ore and fuel on

the stock line causes the charge to descend in an irregular manner, permits the ascending gas stream to channel, and results in the injection into the bosh, tuyère zone and hearth of incompletely treated ore, thereby adversely affecting the reduction efficiency of the hearth. In conventional blast furnace practice non-uniform distribution of ore and fuel on the stock line is avoided: in the present process, however, I may purposefully and desirably impair the reduction efficiency of the hearth in this manner.

3. Allowing the level of the charge to descend too low in the furnace shaft reduces the length of the path of travel of the ore and fuel and, concurrently, the period of time within which the charge remains in chemical and thermal contact with the hot reducing gas ascending through the furnace. Thereby, the furnace is prevented in part from exercising its normal metallurgical effect as a strong reducing means, and "raw ore" (i. e., incompletely reduced iron oxide) arrives in the slag bath, "upsetting" the furnace operation as indicated by the appearance of one, two or three percent of FeO in the slag. While this would not, of course, be economically desirable in conventional blast furnace practice, I may purposefully effect this measure in order to control hearth conditions.

4. Charging coke of poor combustibility,—due to (*a*) low porosity, (*b*) improper coking, (*c*) high ash content, (*d*) defective cell structure or (*e*) abnormal graphitization of carbon,—likewise has an adverse effect on reduction. With reduced coke combustibility, the fraction of the furnace hearth area in which the oxidizing gases O_2, CO_2 and H_2O exist is increased and the FeO content of the slag is elevated above its equilibrium value and above that value sought in conventional blast furnace practice.

5. The effect of carrying the slag bath high in the hearth so that its surface is held in chemically reactive contact with the oxidizing gases existing in the combustion zones adjacent to the tuyères is to decrease the intensity of reduction in the hearth and to increase retention of the manganese in the slag. This measure includes, in the extreme case, carrying the upper surface of the slag bath in contact with, or even above, the tuyère level, so as positively to effect bubbling of air through the liquid slag. Metallurgically, I am here carrying out, to some extent, a Bessemerizing process in the neighborhood of the tuyères and pneumatically oxidizing the manganese content of the metal and concurrently raising the FeO content of the slag above its equilibrium value.

6. By increasing the jet velocity of the air blast through the tuyères sufficiently I have found that I can cause (*a*) lumps of coke to be blown bodily away from the immediate vicinity of the blast entrance and (*b*) the oxidizing zone to extend farther than usual into the furnace, thereby subjecting an enhanced fraction of the hearth contents to oxidation.

7. There are two important physical characteristics of a blast furnace slag which affect the furnace operation, (*a*) its viscosity and (*b*) its "wetting" property toward coke.

When the slag viscosity is too high, the slag does not flow freely through the bosh and into the hearth and this sluggishness of slag flow causes an accumulation of incombustible material in the combustion zone. As a result, the oxidizing zone contiguous to the tuyères extends to cover an enlarged fraction of the hearth, the intensity of reduction there is increased, and the FeO in the slag is maintained at the desired concentration.

Apart from viscosity considerations, slags containing substantial amounts of iron and manganese and relatively small amounts of CaO and MgO show an adhesion for coke carbon.

Basic or even slightly acid slags do not "wet" coke carbon to any material extent but slags low in lime and magnesia and carrying a considerable amount of manganese silicates have a tendency to adhere to coke carbon. That is to say, they form liquid films which "wet" the coke and impair its combustibility. In the present process it is desirable to operate the furnace with a charge which yields a type of slag which will effect a certain amount of "coke wetting."

8. Increasing the water content of the blast above normal moisture content, i. e., operating with a wetted blast, is a powerful means of impairing the intensity of hearth reduction. Introduction of water, e. g., as a liquid spray or as live steam, in controlled amount, into the blast, is easily effected in practice, and functions in a manner counter to that of a dried blast.

Each of the several measures above described, either alone or in combination, when used under proper control, is directed to the one end of limiting the fundamentally high intensity of reduction that exists in the hearth of a normally operated blast furnace, for the express purpose of effecting a departure from equilibrium which results in suppression of manganese metallization and enhancement of the FeO content of the slag. Adoption of any one of the eight measures enumerated above or others of like effect, makes possible raising the FeO content of the slag above equilibrium value (i. e., a fraction of one per cent at usual blast temperatures), up to say, one, two, or more, per cent.

The process of the present invention makes possible the maintenance of a higher FeO value in the slag than thermodynamic equilibrium requires,—i. e., the maintenance of non-equilibrium conditions. By thus maintaining a high FeO value in the slag I depress the Mn content of the pig iron and hence effect satisfactory retention of MnO in the slag even when operating with such relatively high slag, metal and hearth temperatures as are normal in conventional blast furnace practice.

The objectives of this phase of the complete process can, in general, be realized with blast temperatures as low as 1,000° F. However, with slag temperatures as high as 2,730° F., and with blast temperatures below 1,000° F., a relatively high ratio of fuel to ore is required in order to keep the furnace in operation. Although I do not wish to limit the process of the present invention to any minimum blast temperature, in the sense that I am able to make the process operate with cold blast, I have found that the economy of the process and the operation of the furnace are greatly improved by employment of relatively high blast temperatures. For economical reasons, I prefer to use blast temperatures above 1,800° F. In fact, I have found that with blast temperatures in excess of 2,000° F., e. g., from 2,200° to 2,600° F., it is practically impossible to produce furnace difficulties by an indiscretion in the carrying out of the process since the slag produced is quite fluid at 2,300° F. and

the freezing point of the metal produced is below 2,200° F.

No special skill or experience is required for the carrying out of this process. With any given ore, coke, burden and furnace, and with high blast temperature available, the furnace can be put into operation according to conventional blast furnace principles. Analysis of Mn in the metal and of FeO in the slag should be taken, after the furnace has started to operate, and likewise optical pyrometer readings of the temperatures of the slag at flush and the metal at cast, which data may be used in calculating the equilibrium constant "K" in Equation 2 and in determining the temperature of reduction "T" for the particular burden, and hence in ascertaining the degree, and direction, of departure from thermodynamic equilibrium. Then one or more of the several special measures, above described, for increasing the FeO content of the slag is or are practiced, and prompt analysis of the FeO content of the slag made at each flush. As the FeO is increased and the Mn content of the pig iron depressed, the economy of the process can be used as criterion for determining the optimum FeO content. The maximum value of FeO in the slag is fixed by the ratio of MnO to FeO in it, in order that the slag shall have the "artificial manganese ore" characteristics above mentioned and be within the "ferro" limit (i. e., capable of smelting, in a subsequent operation, to ferro-manganese). The ratio of Mn to Fe in the slag should not be less than 8 to 1, for 80% ferro-manganese and, in general, should be 12 or 14 to 1. On the other hand, the minimum limit of FeO in the slag will depend upon the maximum tolerance of manganese in the metal. As a general observation, it may be stated that the Mn in metal may desirably be held between 0.5% to 1.0% as a lower limit and 3.5% to 4.0% as an upper limit, and the MnO retained in the slag may desirably amount at least to 70% of the total manganese content of the ore and preferably should amount to from 85% to 95% thereof.

The following specific examples are added to the foregoing description by way of illustration only. The invention is not limited to the specific conditions enumerated therein, except as may be indicated in the appended claims.

I may employ a blast furnace of usual design, 86′ tall from iron notch to lip ring of the bell, with a charge column measuring 72′ vertically from the center line of the tuyères to the normal stock line: The furnace has a hearth diameter of 14′6″, a bosh diameter of 19′0″, a bosh angle of 76°, and a stock line diameter of 12′6″. The active volume of the charge column (between tuyères plane and stock line) is 14,850 cu. ft. Each 20-minute round of 28,000 lbs. of ore and 7,175 lbs. of coke occupies a volume of 436 cu. ft., and forms a layer on the stock line 43″ thick (average). The average time of passage of the charge through the furnace,—herein called "time of passage",—is 10 hours 30 minutes. The furnace is provided with a "McKee" top, with rotating distributor, which device may be adjusted to rotate on a predetermined schedule. In conventional practice this device is so adjusted as to provide for uniform distribution of the charge ingredients on the stock line (i. e., "peripheral symmetry" of charge).

I charge into this blast furnace, at 20-minute intervals, rounds or charges consisting of 28,000 lbs. of ore and 7,175 lbs. of coke, and no limestone. Analyses of the ore and coke charged are:

6,350 lbs./ton		1,568 lbs./ton	
Ore:		Coke:	
Fe	33.00	Moisture	1.50
Mn	11.56	Volatile matter	1.20
P	0.205	Ash	4.50
SiO_2	8.1	Fixed carbon	92.80
Al_2O_3	2.15	S	0.45
CaO	0.73	Fe	0.78
MgO	0.34	SiO_2	2.19
CO_2	0.41	Al_2O_3	1.06
Combined H_2O	7.89	CaO	0.28
Moisture	14.50	Nitrogen	0.35

I blow this furnace with 16,680 cu. ft. of air preheated to 1,900° F. In this operation I produce daily 318 long tons of pig iron and 240 long tons of slag. The metal analyzes: Si—0.25%; S—0.07; P—.59; Mn—2.20; C—3.85; Fe—93.04. The slag analyzes: SiO_2—31.40%; Al_2O_3—9.05; CaO—2.96; MgO—1.25; FeO—3.50; MnO—51.66; S—0.31; P_2O_5—less than 0.03. The temperature of the emergent metal is 2,700° F., and that of the slag is 2,780° F.

At the hearth temperature realized in the above illustrated example, had there been a reasonable approach to thermodynamic equilibrium, the FeO content of the slag would have been much lower (less than 1%, for example) and the manganese in the metal would have been four or five per cent.

I am able to produce the above described results,—which represented a marked departure from equilibrium results,—by a variety of means. For example, in one mode of carrying out the process of the invention I effect nonuniform distribution of the stock on the stock line. I find that they may be done, using a furnace provided with the type of top above described, by imparting to the charge ingredients a selected asymmetry or peripheral nonuniformity through appropriate predetermined adjustment of the schedule of the distributor. Thus, for example, the distributor may be so rotated as to deposit 17,000 lbs. of the total ore of one round in the first hemicircle and only 11,999 lbs. of ore in the second hemicircle. Coke deposition, in accordance with this example, is similarly effected, 2,872 lbs. thereof being deposited in the first hemicircle and 4,303 lbs. thereof being deposited in the second hemicircle. Thus, the ratio of ore to coke in the first hemicircle of the stock line is 5.92 to 1, whereas it is only 2.55 to 1 in the second hemicircle, although the total ore (28,000 lbs.) and the total coke (7,175 lbs.) have the ratio 3.90 to 1.

By the above distribution I, in effect, overburden the first hemicircle of the furnace and "underburdened" the second half. If all of the iron in that portion of the charge lying in the first half were metallized, it would means that only 1,025 lbs. of coke is consumed per long ton of pig iron produced. However, this half of the furnace, under the conditions described, is not able to metallize all of the iron therein because of the under-fueling, and the melted ore runs into the hearth with from 10 to 12% of FeO remaining unreduced. Simultaneously, in the second half of the furnace, where coke is in great excess, iron is metallized with a con-

sumption of 2,400 lbs. of coke per ton of metal produced. This latter, under the conditions described, is a semi-spiegel showing from 8 to 19% Mn and Si in excess of 1%. The slag flowing into the hearth on this same side has a very low content of FeO.

As the metals from the respective halves of the furnace flow into the hearth they commingle and diffuse, yielding a metal bath indicating 4 to 5% Mn.

In like manner, the slag (substantially free from FeO) from second side, commingles with the oxidizing, "high-iron," scouring slag from the first half, and by admixture and diffusion yields a slag containing from 5 to 6% FeO.

Chemical reaction between the FeO of the slag and Mn of the metal takes place according to Equation 1, and although heat is generated by the exothermic reaction, tending to elevate metal and slag temperature and thereby to lower the FeO content of the slag, I have found that opportunity is not afforded for the two liquids to attain thermodynamic equilibrium and thus that the desired objective is effected.

In an alternative procedure under phase II above, and while employing conventional symmetrical distribution of the charge material at the stock line of the blast furnace, I impair the reduction efficiency of the hearth by dropping the stock line a considerable distance below the level conventionally adhered to. For example, by protraction of the interval of each round to 30 minutes (instead of 20 minutes) the level of the top of the stock line is caused to move down in the furnace 0.7'' per minute. By maintaining this retarded charging schedule for 12 hours, I drop the stock line 42', after which event charging at 20 minute intervals is resumed. With this low stock line (30', as opposed to the former 72'), the average time of passage is decreased from 10 hours 30 minutes to about 5 hours. This shortening of the charge column is sufficient to cause injection of "raw ore" into the furnace hearth, thereby diminishing the normally high intensity of reduction of the hearth and insuring the desired retention in the slag of most of the Mn content of the ore in non-metallized form and the production of metal containing Mn less than 4%.

Because of the variables encountered (e. g., the reducibility, porosity, density, composition, moisture content, etc., of the particular ore, especially the "combined water," the clay content, and the "caking" or agglomerating characteristics of the ore, the characteristics of the fuel, etc.) no quantitative formula for shortening the "time of passage" can be laid down. However, one skilled in the art may, by analyses of the metal and slag, and observation of the slag and metal temperatures, readily determine the optimum stock line level for any "new" or previously untried ore and thereafter proceed in accordance with the above principle. It may be remarked here that observance of this embodiment of the invention makes possible a material shortening of the stack of a furnace to be built for carrying out this process, thereby effecting a saving in the cost of the furnace per se, and a lowering of the pressure required to blow the wind into the furnace (i. e., further savings in investment and operating costs in the engine room).

As a third alternative procedure under phase II above, I maintain conventional symmetrical distribution on the stock line, maintain the level of the stock line at 72' above the tuyères, but upset the charge column descent by employing an asymmetrical tuyère system. Thus, in the case of an existing blast furnace provided with 8 symmetrically arranged tuyères each 4'' in diameter, total tuyère cross-sectional area 0.695 sq. ft., I replace the tuyères on the first hemicircle with tuyères 4⅝'' in diameter and on the second hemicircle with tuyères 3¼'' in diameter. The new tuyères have the same total area as the replaced tuyères, but two-thirds of the wind is now blown in at the first hemicircle and only one-third thereof at the second hemicircle. This causes the rate of coke consumption in the first hemicircle to be doubled, and the rate of descent of the stock column in that half proceeds twice as fast as in the other half. Accordingly, the stock line,—even though the charge had been deposited in a uniform manner at the stock line,—is caused to "dip" or become inclined to such an extent that when the average level has descended about 10' the plane of the round is inclined about 35° from the horizontal. The end result of this operation is the same as that flowing from asymmetrical distribution (first example above) and as that flowing from dropping the stock line (second example above).

The inventive objective of phase II may, I have found, be reached, with better all-around results, with more opportunity for nice control and with less liability to error due to the "personal equation," by combining the features (1) a moderate drop in stock line level (15' to 20'), and (2) a limited asymmetry of stock distribution on the stock line (e. g., 5% excess of ore on one side over that on the other side, and 5% excess of coke on the latter over that on the former), with (3) the employment of tuyères of 4¼'' diameter on one side of the furnace and tuyères of 3¾'' diameter on the other side. These individually less drastic measures combine desirably to bring about injection of suitable amounts of FeO into the hearth with consequent diminution of the intensity of reduction in the latter and the promotion of a slag containing by far the greater part of the manganese of the charge in non-metallized form.

In cooperation with any one or more of the above illustrated measures under phase II above, (e. g., in cooperation with the combination described immediately above) I may and preferably do employ the measure of oxidizing the slag directly with the blast. I control the average upper level of the slag bath, preferably through the agency of a plurality of cinder notches—with associated coolers and monkeys—located at differing distances below the tuyère level, so that the same is in close proximity to the blast entrance. Thus, I may place the topmost cinder notch within 24'', or less, of the center line of the tuyères, and dispose one or, preferably, more cinder notches at spaced intervals therebeneath.

It has been shown that, with run-of-the-oven coke, oxygen gas is found as far as 16'' to 20'' from the blast entrance, and that CO_2, in an amount giving a ratio of CO_2 to CO as great as 0.25 to 1 (which amount, at hearth temperature, is oxidizing in the reaction $Fe+CO_2=FeO+CO$) as far as 26'' to 30'' inwardly from the tuyère nose. Hence, by carrying the slag bath upper surface within 26'' to 30'' from the tuyère the former is directly subjected to gases containing a sufficient proportion of CO_2 to CO to oxidize

some of the iron to FeO. When I carry the slag level within 16'' to 20'' from the tuyère the slag encounters gases containing CO_2 and O_2, which gases can and do oxidize some of the FeO to Fe_3O_4, thereby further enhancing the oxidizing intensity of the slag.

Considerable decrease in intensity of reduction in the furnace hearth may be effected by treating some or all of the coke of the charge as follows: The coke, as formed, is quenched in an aqueous slurry of clay or other incombustible inert mineral matter, the relative amount of such mineral matter being adjusted so that the coke when dried carries a thin coating of the mineral matter. I have found that such coatings inhibit prompt combustion of the coke on the latter's arrival in the tuyère zone, and hence diminish reduction intensity.

The use of coke in large lumps serves to extend the dimensions of the combustion zone and therefore to diminish the intensity of reduction in the furnace hearth. The linear dimensions of the combustion zone are almost directly proportional to the linear dimensions of the coke lumps.

An equally effective means of extending the dimensions of the combustion zone is the employment of higher jet velocities of the incoming air. I have found that when the jet velocity of the tuyère is increased to an extent such that lumps of coke are blown away from the tuyère nose the intensity of hearth reduction is measurably reduced. Thus, with 2,100 cu. ft./min. of air (measured at 60° F. and 30'' Hg.) blown through each of the eight 4'' tuyères, at 1,900° F. hot blast and 14 lbs. gauge pressure in the hearth, the velocity of the wind, at the tuyère nose, is about 950 ft./sec., and its hydrodynamic impact pressure is 3.3 lbs./sq. in. At this very considerable pressure the blast forces back the lumps of coke and tends to produce a so-called "gassy tuyère." Substitution of 3½'' tuyères for the 4'' tuyères makes possible raising the jet inpact pressure to 5.65 lbs./sq. in., and desirably extends the combustion. Employment of such high jet velocities is limited by consideration of blowing equipment available, of power consumption, etc.

Perhaps the most convenient and positive of all the methods listed above for limiting the free energy of reduction in the hearth, and the one which is most easily controlled, is the introduction of added moisture into the blast. In the above operation I prefer to reduce the burden to 26,800 lbs. of ore and 7,175 lbs. of coke per round, to hold the blast temperature at 1,900° F., and to introduce 102 lbs. of steam per minute into the hot blast main. This represents about 20 boiler horse-power, and is an insignificant demand on the boiler room. I prefer to jet this moisture as boiler steam into the hot blast main at a point near the stove end, in order to permit diffusion of air and steam before the blast reaches the bustle pipe. The wetted blast here contains 11% by volume of H_2O, consumes 3.3% of the carbon being burned at the tuyères, and absorbs heat equivalent to one hundred degrees of hot blast. That is to say, the introduction of 11% of H_2O vapor into the blast is the thermal equivalent of lowering the blast temperature 100° F. Its operating advantage lies in the ease and speed with which its effect can be controlled.

With the flow of steam into the hot blast main controlled by a valve, I can sight an optical pyrometer down the tuyère, open the steam valve, and the added moisture arrives at the tuyère nose within 1/20th of a second of the time of valve opening; the moisture completes its reaction with hot carbon in the tuyère zone within ½ second, being converted into CO and H_2, and the complete effect of the steam can be observed within a second's delay.

A further operating advantage accrues from providing individual steam connections to the goose necks, or blow pipes, of the tuyères, and introducing 12 lbs. of steam per minute into each tuyère for predetermined periods of time. Thereby the degree of control possible over intensity of reduction may be considerably enhanced.

The preliminary essential metallurgical treatment of the manganese-iron ore having been effected in accordance with method I or with method II above, I complete the process by smelting the "artificial manganese ore" product, or slag, therefrom to produce ferro-manganese. In the "artificial manganese ore" product obtained from the first step (method I or method II above) the manganese contained therein exists in the form of a lower oxide (e. g., MnO) combined with other common refractory less reducible oxides (e. g., SiO_2, Al_2O_3, TiO_2, Cr_2O_3, CaO, MgO, BaO, etc.) and associated with an oxide of iron.

While the essential and major metalliferous component of the furnace burden is the above-described primary slag, I may, for the purpose of controlling the resulting alloy composition and for other purposes, add minor charge constituents such as Fe_2O_3 (as iron ore), MnO_2 (as manganese ore, or manganiferous iron ore), sand, clay, fluorspar, and, at convenience, metal (e. g., iron, steel and/or alloy scrap).

In my preferred method (III) for producing ferro-manganese from the above defined primary slag I charge a blast furnace with solid carbonaceous fuel, a suitable fluxing agent and a burden consisting essentially of the aforesaid primary slag, blow the charge with a preheated blast, and maintain the hearth at a temperature of at least 2,600° F. while adjusting the temperature of blast pre-heat to a value in excess of 1,600° F. and while employing a minimum proportion of the fuel with respect to the burden to effect reduction of the manganese and iron contents of said burden. With the smelting operation conducted in this manner, there are produced (*a*) an alloy of manganese and iron and (*b*) a final slag containing a desirably low amount of manganese.

Method III, above briefly characterized, will now be described with greater particularity in the immediately following paragraphs:

In the past, the greater part of the world's supply of manganese-iron-carbon alloys has been produced from manganese-bearing starting materials in which the manganese was present in the form of "free" manganese oxides in a higher state of oxidation (MnO_2 preponderantly, with lesser amounts of Mn_2O_3, Mn_3O_4, $Mn(OH)_3$, etc.). All natural manganese ores contain a "gangue," i. e., accompanying amounts of common refractory irreducible oxides (SiO_2, Al_2O_3, TiO_2, Cr_2O_3, CaO, MgO, BaO, K_2O, Na_2O, etc.) but the manganese oxide ("true" ore) and other mineral constituents (gangue) have been conjoined as a "physical mixture" (and not as common constituents of a glass, or fused slag), with little or no chemical combination between the manganese oxide and the gangue.

In the blast furnace production of manganese

alloys (e. g., ferro-manganese), the reduction reaction can be written as

$$MnO+C \rightleftharpoons Mn+CO \text{ ---------- } (1)$$

or, since the manganese as produced is carburized, the more complicated reaction

$$3MnO+4C \rightleftharpoons Mn_3C+3CO \text{ -------- } (2)$$

may correspond more nearly to the actual mechanism. In Equation 1 the standard change in enthalpy (i. e., "total heat" as defined by Lewis and Randall, "Thermodynamics," 1923) may be represented as $\Delta H°=64,273$ calories per mol, and the standard change in entropy as $\Delta S°=44.62$ E. U. ("entropy units") [illegible]. The equilibrium constant K_1 of [illegible]on 1 defined as $K_1=(Mn)(CO)/(MnO)(C)$ is given by the equation

$$\text{Log}_{10} K_1=9.760-14,050/T \text{ ------ } (3)$$

where the bracketed terms "(Mn)," "(MnO)," "(C)" and "(CO)" refer to the "activity" of the reactants and products, and "T" is the absolute temperature (° Kelvin). For solid carbon the activity (C) is taken as unity, for (CO) the pressure of CO (in atmospheres), and for the metal and slag baths (Mn) is the molar concentration of Mn in the metal (0.640 for 80% ferro-manganese, for example) and (MnO) the molar concentration of MnO in the slag.

In a blast furnace operating with a hearth pressure of 7.3 lbs./sq. inch gage pressure (1.5 atmospheres), and producing standard 80% ferro-manganese, the "temperature of reduction" or the "critical temperature" of manganese reduction as defined by J. E. Johnson, Jr. ("Principles, Operation and Production of the Blast Furnace") is a function of (MnO); i. e., the lower the manganese content of the slag, the higher is the temperature of thermodynamic equilibrium ("critical temperature," "T_c").

In the accompanying drawing are two graphs "A" and "B" illustrating relationships existing between critical temperatures maintained in the furnace hearth and percentages (by weight) of manganese retained in the slags. Curve "A" shows the weight per cent of manganese in the slag as ordinates, and T_c the "critical temperature" in °F. as abscissae. In current ferro-manganese blast furnace practice a slag containing 8% Mn is considered an optimum value; higher manganese content in the slag represents an increased loss of ore-value, and an excess fuel cost is encountered when attempt is made to lower the manganese content of the slag much below 8%.

According to curve "A", with 8% Mn in the slag, the critical temperature T_c is 2,475° F. With the highest blast temperature currently used in manganese furnace practice (1,600° F.), when a pound of carbon is oxidized by the blast, 3,990 B. t. u. are generated by the formation of CO, 120 B. t. u. are absorbed by the reaction of blast moisture with carbon ("water gas reaction"), and 315 B. t. u. are lost to the water cooling devices and by thermal conduction through the brick walls of the hearth ("heat loss"), for a "net" generation of 3,455 B. t. u. per lb. of carbon. The sensible heat of the blast preheated to 1,600° F. is 2,310 B. t. u., and the total heat supplied to the hearth is 5,765 B. t. u. per pound of carbon,—a quantity of thermal energy appearing initially as sensible heat of the hot products of fuel combustion generated in the combustion zone. Unfortunately for the economy of the manganese blast furnace, a large part of this heat is useless, and unavailable for the purpose of supplying energy to the reduction reaction (Equation 1). The heat required to raise the products of combustion to the critical temperature T_c is "unavailable heat," and, since $T_c=2,475°$ F. amount to 4,482 B. t. u. per lb. of carbon, more than three-fourths of the total heat supply is unavailable for manganese reduction even at the high blast temperature of 1,600° F.

A fuel consumption of 4,000 lbs. of coke, 86% fixed carbon, in the standard ferro-manganese operation with imported oxide ore, is considered exceptionally good furnace practice. This result can only be obtained when the amount of gangue (principally, SiO_2 and Al_2O_3) is low, and when adequate CaO and MgO are charged (as limestone and/or dolomite) to combine chemically with the acid oxides of the gangue and thus to permit the manganese oxide to remain "free" and reducible according to Equation 1 supra.

In the present smelting process, method III, wherein the charge material contains combined MnO, the reduction of the manganese is more difficult. Since the principal contaminating impurity, the more usual and preponderant common irreducible refractory oxide diluent, of the primary slag used in the present invention is silica, the typical reaction of the present process may be written

$$MnSiO_3+C=Mn+SiO_2+CO \text{ ------ } (4)$$

For the reaction of Equation 4 the standard enthalpy change $\Delta H°=67,460$ calories per mol, and the standard entropy change $\Delta S°=43.56$ E. U. The equilibrium constant K_4 is defined as $(Mn)(SiO_2)/(MnSiO_3)(C)$ and its value is given by the equation

$$\text{Log}_{10} K_4=9.550-14,760/T \text{ -------- } (5)$$

Values for the manganese content of the slag as ordinates are plotted in the curve marked "B". Comparison between curves A (for free oxide) and B (for silicate) show that whereas a slag containing 8% Mn can be produced from a free oxide ore at a critical temperature of 2,475°, the same result can be obtained in reducing manganese silicate only by raising the temperature of reduction to the critical temperature 2,679° F. The "chemical bonding," as it has frequently been termed, between the MnO and the SiO_2 "resists" reduction and "requires" a higher temperature to "carry out,"—language which can be termed intelligible if interpreted to mean that $\Delta H°$ in reaction Equation 4 is 67,460 as compared with $\Delta H°=64,373$ for Equation 1, and that $\Delta S°=43.56$ for Equation 4 in place of $\Delta S°=44.62$ for Equation 1. The combination of the free oxide MnO with an acid gangue oxide (e. g., SiO_2) alters the enthalpy and entropy changes in the reduction reaction unfavorably, in effect raising the critical temperature T_c by 195° F. In the example given above of an 80% ferro-manganese furnace providing a 1,600° F. hot blast, the "unavailable heat" is increased from 4,482 B. t. u. per lb. of carbon burned at the tuyères, for free oxide ore, to 4,875 B. t. u. per lb. for silicate ore, amounting now to 84.5% of 5,765 B. t. u./lb. carbon supplied to the furnace hearth by fuel combustion plus heat of the hot blast.

Because of the above mentioned disadvantages, it heretofore has been considered economically impossible to smelt such fusion products in the blast furnace for the recovery therefrom of their

metal values; it has been thought that such fusion products, if smeltable at all, were smeltable only in the electric furnace, since difficulties arising from high critical temperatures have no material importance in an electric furnace operation.

A further, less widely recognized, obstacle which complicates the problem of blast furnace smelting of these pre-fused manganese-bearing materials is the volatility of manganese.

According to Ruff and Bormann (Zeitschrift f. Anorganische Chemie, vol. 88, page 365) and Greenwood (Proceedings Royal Society, vol. 82, page 396), for the vaporization of liquid manganese, $\Delta H°=59{,}070$ calories per mol, and the entropy of vaporization $\Delta S°=24.60$ E. U. per mol. From these thermal quantities the vapor pressure of manganese "P", in atmospheres, is given by the equation

$$\text{Log}_{10} P=5.375-12{,}900/T \qquad (6)$$

At the critical temperature of 2,475° F. the vapor pressure of manganese is only 2.04 mm. Hg—a relatively low pressure. When 4,000 lbs. of coke are used per long ton of 80% ferro-manganese, there are produced in the hearth of the furnace 280,000 cu. ft. of gas (measured at 60° F., and 30 inches of mercury). When this gas stream is saturated with manganese vapor at a partial pressure of 2.04 mm. Hg, the total weight of manganese metal carried out of the furnace hearth is 74 lbs. or 4.13% of the 1,790 lbs. of manganese in the ton of 80% "ferro." In the "shaft" of the furnace the manganese vapor condenses to fume as the temperature drops, and is oxidized by the CO of the gas according to the reaction $CO+Mn=MnO+C$, producing a typical "dirty" manganese furnace gas containing manganese oxide fume. In present practice such fume is caught in the gas-cleaning system, is agglomerated, sintered, nodulized or briquetted, and returned to the furnace in a subsequent charge. At low critical temperatures, the economic importance of "fume" is not great. From Equation 6 it will be seen that the vapor pressure of manganese at the higher critical temperature 2,670° F. is 6.53 mm. Hg, and that the total manganese carried out of the hearth in vapor form is 233 lbs. (or 13 per cent of the manganese in the metal).

While it is true that loss of manganese can be largely avoided by gas-cleaning, sintering and returning the fume to the furnace, the loss of high temperature "available heat" from the furnace hearth can not be. The heat required to reduce a pound of manganese from MnO by carbon is 2,110 B. t. u. The latent heat of vaporization is 1,940 B. T. u. per lb. The manganese vapor escaping from the hearth carries out with itself both heat of reduction and heat of vaporization, viz., 4,050 B. t. u./lb., so that, thermally speaking, the 13% manganese as vapor is the equivalent of a 25% loss in reduction efficiency.

In the present process, therefore, an increase in critical temperature results not only in decreasing the fractional part of the total heat which is available for manganese reduction but also in increasing the amount of manganese vaporized in the hearth.

Whereas method III is defined as the smelting of mineral materials containing gangue refractory oxides and oxidic compounds of manganese and iron in which the manganese and iron are present in such ratio as to yield ferro-manganese of at least 50% grade, including the aforesaid primary slags, without definitive restrictions as to the relative amounts of the several oxidic constituents, it usually is the case that such mineral materials contain a much higher ratio of gangue oxides (SiO_2, Al_2O_3, TiO_2, Cr_2O_3, CaO, MgO, etc.) to manganese than do imported or standard merchantable ores currently employed in the commercial production of ferro-manganese. Because of this presence of a large amount of gangue material, an increased amount of limestone and/or dolomite is required, and the "slag volume" (i. e., pounds of final slag produced per long ton of alloy made) is very high, in the cases of many of the manganese-containing mineral compositions to the smelting of which my present process is most directly applicable. Thus, in the illustrative example given below, the slag volume amounts to 5,307 lbs. If that final slag were to contain as much as 8% Mn (which figure is within the acceptable range in current ferro-manganese practice), the loss of manganese into the slag would be 458 lbs./ton of alloy, or 25.5% of the about 1,790 pounds of Mn in a ton of 80% "ferro." With higher thermal requirements in the hearth, higher vapor losses, larger amounts of flux and of fuel, reduced tonnage, and increased manganese losses in the final slags, an attempt to smelt pre-fused silicate and aluminate compounds of manganese by any known blast furnace practice cannot compete with the smelting of "ferro" from "free" oxide ores with low and uncombined gangue.

Method III can most readily be defined and illustrated by reference to the following illustrative example representing a specific mode of smelting a manganese-bearing primary slag:

Example 2

The starting material is a pre-fused "artificial ore" (slag product) having the following analysis:

Artificial ore

	Per cent
Mn (as metal)	41.00
Fe (as metal)	1.55
SiO_2	31.70
Al_2O_3	9.20
MgO	1.27
CaO	3.00
P	0.06

This slag product is charged, into a blast furnace of conventional design, with coke, dolomite, limestone, sintered flue dust and manganese-iron ore, these latter having the following analyses:

	Coke	Dolomite	Limestone	Sintered flue dust	Manganese-iron ore
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
SiO_2	2.19	0.85	1.10	1.40	8.10
Al_2O_3	1.06	0.35	0.74	0.55	2.15
CaO	0.28	29.38	51.00	2.23	0.73
MgO	------	21.18	2.50	0.60	0.34
Fe	0.78	0.31	0.55	8.63	33.00
Mn	------	------	------	62.40	11.56
P	0.02	0.01	0.05	0.11	0.26

One round of this charge comprises 6,560 of the artificial "ore," 4,540 pounds of the dolomite, 3,020 pounds of the limestone, 640 pounds of the manganese-iron ore, 531 pounds of the sintered flue dust, and 3,500 pounds of the coke, and is delivered onto the stock line each 20 minutes. The furnace is blown with 13,600 cu. ft./min. of atmospheric air (measured at 60° F. and 30'' Hg, 60% humidity) preheated to 2,200° F., and there are produced daily 100 long tons of

metal values; it has been thought that such fusion products, if smeltable at all, were smeltable only in the electric furnace, since difficulties arising from high critical temperatures have no material importance in an electric furnace operation.

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	Coke	Dolomite	Limestone	Sintered flue dust	Manganese-iron ore
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
SiO_2	2.19	0.85	1.10	1.40	8.10
Al_2O_3	1.06	0.35	0.74	0.55	2.15
CaO	0.28	29.38	51.00	2.23	0.73
MgO	.....	21.18	2.50	0.60	0.34
Fe	0.78	0.31	0.55	8.63	33.00
Mn	.....	.....	.....	62.40	11.56
P	0.02	0.01	0.05	0.11	0.26

One round of this charge comprises 6,560 of the artificial "ore," 4,540 pounds of the dolomite, 3,020 pounds of the limestone, 640 pounds of the manganese-iron ore, 531 pounds of the sintered flue dust, and 3,500 pounds of the coke, and is delivered onto the stock line each 20 minutes. The furnace is blown with 13,600 cu. ft./min. of atmospheric air (measured at 60° F. and 30" Hg, 60% humidity) preheated to 2,200° F., and there are produced daily 100 long tons of

metal and 236 long tons of slag. The metal and the slag have the following analyses:

Metal	Per cent	*Slag*	Per cent
Carbon	6.85	SiO_2	28.45
Si	1.00	Al_2O_3	9.58
Mn	80.00	CaO	41.71
P	0.28	MgO	15.20
S	0.01	S	0.27
Fe	12.04	FeO	0.58
		MnO	4.47

The slag at flush is at a temperature of from 2,700 to 2,900° F., and the metal at cast is at a temperature of from 2,600 to 2,750° F.

The pressure in the bustle pipe averages 7 lbs./sq. in.

The furnace discharges 19,250 cu. ft./min. (measured at 60° F., 30'' Hg) of exhaust gas (CO_2 8.22%; CO 34.23%; H_2 1.57%; N_2 55.98%; net calorific value, 107.4 B. t. u./cu. ft.), which gas emerges from the furnace at the average temperature of about 540° F., and carries a heavy loading of "flue dust" or fume. I pass this gas through a suitable dust catching means, thereby cleaning the gas and recovering 24 long tons of flue dust and fume per day. This latter I sinter and return to the stock line of the furnace.

It will be seen, from these data, that a final slag containing only 3.45% Mn (4.47% MnO) is produced. For a "free" oxide ore, the critical temperature of reduction necessary for getting this low Mn value in the final slag would be 2,590° F. (curve A). However, the charge material of the example is a blast furnace slag, with the CaO, MgO, Al_2O_3, SiO_2, MnO, FeO, etc., combined into the several mineral constituents determined by the phase-rule diagram for the system (not well known) the most prominent constituent apparently being rhodonite (manganese metasilicate, $MnSiO_3$), with anorthite ($CaAl_2Si_2O_8$) as the most prominent inert diluent. For this blast furnace slag to be smelted so as to yield a final slag containing only 3.45% Mn a critical temperature of about 2,810° F. is necessary (curve B).

The addition of the tremendous quantities of limestone and dolomite, in the charge given in the above illustrative example (7,560 lbs. of carbonate flux to 3,105 lbs. of manganese) produces a basic slag with an analysis, given in molar concentrations, as follows:

CaO	42.3	Bases 63.90	Ratio 1.98-to-1
MgO	21.55		
Al_2O_3	5.35	Acids 32.29	
SiO_2	26.94		

in which the molar concentration of bases to acids is almost 2 to 1.

The term "basicity" as here employed means the ratio of the sum of molar concentrations of CaO and MgO (and other alkali metal, or alkaline earth metal, oxides) to the sum of the molar concentration of the amphoteric and acid oxides (SiO_2, TiO_2, ZrO_2, Al_2O_3, Fe_2O_3, Cr_2O_3, etc.), where, following common terminology, a basicity of unity is called "neutral," less than unity is "acid" and greater than unity is "basic."

The basicity of this slag is far in excess of any blast furnace slag known to have been produced heretofore. With a slag volume of 5,300 pounds to 3,500 pounds of coke, no such high-melting slag could be produced using conventionally employed blast temperatures. That is to say, the high basicity of the slag lowers the critical temperature by about 100° F. and, as such, contributes to the successful realization of the present process, but could not have been handled with blast preheats in the usual range. The unusually high blast temperatures employed by me, which make possible the handling of the highly basic slag, also cooperate to increase the "available hearth heat" and make operation of the furnace with a low coke consumption possible. With the low coke consumption thus made possible, the total volume of gas produced is lowered, thereby diminishing the quantity of manganese vapor carried out of the hearth, and losses of high-temperature "available" heat,—in the forms of "heat of reduction" and "heat of vaporization",—are minimized.

In general, in any ordinary operation embodying the concept of method III, I employ one or more of the following expedients: (*a*) I use a blast temperature greater than 1,600° F.; (*b*) I so operate as to produce a slag of high basicity (e. g., from 1.5-to-1 to 2- or more-to-1); (*c*) I restrict the coke consumption to a lower figure than is employed in conventional practice, even with "free" oxide ores; and (*d*) I maintain the hearth temperature higher than is customary in ferro-manganese operations. Whatever the combination of operative measures employed, the invention resides in the conversion to manganese metal or manganese alloy, in a blast furnace, of a manganese-bearing mineral material containing substantial amounts of gangue refractory oxides and oxidic compounds of manganese and iron in such proportions as to yield ferro-manganese of at least 50% grade.

The chemical principles involved in the present process are different from those involved in the smelting of standard manganese ores. By the process of the present invention sources of manganese are rendered commercially available to industry, which sources heretofore have not been employable.

I am aware that in ferro-manganese and spiegeleisen furnace operations relatively small amounts of high-manganese slag from a prior operation, and manganese-bearing slags from the Bessemer converter, acid open hearth, and (where phosphorus contamination permits) from basic open hearth operations, have been added to the charge. But, in such cases, the charge principally consists of "free" oxide ore. In method III, I may (as in the illustrative example) add a minor amount of a free oxide ore to the charge consisting principally of the above-described primary slag, for the purpose of controlling the resulting alloy composition and to effect minor economies. Such an addition is not an essential feature of the present process, and may be omitted.

It will be apparent, from a consideration of the foregoing explanation of the thermal efficiency of manganese reduction in the blast furnace hearth, that the higher the blast temperature the higher will be the total heat and, also, the per cent of hearth heat available for the reduction. The upper limit of blast temperature is, largely, determined by the heating equipment available. With modern types of regenerative stoves (e. g., that described in U. S. Reissue Patent No. 19,757) blast temperatures of about 2,600, 2,700° F. (for fire brick refractories) and of above 3,000° F. (for magnesia, chrome and zircon refractories) are attainable. I contemplate, in the carrying out of method III, using

blast temperatures between about 1,600° F. and the critical temperature of reduction of manganese, varying the blast temperature between those two limits as the particular conditions may require.

It has been pointed out hereinbefore that with increase in blast temperature it is desirable to decrease correspondingly the ratio of carbon to manganese in the charge, in order to prevent undesirable increase in hearth temperature and the production of too great a volume of blast furnace gas per unit of manganese. Were such decrease in coke not co-related to increased blast temperature, excessive volatilization of manganese would, of course, result. The blast furnace operator, aided by an optical pyrometer sighted on the slag and metal removed from the hearth, can readily adjust the coke charge and the blast temperature to provide the desired hearth temperature.

The expression "hearth temperature" as used herein is intended to mean the algebraic average of the temperatures observed with an optical pyrometer (corrected for emissivity) sighted on the emergent streams of metal and slag at "cast" and "flush," respectively.

I have found, when I subject a phosphorus-containing manganese-iron ore to the blast furnace conditions of methods I–II above, by which I am enabled to metallize a substantial portion of the iron while retaining most of the manganese in the slag as an oxide, that, fortunately, the phosphorus content of the ore is almost completely reduced and is incorporated as an impurity in the metal, thereby effecting a highly desirable separation of phosphorus from manganese. This is a particularly important feature of the special embodiment of my invention which consists in the successively performed steps of smelting a material containing iron, manganese and phosphorus in a blast furnace under conditions adapted to produce a metal containing the greater parts of the iron and phosphorus contents of the material and to retain the greater part of the manganese content of the material in non-metallized condition incorporated in a completely fused slag, separating the metal and the slag, and thereafter smelting the slag in a blast furnace under conditions adapted to produce a manganese alloy high in manganese, low in phosphorus, and exhibiting a ratio of manganese to phosphorus greater than 10.

This application contains subject-matter in common with my applications Serial Nos. 234,847 and 234,848, filed October 13, 1938, and is a continuation-in-part of said applications.

I claim:

1. Process which comprises charging manganese-iron ore and solid carbonaceous fuel into a blast furnace; blasting the charge with air preheated to a temperature of at least 1,700° F. while adjusting the supply of solid carbonaceous fuel with respect to the sensible heat of the blast so that the total heat supply is insufficient to metallize the major portion of the manganese but is sufficient to metallize the major portion of the iron content of the ore; separating the resulting metal from the resulting slag; charging into a blast furnace solid carbonaceous fuel and a burden consisting mainly of said slag; blowing the charge with a preheated blast; and removing from the furnace an alloy of iron and manganese and a slag containing a relatively low amount of manganese.

2. In the process for treating poor manganese ore containing phosphorus involving the steps of first smelting the ore in a blast furnace with acid burdening to a phosphorus pig iron poor in manganese and then as a second step charging the resultant primary slag rich in manganese and poor in phosphorus, together with solid carbonaceous fuel and sufficient calcium base fluxing agent to make the final slag definitely basic, into a blast furnace and smelting the charge, with the aid of a preheated blast, to produce ferro-manganese poor in phosphorus, the improvement of the second step of the process, which consists in restricting the fuel-to-primary slag ratio to not greater than unity while maintaining the furnace hearth at a temperature of at least 2,600° F. by adjusting the temperature of the blast to a value in excess of 1,600° F., whereby to provide in the hearth a maximum amount of heat of high availability for manganese reduction.

3. In the art of metallizing manganese and iron, in the form of ferro-manganese of at least 50% grade, from a mineral material containing oxidic compounds of manganese and iron, present in a ratio suitable for the direct production of ferro-manganese, together with refractory oxide gangue material including at least 18% silica, the improvement which comprises charging the mineral material together with solid carbonaceous reducing agent and basic fluxing material, into a blast furnace while so proportioning the components of the charge that the fuel-to-mineral material ratio is less than unity and that the resulting slag has a molar basicity of the order of 1.5, and blasting the charge with a blast preheated to a temperature, in excess of 1,600° F., varying with the critical temperature of reduction of manganese obtaining under the conditions employed.

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Dec. 9, 1941. P. H. ROYSTER 2,265,866

SMELTING MANGANESE ORE

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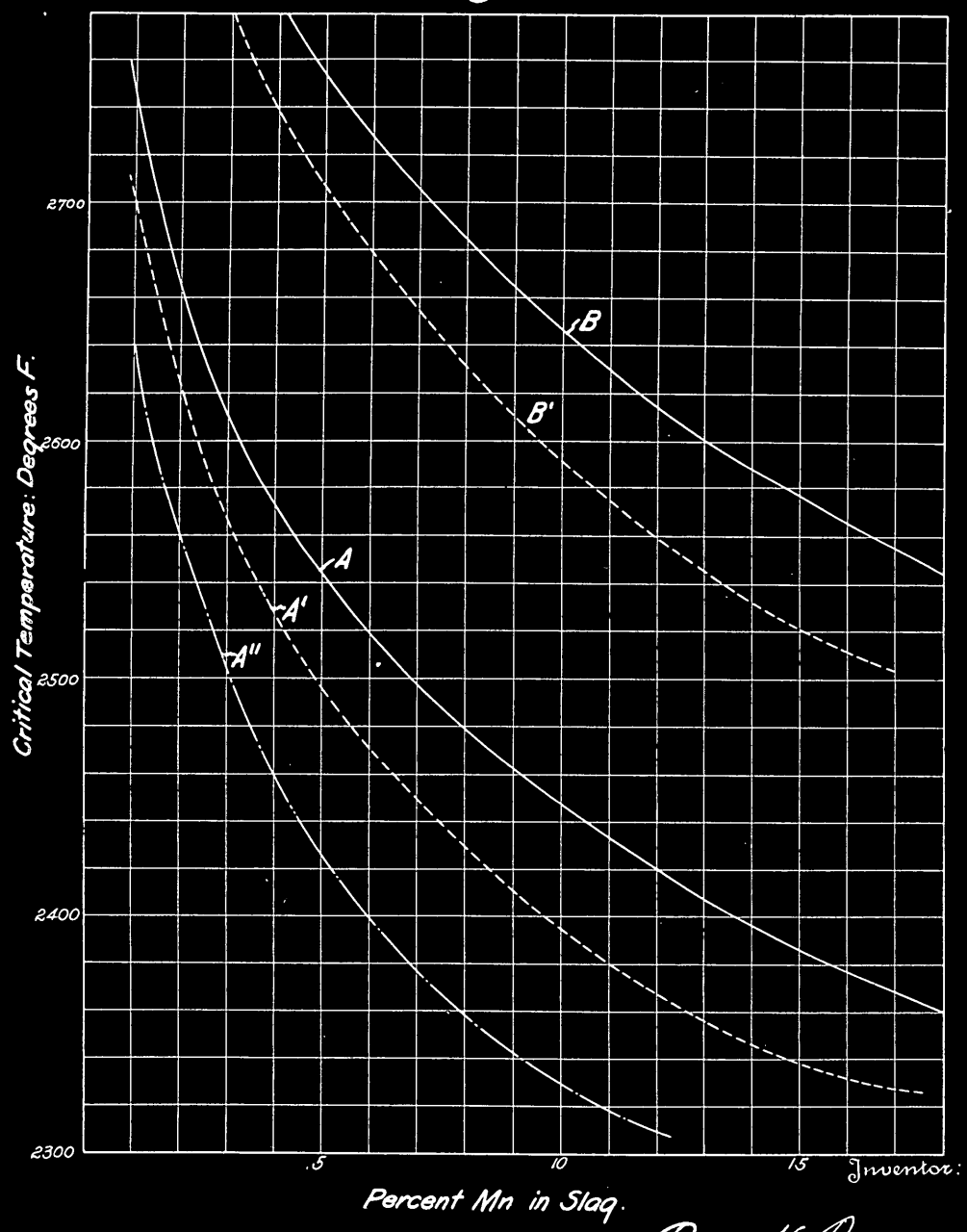
Fig. 1.



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SMELTING MANGANESE ORE

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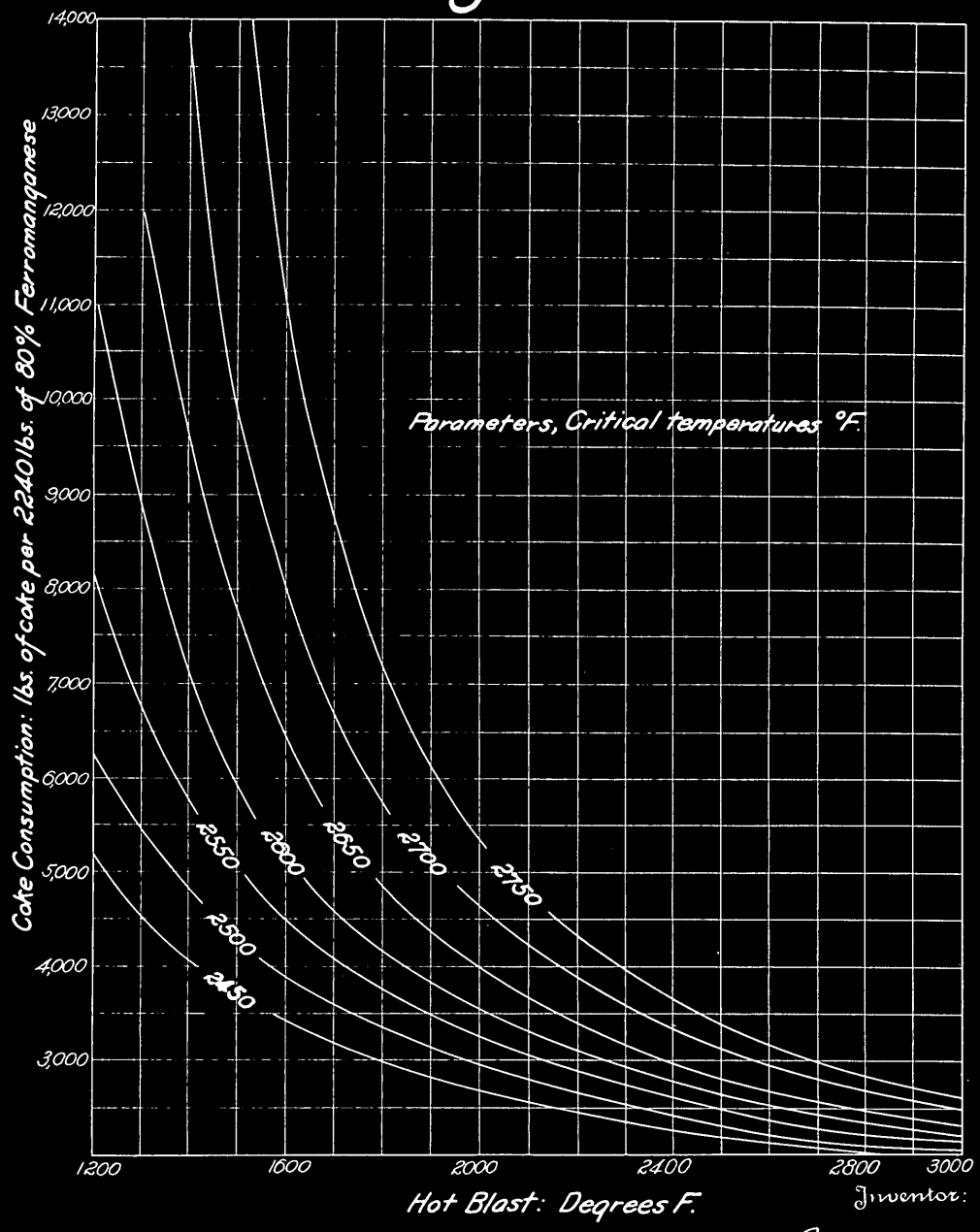
Fig. 2.



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SMELTING MANGANESE ORE

Percy H. Royster, Bethesda, Md.

Application March 9, 1939, Serial No. 260,867

4 Claims. (Cl. 75—131)

This invention relates to the smelting, in the blast furnace, of natural ores, beneficiated ores, and the like, containing reducible manganese compounds, whereby to metallize their manganese contents. The invention is concerned more particularly with an improved smelting process for the production, in the blast furnace, of alloys of manganese and iron.

The improved smelting process of the invention is applicable to the metallization of manganese occuring in ores (or in metallurgical equivalents thereof) containing reducible manganese compounds, with or without reducible compounds of other metals, commingled with much silica. Production, in the blast furnace, of ferro-manganese of "80%" grade from ores (or metallurgical equivalents thereof) containing much silica and/or other acidic refractory oxides is a particular object of this process, although production of alloys containing from 50% to 90% of manganese is within the purview of the invention.

By the expression "manganese ore or metallurgical equivalent thereof" I mean to include both naturally occurring and synthetically produced mineral compositions containing oxides of manganese and iron, silica and alumina, in which compositions the manganese and iron are present in ratios adapted to yield ferromanganese of at least 50% grade. In the appended claims the expression "ore" includes metallurgical equivalents of a naturally occurring ore.

In the smelting of an ore in which the silica is low with respect to manganese content, the ore does not melt to a fluid fusion product until relatively high temperatures are reached. For example, a manganese ore containing 48% to 52% Mn and 6% to 12% SiO_2, when melted, forms a fusion product in the binary system MnO-SiO_2 containing from 89.4 to 81.4 molar per cent of MnO and 10.6 to 18.6 molar per cent of $MnSiO_3$. While the eutectic in the binary system MnO-$MnSiO_3$ is low-melting and fluid, the great preponderance of MnO in this low silica ore in excess of said eutectic composition renders said ore high-melting and viscous. In the blast furnace smelting of such an ore, a liberal supply of limestone or dolomite would be added to the furnace burden where, as the ore and stone descended through the shaft, incipient fusion initially would take place between the CaO and MgO (resulting from calcination of the stone at about 1,650° F.) and progressive fusion of the ore and bases would form reaction products in the ternary system MnO-CaO—SiO_2. Some of the silica would be combined with CaO and MgO to form the metasilicates $CaSiO_3$ and $MgSiO_3$, thereby reducing the relative amount of the low-melting and fluid $MnSiO_3$ formed. The success heretofore attained in the blast furnace production of ferro-manganese has depended in large measure upon the retention of the manganese oxide of the ore in a non-fluid state in the furnace shaft above the tuyères and in the path of the ascending heated gases, so that a large part of the heat necessary for effecting the reduction of the MnO to metal by solid carbon could be brought into a satisfactory approach to equilibrium. The reduction of MnO by solid carbon according to the equation

$$MnO+C \rightleftharpoons Mn+CO \qquad (1)$$

is strongly endothermic, absorbing about 2,300 B. t. u. per pound of manganese.

The above outline of the conduct of a metallurgical grade of manganese ore, i. e., a manganese ore having a relatively low SiO_2 content, in its descent to the blast furnace hearth is given in order to explain the differences between its pyrometallurgy and the pyrometallurgy of an ore (or metallurgical equivalent, containing much contaminating silica. I have found experimentally that such an ore-melt, when maintained at 2,100° F., could quite readily be stirred with a carbon rod, and that the temperature of the melt had to be reduced to below 2,050° F. before the same could be called "sluggish" or "slow flowing."

When such a mineral composition as that just described is subjected to treatment according to conventional ferro-manganese blast furnace practice, the results are metallurgically unsatisfactory and economically unacceptable.

The charge material liquefies too early in its downward course through the furnace shaft, promptly flows into the hearth where it ceases to be in contact with hot reducing gases, and resists reduction.

This latter course of events probably explains the prior art conception that it was impossible to reduce to metal the manganese content of such an ore (or metallurgical equivalent) typified by manganese-bearing material containing 18% or more of SiO_2 or containing 25% or more of gangue material, without at the same time reducing considerable (e.g., 10% to 25%) of the SiO_2 content thereof.

As a result of conventional practice applied to such ores, the manganese content of the resulting slag is high. A great increase in coke

consumption over conventional practice is necessary (in order to maintain even unsatisfactory operation of the furnace), large additions of flux are required, daily tonnage of metal is low, and excessive losses of manganese and of heat result from the large volume of gases produced in the furnace, which gases leave the latter at an excessively high temperature, thereby adversely influencing vaporization of manganese. The fraction of total manganese charged which is lost in the final slag is great, due to two causes: first, the actual manganese content of the final slag is high, and second, the "slag volume" (i. e., pounds of slag per long ton of metal produced) is very much greater than are the slag volumes met with in smelting standard manganese ores.

From the foregoing discussion is will be appreciated that economical metallization, in the blast furnace, of manganese from such high-silica ores (or metallurgical equivalents) cannot be effected by carrying out the ferro-manganese blast furnace procedure which is conventionally considered "good practice."

It is an object of the present invention to provide an improved process for the economical metallization, in a blast furnace operation, of manganese from a "high silica" manganese ore (or metallurgical equivalent thereof) containing manganese and common acidic refractory oxides (e. g., SiO_2, Al_2O_3, etc.) in a ratio less than 4 to 1. The invention also has as its object the provision of a blast furnace smelting process which minimizes losses of manganese into the slag and out the stack. Another object of invention is the provision of an improved blast furnace process of smelting low manganese-high silica ores (or metallurgical equivalents), which improved process involves the consumption of relatively small amounts of solid fuel (e. g., materially less fuel than ore, by weight).

These, and other, inventive objects are realized by the process of the present invention, according to which at least the major part of the manganese contained in a siliceous manganese ore of relatively low Mn-to-SiO_2 ratio of the types just described, is metallized in a blast furnace operation conducted under chemical and thermal conditions adapted to increase the quantity of available heat supplied to the furnace hearth and to promote the reaction of reduction of MnO in solution in the slag by contact of the latter with solid carbon.

In smelting a manganese-SiO_2 mixture (e. g., an ore of the sort above described), I charge the blast furnace with appropriate amounts of the mixture, solid fuel (e. g., coke), and a suitable basic fluxing agent (e. g., a limestone and/or dolomite, natural or calcined), and blow the charge with a preheated blast. For increasing the quantity of available heat supplied to the furnace hearth I may:

I. Increase the blast temperature, and/or
II. Decrease the critical temperature of reduction of the manganese, and/or
III. Decrease the partial pressure of the gaseous product of the reduction of MnO by solid carbon, and/or
IV. Increase the activity of the manganese compound existent in solution in the slag, and/or
V. Increase the time of contact of slag, metal and carbon, and/or
VI. Decrease the dimensions of the oxidizing zone adjacent the blast entrance.

A fuller explanation of these six measures follows:

I. By increasing the blast temperature beyond that which has heretofore been employed in the blast furnace production of ferro-manganese I desirably increase the total sensible heat of the blast gases (oxygen and nitrogen) entering the furnace, and increase the amount of available heat per unit of fuel consumed without changing the amount of unavailable heat. In general it is a feature of the process of the present invention to preheat the blast to a temperature of at least 1600° or 1650° F. Increasing the blast temperature tends to increase the temperature of the gases produced in the combustion zone without concurrently increasing the "critical temperature" (J. E. Johnson, Jr., "Principles, Operation and Products of the Blast Furnace") of reduction of MnO.

II. The critical temperature of the reduction of manganese may, when the blast temperature is maintained at a sufficiently elevated value, be decreased by increasing the non-oxidizing constituents of the blast (i. e., operate with a blast containing a lesser proportion of oxygen than has ordinary atmospheric air). This expedient is effective for reducing "Tc", since dilution of the blast with nitrogen decreases the partial pressure of the carbon monoxide in the hearth: As the partial pressure of the carbon monoxide is decreased the content of MnO in the slag decreases in direct linear proportion.

III. I may decrease the partial pressure of the gaseous product of reduction of NnO by solid carbon,—and hence decrease the critical temperature of the reduction,—either by

(*a*) Lowering the hydrostatic pressure inside the furnace hearth, or by
(*b*) Decreasing the percentage of CO present in the furnace hearth gases.

Measure (*a*) may be effected by operating the furnace under "slow blowing" conditions, permitting time for the CO (produced from the MnO reduction) to diffuse from the carbon-manganese oxide interface and for dilution of the gases at the interface with non-reactive nitrogen to take place; or, by shortening the charge column of the furnace to a height materially less than conventional for said furnace (whereby hearth pressure is reduced); or, by decreasing the vertical height of the slag bath (whereby the hydrostatic pressure of the slag, and its MnO content, is reduced); or, by mechanically removing furance gases by means of an "induced draft" or "vacuum" applied to the exhaust conduit system of the furnace. Maintaining the hydrostatic pressure in the slag at a low level (as by keeping the slag bath shallow by frequent flushes between consecutive casts) accelerates the rate of movement of CO from the slag. Rapid removal of CO from the slag displaces to the right the equilibrium in the reaction expressed by Equation 1 and hastens the conversion of the MnO of the slag to metallic manganese and decreases the content of MnO remaining in the slag.

Measure (*b*) above may be effected by suitably diluting the air employed in the blast of the furnace, with nitrogen or equivalent non-oxidizing gas. In this connection it is noted that CO is not the equivalent of nitrogen since the former, under the conditions obtaining in the furnace hearth exerts oxidizing properties with respect to metallic manganese. It is to be noted also, that measure (*b*) above becomes available

only as the blast temperature is so greatly elevated as to approach the critical temperature of reduction of MnO.

IV. The activity of the manganese compound existing in the slag may be increased by increasing the basic oxide content of said slag, whereby the chemical combination between CaO and/or MgO and the Al_2O_3, Cr_2O_3, SiO_2, TiO_2 and other acidic oxides of the slag (forming silicates, aluminates, alumino-silicates, etc., of the bases) is increased, and chemical "fixation" of the manganese as silicates, aluminates, or alumino-silicates of manganese is decreased.

As appears from the foregoing, the smelting of high-silica manganese ores in which the ratio of manganese to silica is 3-to-1 or less, e. g., a manganese-iron ore (or equivalent) in which the ratio of manganese to silica is less than 3-to-1 and in which the ratio of iron to manganese is less than 1-to-8, by conventional blast furnace practice is uneconomical for the following reasons:

(*a*) Increased "fuel consumption" (i. e., pounds of fuel per long ton of metal) is necessary, due to the increased weight of material to be smelted per unit of metallized product;

(*b*) Increased addition of basic fluxing agent is required because of the greater weight of acid gangue oxides in the lower grade ore and because of the increase in fuel ash by reason of (*a*) above;

(*c*) Greater "slag loss" of manganese is encountered because of the increased "slag volume" (i. e., pounds of slag per long ton of metal), since the measure of the "slag loss" of manganese is the product of the "slag volume" multiplied by the weight per cent of manganese retained in the slag;

(*d*) The "reducibility" of the MnO in the charge is low because of dilution of the MnO with a large volume of the gangue oxides contained in such ore; and

(*e*) The "reducibility" of the MnO in the charge is further decreased by chemical combination of MnO with acidic gangue oxides to form silicates, aluminates, and aluminosilicates of manganese.

The increase in amount of fluxing agent employed is a necessary result of the composition of the siliceous ore and cannot be obviated. In fact, in the process of the present invention the increase in amount of fluxing agent is greater than the proportional increase in acidic gangue oxides, since it is desirable to increase the "basicity of the slag"—i. e., ratio of (CaO plus MgO) to (Al_2O_3 plus SiO_2) by weight.

The principles of the process of the present invention will be described with greater particularity in the following paragraphs, with reference to the accompanying drawings, in which

Fig. 1 is a chart comprising graphs showing relationships between critical temperature "Tc" and content of manganese (in percent by weight) in the resulting slag, and

Fig. 2 is a chart composed of a family of curves showing relationships between blast temperature, coke consumption and critical temperature.

In carrying out the process of the present invention I employ an extremely basic slag whenever the same is economically feasible. Thus, when limestone is relatively cheap (e. g., less than $1.00 per ton) and when coke is relatively expensive (e. g., more than $5.00 per ton), I employ a basicity ratio higher than hitherto has been employed either in pig iron practice or in ferro-manganese practice, e. g., a basicity ratio as high as 1.5.

For a blast furnace with a hearth pressure of 7 lbs./sq. in. (gauge) producing 80% ferromanganese, in a case where the slag basicity is sufficiently high, e. g., 1.5, the critical temperature "Tc," in degrees F., may be plotted against the weight per cent of metallic manganese in the slag as shown in curve A of the graph designated Fig. 1 of the accompanying drawings.

On the contrary, when coke is relatively cheap and limestone is relatively expensive the basicity of the slag must, for economical reasons, be decreased, and can be made less than unity with resulting economy. With decrease in the basicity of the slag, the critical temperature of reduction of manganese is shifted upwardly. Thus, in the case of an extremely acid slag (e. g.,

$$(CaO+MgO)/(Al_2O_3+SiO_2)=0.85$$

or less).

Tc may be plotted as curve B in Fig. 1.

For slag basicities intermediate 0.85 and 1.5 there exist a family of curves lying between curve A and curve B. This family of curves is represented by the following equation:

$$\log_{10}\frac{21.7m}{PM}=V-\frac{W}{Tc+460}$$

wherein

m=Mn in slag, in weight per cent,
M=Mn in metal, in weight per cent,
P=hearth pressure, in lbs./sq. in., absolute,
Tc=critical temperature, in °F.
Tc+460=critical temperature, absolute, and V and W are parameters whose values are given by the equations,
V=7.23+0.6G, and
W=28,240−200G,
where

$$G=\frac{CaO+MgO}{Al_2O_3+SiO_2}$$

A considerable decrease in critical temperature of reduction of manganese can be effected by lowering the hearth pressure. Hearth pressure may be reduced as low as, say, 1 lb./sq. in. by one or another, or by a combination of two or more, of the following measures:

1. Employing a larger diametered furnace of standard height;
2. Employing a shorter furnace shaft, with "standard" diameter;
3. In a "standard" furnace, carrying the stock line lower than customary;
4. Blowing the furnace at a lower rate than customary.

The effect of such a drop in hearth pressure is to shift curve A (Fig. 1) downwardly into the position shown as curve A^1. Similarly, critical temperatures, for 1 lb./sg./in. hearth pressure, is shown in curve B^1.

I may, with very desirable results, reduce the hearth pressure,—e. g., to a value below atmospheric pressure,—by the use of an exhauster, or induced draft blower, operating upon the outlet gases. Illustrative of the effect of this measure is the following: For the case of a hearth pressure of 5 lbs./sq. in. below atmospheric, the critical temperatures illustrated in curve A, Fig. 1, are shifted downwardly to those in curve A^{11}, and in curve B to curve B^{11}.

The effect of lowering the critical temperature Tc is to effect a remarkable decrease in coke con-

sumption, in producing ferro-manganese, by increasing the fraction of the heat, supplied to the combustion zone, which is available for manganese reduction. For example, when one pound of coke-carbon is burned at the blast entrance by air (60% humidity, 60° F.) to form CO and N_2 (plus 1.2% H_2), there are generated 3,990 B. t. u. If the blast be preheated to 2,000° F., its sensible heat is 2,940 B. t. u., making a total (gross) value of 6,930 B. t. u., from which latter must be subtracted 117 B. t. u. for the endothermic reaction of blast moisture with carbon and 630 B. t. u. lost to the tuyère and bosh water-cooled devices and for conduction through the brick work, leaving a net combustion zone heat of 6,183 B. t. u. per pound of carbon burned by the O_2 of the blast. If the reaction of Equation 1 is carried out at a reduction temperature of, say, 2,500° F. (6.9% Mn in the slag,—curve A of Fig. 1), the combustion zone gases cannot be cooled below 2,500° F. by absorption of heat in carrying on the endothermic reduction reaction (Equation 1); therefore, these gases carry away from the reduction zone the sensible heat which was required to heat them up to 2,500°, i. e., 4,525 B. t. u. per pound of carbon burned to CO. In other words, 73% (4.525/6,183) of the net combustion zone heat is "unavailable" for manganese reduction. This situation is made even worse when Tc is raised to 2,700° F., in which latter event the "unavailable" heat is 4,925 B. t. u./lb. of carbon, or 79.7% of the net heat.

In order to make completely clear the relationship between the critical temperature Tc, the blast temperature and the coke consumption, I have computed the thermal requirements for producing one long ton of 80% ferro-manganese, in a typical blast furnace; these results are given in Fig. 2 as a family of curves with blast temperatures as abscissa and coke consumption as ordinates, and with the critical temperature as a parameter for each curve as marked by 50 degree (F.) steps from 2,450° to 2,750° F.

In the following I shall describe my process as applied to the production of ferro-manganese of "80%" grade from an ore of the following analysis:

	Per cent
Mn (as metal)	35.5
Fe (as metal)	3.2
SiO_2	21.5
Al_2O_3	5.3
MgO	2.5
CaO	0.8
BaO	0.7

This ore would, under conventional practice, be considered "non-merchantable" because of its high concentration of the acidic gangue oxides SiO_2 and Al_2O_3.

A "standard" grade of ore operable under current practice for production of ferro-manganese has an analysis, for example, of: Mn—49.25%, Fe_2O_3—4.5%, SiO_2—8.0%, Al_2O_3—3.0%, CaO—1.5%, MgO—1.25%, and BaO—0.85%. In smelting this latter ore in accordance with conventional "best practice," one would charge into a blast furnace 4,375 lbs. of the ore, 950 lbs. of limestone and 4,100 lbs. of coke, blow the furnace charge with air at 1,550° F., and produce 1 long ton (2,240 lbs.) of 80% ferro-manganese and 1,300 lbs. of a slag analyzing 8.0% manganese. With manganese at 33¢ per unit, coke at $3.50 per ton, and limestone at $1.75 per ton, the "smelting cost" would be $9.45, including $7.18 for coke, $0.74 for flux and $1.53 for manganese "lost" in the slag.

With the siliceous ore given hereinbefore, the slag volume (in the immediately preceding example) is increased to about 4,500 lbs. In order to hold the manganese slag loss to the 104 pounds of the above example, or to a lesser figure, when employing the above siliceous ore, it is necessary so to operate the blast furnace that the slag contains not more than 2.3% Mn. Reference to Fig. 1, however, shows that the critical temperature of manganese reduction for a 2.3% manganese slag is 2,650 F. Reference to Fig. 2 shows that with 1,550° F. hot blast the coke consumption at Tc=2,650 F. is 7,000 pounds per ton of metal, which figure represents an increase in fuel cost of $5.25 per ton of metal. For a "neutral" slag, the siliceous ore requires 3,300 pounds of limestone per ton of metal, which figure represents an increase in flux cost of $1.86. The total increased materials cost called for by use of the siliceous ore under the furnace conditions just mentioned is $7.11.

But when the furnace is blown with air preheated to 1,870° F. the coke consumption is reduced to 4,100 pounds,—a figure equal to the "standard" ore's competition in this respect,—and when the furnace is blown with air preheated to 2,300° F. the coke consumption (corresponding to Tc=2,640° F.) is reduced to 3,050 pounds. This latter reduction in coke consumption "cancels" the added expense of the flux, thereby showing that the metallurgical penalty on the siliceous ore can be obviated by raising the blast temperature from the conventional figure of 1,550° F. to 2,300° F.

It is to be noted that if, in the above example, the loss of manganese into the slag is maintained at, say, 4.3%, instead of at 2.3%, the temperature of the hot blast must be elevated to about 2,600° F. in order to make the smelting of this ore competitive with smelting a "standard" ore.

Another example of application of the concepts of the present invention to smelting of an ore containing 21% SiO_2 in competition with an ore containing only 8% SiO_2 is as follows, in which example coke is valued at $5.00 per ton, limestone at 85¢, and ore at 26¢ per unit: When smelting an ore containing 8% SiO_2, using a blast temperature of 1,550° F., 4,100 lbs. of coke and 950 lbs. of limestone are employed. The slag volume is 1,300, and the slag contains 8% Mn. When employing the siliceous ore (21% SiO_2), I use a blast temperature of 2,000° F., a coke consumption of 3,600 pounds (corresponding to Tc=2,610° F.,—Fig. 2), and a flux consumption of 3,300 pounds. Under these conditions the slag volume is 4,500, and the content of manganese in the slag is 2.95%. The materials cost is substantially identical with that of the just mentioned "standard" practice applied to ore of 8% SiO_2.

Substantially the same end can be attained by reducing fuel consumption to 3,400 pounds and holding the blast temperature at 2,000° F. (thereby raising the content of manganese in the slag to 4% and lowering Tc to 2,572° F.)

Reference to Figs. 1 and 2, and knowledge of prevailing unit costs of ore, coke and flux, will enable the operator to adjust the operation of the blast furnace for smelting a given siliceous ore under the economically most favorable conditions.

I claim:

1. Process of producing ferro-manganese con-

taining at least 50% of manganese, in the blast furnace, from a manganese-bearing ore containing more than 18% silica, which comprises feeding the furnace with a charge consisting essentially of the ore, a basic fluxing agent and a solid carbonaceous fuel; and blowing the charge with a gas, containing oxygen and nitrogen, preheated to a temperature equal to the critical temperature of reduction of manganese, the blown gas containing a lesser proportion of oxygen than does atmospheric air.

2. In the process of producing, in the blast furnace, ferro-manganese of at least 50% grade from a manganese-bearing ore, the improvement which consists in blasting a furnace charge, consisting essentially of the ore, a basic fluxing agent and a solid carbonaceous fuel, with a blast preheated to a temperature in excess of 1,600° F., and simultaneously sufficiently decreasing the hydrostatic pressure of the CO within the resulting slag bath, by reducing the hearth pressure to a value of the order of 1 lb./sq. in. gauge, as materially to lower the critical temperature of reduction of manganese.

3. Process of producing ferro-manganese containing at least 50% of manganese, in the blast furnace, from a manganese-bearing ore containing more than 18% silica, which comprises feeding the furnace with a charge consisting essentially of the ore, a basic fluxing agent and a solid carbonaceous fuel; blowing the charge with a gas, containing oxygen and nitrogen, preheated to a temperature in excess of 1,600° F.; and so adjusting the rate of introduction of the preheated blast, with respect to the dimensions of the furnace, and the particle size and proportions of the charge ingredients, as to maintain the static pressure of gases within the furnace hearth at not to exceed 5 lbs./sq. in. above atmospheric pressure.

4. In the process of producing manganese alloys in the blast furnace, the improvement which consists in maintaining the furnace hearth at a static pressure less than atmospheric pressure by accelerating the exhaust of furnace gases by means of an induced draft.

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has been recovered as metal in the form of ferromanganese. This average loss of 16 per cent has been divided about evenly between slag and flue dust. It is emphasized here that the loss due to volatilization can be almost entirely eliminated by the installation of suitable electro-static precipitators. Also, the manganese content of the slag can be substantially reduced by increasing the usual hearth temperature some 400° Fahrenheit.

As has been pointed out in the preceeding paragraphs, present ferromanganese practice is a compromise between metal loss in the slag and volatile loss in the furnace fume. The total metal loss is held to about 16 per cent only because high grade foreign ores have, so far, been available. It is again pointed out that if certain metallurgical improvements were employed in the smelting of ferromanganese from these same high-grade foreign ores, the total metal loss need not exceed four per cent.

In order to smelt lower grade ores, i. e., those having a silica plus alumina to manganese ratio higher than about one to four, present ferro-

manganese furnace practice must be altered in two respects:

1. The temperature of the reduction zone (hearth temperature) must be increased to the point of optimum equilibrium between metal in the slag and metal in the alloy.

2. At this higher temperature, manganese volatilization is even higher than in present practice. The fume must be collected and returned to the furnace. This fume control is a well established practice in other smelting processes and suitable equipment is available.

Selective Reduction of Phosphorus, Cobalt, Nickel, Copper and Iron:

In addition to the fact that direct smelting of this ore to ferromanganese would generate a very high proportion of slag to metal, the phosphorus content would be considerable above the commercial minimum. Therefore, it is necessary to divide the smelting of this ore into these two separate operations.

1. Selective reduction of the most easily reducible oxides to metal while retaining practically all of the manganese as an unreduced silicate slag.

2. Re-smelting of the cold slag from the first step into phosphorus-free ferromanganese.

Incidental to the dephosphorizing operation, practically all of the copper, nickel and cobalt would be recovered in the high phosphorus pig iron which is produced in the first furnace campaign. These metals are present in sufficient quantities as to constitute a valuable by-product.

The pyrometallurgy of low grade manganese ores high in iron, phosphorus and silica has been thoroughly investigated and successfully solved. A project of blast furnace research on manganiferous ore was pursued during 1939, 1940 and 1941 at Toledo, Ohio. The research was financed by several major iron and steel companies among which were Bethlehem Steel, Interlake Iron and Steel, Pickends-Mather and Youngstown Sheet and Tube. The director of research during the entire campaign was Percy H. Royster.

The selective reduction metallurgical detail is described in the accompanying patents No. Re. 22,063, reissued April 7, 1942, and No. 2,265,865, issued December 9, 1941.

The reduction of ferromanganese from high silicate ore is described in the accompanying patent No. 2,265,866, issued December 9, 1941.

The writer has examined the data collected during the experimental furnace operation at Toledo and he finds that the thermodynamic calculations of Mr. Royster are supported by experimental fact.

PROPOSALS

Acquiring Options to Mining Rights:

It would be desirable and it is possible to insure that the entire manganese ore resources of this region be tributary to this proposed ferro-manganese plant. There are not more than 300 mining claims which are worth optioning. These can probably be had on a minimum royalty basis of $100 a year plus the obligation of performing the annual assessment work. Five or ten cents a ton or ore mined would probably be the maximum royalty if negotiations should be completed before physical operations are resumed.

In addition to the optioning of ground already held by others, the operating company should expect to locate from 200 to 400 mineral claims as exploration gets under way.

Program of Exploration:

Under the section entitled ORE RESERVES is a list of survey subdivisions locating nearly one hundred natural exposures of manganese in the novaculite beds. Between these known occurrences of Manganese minerals, the novaculite is generally continuous and offers a fertile field for exploration. (See U.S.G.S. Bulletin 808, Plate III.)

Before the site of the ferromanganese furnace plant is definitely selected, more should be known about the tonnage and grade of the many ore occurrences. In order to expedite this, the following men and equipment should be put to work at the outset.

1 Geologist
1 Assistant geologist
1 Sample foreman
1 Labor and equipment foreman
2 Bulldozer operators
4 Wagon drill men
4 Wagon drill helpers

The estimated weekly cost of the above personnel is $1,200 a week.

2	large bulldozers	$ 800	per week
4	315 cu.ft. air compressors	550	" "
4	large wagon drills	100	" "
2	4-wheel drive ½-ton trucks	120	" "
	Estimated equipment rental	$1,570	per week

Incidental equipment and supplies	$1,200	per week
Field office expense	150	" "
Total estimated direct weekly cost of proposed exploration program	$4,120	per week

The work would be most effective if completely laid out before leafy foliage of summer returns. January, February, March and April would allow 16 weeks of reconnaissance work. If properly directed, this should be sufficient for several months of actual exploration and development.

The initial program of surface trenching and drilling should be continued until a total of three million tons of at least four per cent manganese ore is indicated beyond any reasonable doubt. This is the minimum ore required to insure the return of capital investment.

Three million tons of four per cent ore is the equivalent of 12 million units of manganese. At the properties known as New Find, Hurricane Bill and Coon Creek, more than half of this minimum may already be considered as indicated.

The writer expects that an intensive exploration and development program lasting five months and costing less than $100,000 would indicate the balance of the 12,000,000 units of manganese.

Mining:

This project as conceived by the writer should maintain an annual ferromanganese production of some 40,000 annual gross tons. The rate of mining would vary somewhat with the grade of ore.

Taking into account the recoveries of manganese in the selective reduction step and in the reduction to ferromanganese, 3.64 tons of 26.5 per cent sink-float concentrate will produce one ton of 78 per cent ferromanganese. Assuming an average ore grade of 5 per cent manganese and a sink-float recovery of 85 per cent, 6.24 tons of ore must be mined for each ton of concentrate. The estimated over-all ratio of concentration is, therefore, 22.7 to one. Thus, 22.7 tons of crude ore must be mined for each ton of ferromanganese. This is an annual mining rate of 930,000 tons or 3,700 tons daily on a 250-day years.

The stripping of overburden involves most of the mining cost, and for purposes of estimate, the average ratio of stripping is assumed to be three to one of ore. This would involve the daily removal of some 5,000 cubic yards of overburden.

The overburden as well as the ore must be drilled and blasted. Although the former can be excavated somewhat more cheaply than the ore, it is estimated here that each would cost one dollar a cubic yard, or 50 cents a ton. At the assumed average stripping ratio of three to one, the total cost of mining would then be 4 x 50 or $2.00 per ton of ore mined.

The selection of equipment exactly suitable for this type of operation will require some further study during the period of exploration and development.

The estimated cost of the necessary mining and stripping equipment is $1,200,000.

Crushing, Screening and
Heavy-Media Beneficiation:

The tests so far run indicate that adequate liberation of mineral from gangue is effected by crushing the higher grade ores to two-inch size. The poorer ores require crushing to about three-quarters of an inch. Crushing all the ore to three-quarters inch screen size can be accomplished in two stages.

The primary crusher should have a gape large enough to accept the largest rock which will pass through a 1½ cubic yard shovel dipper. This is a crusher opening of not less than 30 x 36 inches.

The secondary crusher must have the capacity of crushing 6-inch material to three-quarter inch screen size at the rate of not less than 100 tons an hour. The standard 4¼ foot Symons Cone crusher would meet these requirements.

The heavy-media plants should have a capacity of at least 50 tons an hour of plus 10-mesh crude ore.

There are several makes of this type of equipment. One standard form is indicated on the accompanying photostat.

The heavy-media plants would run 24 hours a day, seven days a week. The crushing plants would run 16 hours a day, five days a week, as would the mining operation.

Three semi-portable crushing and heavy-media plants located at or near the sources of ore would treat 110,000 tons of ore a month. These three would cost, erected and powered, $300,000 each.

The reject from the heavy-media plant would amount to about four-fifths of the material mined. This substantial tonnage could most cheaply be disposed of by employing light dump trucks to shuttle between a tailings bin and the disposal area. This hauling distance would be but a hundred yards or so, and not require large equipment.

Hauling of Concentrate to Smelter:

About 600 tons of concentrate a day, seven days a week must be transported from the three concentrating plants to the smelter. As the average haul may be seven miles, this is 4,200 ton miles a day. Two 15-ton diesel units could easily handle this in 16 hours.

Receiving and Bedding of Concentrate:

Several equipment manufacturing companies can furnish conveying equipment and appurtenances for bedding and reclaiming of ores. All equipment, including the concrete flooring for the bedding system would cost about $5 per ton of ore storage capacity.

It would be convenient to have two piles at least of 6,000 tons each. This would cost an estimated $60,000.

Outline of Proposed Pyrometallurgy:

The heavy-media concentrate would be reclaimed from bedding and charged into the furnace without the addition of any flux whatever. Sufficient semi-anthracite coal would be charged in an exact proportion which, with 3000° F. of hot blast, would maintain a hearth temperature (observed exit temperature of metal and slag) of 2450° Fahrenheit. At this temperature, although the manganese silicate slag is quite fluid, little or no reduction to metallic manganese can take place. However, most of the iron and practically all of the phosphorus, copper, cobalt and nickel are removed from the silicate slag and are recovered in the form of a ferrophosphorus complex pig iron.

The slag from this selective reduction step is allowed to accumulate in the amount of several thousand of tons. The furnace is then purged by running blanks of barren material and coal. The selective reduction campaign is thus interrupted.

The manganese silicate slag is now to be crushed and charged into the same furnace and the ferromanganese campaign is begun. Sufficient limestone is added to the burden so that the ratio of bases (CaO + MgO) to acids (SiO_2 + Al_2O_3) is somewhat greater than 1½ to one. The manganese-iron ratio is adjusted by the addition of iron ore or scrap.

Sufficient semi-anthracite coal is charged to maintain a hearth temperature above 3200° F., using a hot blast of 3000° F. More than 90 per cent of the manganese is reduced from the slag and most of this is recovered in the form of standard ferromanganese. The balance of the manganese not contained in the waste slag is caught in the electrostatic precipitator, pelletized and returned to the furnace.

The pig iron from the first shaft furnace operation would be oxidized in a basic lined Pierce-Smith copper-type converter. This oxidation process would consist of three steps.

1. With addition of silica, a small amount of manganese silicate would be formed for return to the shaft furnace as manganese ore.

2. Limestone would be added for the elimination of phosphorus as tri-calcium phosphate which would be removed for sale as fertilizer.

3. Silica would again be fed to the converter to form iron silicate. This blow would be continued until the iron was nearly all removed. The remaining metal would then consist chiefly of cobalt, nickel and copper.

Calculation of Manganese Equilibrium Between Alloy and Furnace Slag:

There is considerable experimental evidence to the effect that the ratio between reduced manganese (Mn) in the alloy and unreduced manganese (MnO) in the slag is primarily a function of temperature, and secondly, of hearth pressure. In other words, the criteria of chemical equilibrium apply here as in all chemical reactions.

$$\underset{\text{solid}}{MnO} + \underset{\text{solid}}{C} \qquad \underset{\text{solid}}{Mn} + \underset{\text{gas}}{CO}$$

Because the metal content of blast furnace slags is of such paramount importance in the smelting of low grade manganese ores, the calculations for predicting the equilibrium constant between slag and alloy are here set forth in some detail.

	MnO +	C	Mn +	CO
	24.00	8.29	19.69	14.60
	14.40	1.36	7.59	47.31
Entropy @ 2000° K	38.40	9.65	27.28	61.91

Entropy of Reactants 48.05

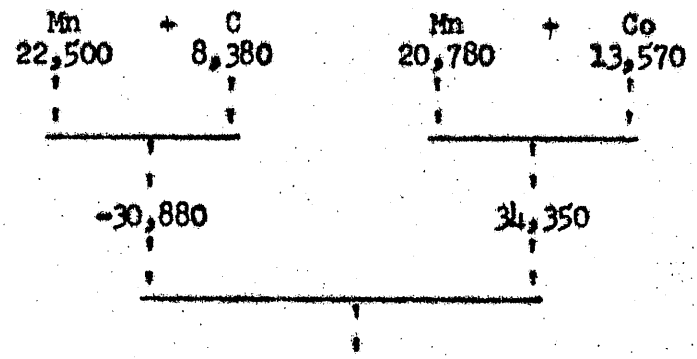
Entropy of Products 89.19

Net Entropy Change at 2000° K =

Delta S = 41.14 Cal/° C/Mole @ 2000° K

The entropy data of Mn, MnO, C and CO is taken from the Bureau of Mines Bulletin 477 by K. K. Kelley, which was published in 1950.

Calculation of the endothermic net heat at 2000° K (3140° F.) from Bureau of Mines Bulletin 476 by K. K. Kelley:



3,470 Cal/mol at 2000° K
over room temp. heat of formation

	MnO	90,300
	CO	-26,394
Heat of formation at room temperature		63,906
Add increase at hearth temperature		3,470
Endothermic net heat at 2000° K		67,376 Cal/mole

The equations used in the following thermochemical cmputations are expressions of the basic laws of thermodynamics, and are to be found in any text on the subject.

By definition, the free energy change of a chemical reaction is zero at equilibrium. For all practical purposes, such conditions are approached in the hearth of a blast furnace.

$$\Delta F = -RT \ln K = 0$$
$$\Delta F = \Delta H - T \Delta S = 0$$

and,

$$-RT \ln K = \Delta H - T \Delta S$$

Rearranging, and dividing through by T,

$$R \ln K = \Delta S - \Delta H/T$$

In the above equation,

R is the universal gas constant, or 1.987 calories/mole/K°

K is the ratio, at equilibrium and one atmosphere pressure, of the molar concentration, of reduced manganese metal in the alloy, (Mn_1) to the unreduced manganese (Mn_2) in the slag.

K may be written M_1/M_2 and expressed as a ratio of the respective chemical analyses.

The natural logarithm may be converted to log base 10 by multiplying by 2.3026. "R log base e" thus becomes 1.987 x 2.3026 or 4.574.

Delta H is the total heat requirements in calories per mole at 2000° K as determined above.

T = Temperature is Kelvin (Absolute, centigrade).

Rewriting:

$$R \ln K = \Delta S - \Delta H/T$$

$$\log_{10} K = \Delta S/4.574 - \Delta H/4.574\ T$$

Let $B = \Delta H/4.574 = \frac{67,376}{4.574} = 14,720$

Let $A = \Delta S/4.574 = \frac{41.14}{4.574} = 8.99$

Let $C = \mathrm{Log}_{10}\ Mn_1/Mn_2$

Then the equation becomes:

$$C = A - B/T \text{ or}$$

$$T = B/(A-C)$$

The following tabulations are for the purpose of determining equilibrium temperatures, given an alloy containing 78 per cent of manganese and various slag analyses for manganese.

		A	B	C	D	E
(Alloy)	Mn_1 =	78.0%	78.0%	78.0%	78.0%	78.0%
(Slag)	Mn_2 =	1.0%	2.0%	3.0%	6.0%	10.0%
Mn_1/Mn_2	=	78.0	39.0	26.0	13.0	7.8
	C =	1.8920 14,720	1.5910 14,720	1.4149 14,720	1.1139 14,720	0.8920 14,720
	A =	8.99	8.99	8.99	8.99	8.99
A - C	=	7.10	7.40	7.57	7.88	8.10
	T =	2075°K -273°	1980°K -273°	1945°K -273°	1870°K -273°	1820°K -273°
		1802°C	1717°C	1672°C	1597°C	1547°C
		3277°F	3119°F	3002°F	2902°F	2812°F

The above calculated "D" and "E" hearth or "smelting zone" temperatures are within 100° F. of the observed slag exit temperatures of commercial furnaces as reported by the Bureau of Mines in Bulletin 173.

Hearth Heat Balance:

Heat Sources:

From the discussion contained in the preceding paragraphs, it becomes apparent that metal recovery is a function of high hearth temperature and (low) hearth pressures

Heat is supplied to the blast furnace in two ways. The first source is fuel which is charged into the furnace with the ore and burned to carbon monoxide at the tuyeres. The second and more important thermal input, so far as total heat quantity is concerned in the proposed furnace, is the preheated air blast.

The following heat calculations are based upon the burning of one pound of carbon at the balst furnace tuyeres. Carbon burned at the tuyere (CAT) is the total carbon gasified less that used for direct reduction (DRI). No indirect or shaft reduction (IRI) by carbon monoxide (CO) is assumed in any calculations for this proposed furnace.

(a) Thermal Input from Fuel:

Carbon burned at the tuyers (CAT) to carbon monoxide liberates 3,963 Btu per pound. The oxygen of 74.87 cubic feet of standard dry air is thus combined. The following calculations for fuel requirements will be based on this unit, i.e., one pound of carbon burned at the tuyeres to CO.

(b) Thermal Input from Air at 3000° F:

More important so far as total input is concerned is the sensible heat of the preheated air blast at 3000°.

Sensible heat of the dry blast per pound of carbon burned at the tuyeres is:

$$\frac{74.89 \times (3000 - 69^{\circ})^{1/}}{17.37 \text{ (water-pound equivalent)}^{2/}} = 4630 \text{ Btu}$$

1/ Standard air: One atmosphere at 69° F.

2/ Water-pound equivalent: Volume of gas having a specific heat of unity, i.e., one Btu per degree Fahrenheit.

There is thus a thermal input of 1.58 Btu per CAT for each degree F. rise in blast temperature. It is important to note that at a hot blast temperature of 2500° F., the thermal input of the heated air is equal to that of burning fuel to CO with the same amount of air within the furnace itself.

(c) Thermal Input from the Moisture Contained in the Heated Blast:

Assuming 3.5 grains of moisture per cubic foot,

$$\frac{.30 \times 3.5 \times 74.87 \times (3000° - 69°)}{100 \quad 36.90 \text{ (water-pound equivalent)}} = 61 \text{ Btu}$$

which is the sensible heat per CAT of the moisture in the heated blast.

(d) Total Thermal Input
(THINP) at the Hearth:

Per CAT, (per pound carbon burned to CO at the tuyeres) ..... 3,963 Btu

Dry blast, 74.87 cu.ft. dry air at 3000° F, sensible heat ..... 4,630 "

Water Vapor, sensible heat at 3000° F..... 61 "

Total THINP per CAT .....8,654 Btu

From the total THINP per CAT deduct the heat consumed in converting the moisture in the blast to H_2 and CO. Also deduct the bosh heat loss, most of which is accounted for in the bosh and tuyere cooling water.

Deduct Btu absorbed in decomposing H O in blast air ..... 118 Btu

Cooling water heat loss per CAT estimated from experiments ..... 600 "

Total deduction per CAT ..... 718 Btu

Net THINP per CAT at the hearth (8,654 - 718) .....7,936 Btu

Selective Reduction of Iron, Phosphorus, Copper, Cobalt and Nickel:

In this first operation, the proposed furnace would be burdened only with the sink-float concentrate of the following expected analysis:

Manganese	26.50	per cent
Iron	3.85	" "
Cobalt	0.08	" "
Copper	0.02	" "
Nickel	0.07	" "
Phosphorus	0.19	" "
Silica	47.50	" "
Total Water	5.50	" "
Balance less than	.80	per cent

Hearth Heat Requirement Per Ton of Ore Dephosphorized:

For the basis of calculation, it is assumed that a ferrophosphorus of the following analysis will result from the selective reduction furnace operation.

Carbon	4.00	per cent
Silicon	.40	" "
Iron	83.00	" "
Manganese	4.52	" "
Phosphorus	4.26	" "
Copper	0.45	" "
Cobalt	1.80	" "
Nickel	1.57	per cent

It is supposed here that the reduction of FeO, CuO, CoO, and NiO is accomplished by direct reduction with incandescent carbon and not with carbon monoxide in the furnace shaft. MnO, P_2O_5 and SiO_2 are not reduced by CO under any circumstances.

The endothermic requirements per ton of ferrophosphorus are calculated as follows:

8 lbs. of Si as SiO_2 @ 9500 Btu/lb.	76,000	Btu
1660 lbs. of Fe as FeO @ 1213 Btu/lb.	2,011,920	"
90.4 lbs. of Mn as MnO @ 2110 Btu/lb.	199,784	"
85.2 lbs. of P as P_2O_5 @ 9600 Btu/lb.	817,920	"
76.4 lbs. of CO, Cu, Ni as Oxide	75,000	"
Total heat for endothermic reactions per ton of ferrophosphorus	3,180,624	Btu

The hearth temperature (observed exit temperature of slag and metal) is to be maintained at 2450° F. for reasons of thermo-chemical equilibrium between metal and slag. The furnace stock line will undoubtedly be cold because of the large amount of burden. The stock reaching the hearth will probably be well below its minimum free running temperature.

An assumption of 1450° F. for the burden reaching the hearth will introduce no great error.

Super heat for metal, 2000 lb. x 0.18 x 1000° F.....	360,000 Btu
Super heat for slag, 47,400 lb. x 0.286 x 1000°F	13,746,000 "
Endothermic heat for metal reduction	3,180,600 "
Total heat required at the hearth per ton of ferrophosphorus	20,286,600 Btu

Unavailable and Available Hearth Heat:

With all O_2 in the air burned to CO, the resulting bosh gas is 1.209 times the volume of original air.

Then, the sensible heat of the gases leaving the hearth is:

$$\frac{74.87 \text{ cu.ft. air} \times 1.209 \times 2450^{\circ}\text{F.}}{48 \text{ (water-pound equivalent)}}$$

Or, 4,623 Btu per CAT as unavailable to the hearth.

The available net hearth heat is calculated as follows:

Net thermal input per CAT	7,936 Btu
Add sensible heat per pound of coke reaching the hearth at 1450° F....	370 "
Deduct sensible heat of gas leaving the hearth	4,623 "
Total available hearth heat per CAT	3,683 Btu

Carbon Burned at the Tuyeres (CATS):

$$\frac{\text{Total heat required, } 20{,}286{,}600}{\text{Available Hearth Heat per CAT, } 3{,}683} =$$

5,508 pounds CAT

Capacity of Furnace Blowing
20,000 Cubic Feet of Wind a Minute:

The total wind blown in 24 hours, less average off-time of 20 minutes, is 1,420 x 20,000 = 28,400,000 cubic feet.

Since 5,508 pounds of carbon burned at the tuyeres will produce one ton of ferrophosphorus, and 74.87 cubic feet of standard air are required to burn one pound of carbon to CO, then the furnace capacity is:

$$\frac{28,400,000}{74.87 \times 5,508} \text{ or } 68.8 \text{ tons}$$

per 24 hours of ferrophosphorus.

The manganese silicate dephosphorized in 24 hours is:

23.7 x 68.8 or 1,630 tons,

furnace capacity.

Fuel Requirement for Selective Reduction of Phosphorus, etc.:

The semi-anthracite coal available in Arkansas is about one-half the price of coke and has about 90 per cent as much fixed carbon. The writer believes this Arkansas hard coal will serve quite as well as coke for this purpose.

The coal available for furnace fuel has the following analysis, dry basis:

Fixed carbon	72.0 per cent
Volatile matter	18.0 per cent
Ash	8.5 per cent
Sulphur	1.5 per cent

The following computations are in terms of carbon per ton of ferrophosphorus for ease of calculation:

CAT carbon burned by dry air.....	5,508 pounds
Carbon reacting with blast moisture	45 pounds
Carbon for direct reduction:	
90.4 lb. Mn as MnO x $\frac{12}{55}$	
$\frac{\text{Mol. wt. carbon}}{\text{Mol. wt. Mn}}$	20 pounds
8 lbs. Si x $\frac{24}{28}$	7 pounds
1660 lbs. Fe x $\frac{12}{56}$	356 pounds
85.2 lbs. of P x $\frac{60}{62}$	83 pounds
76.4 lbs. of Co, Cu, Ni, $\frac{12}{60}$	15 pounds
Total carbon gasified per ton ferrophosphorus	6,034 pounds
Carbon for Carbide (4%)	80 pounds
Total Stockline Carbon	6,114 pounds
Semi-anthracite charged per ton of ferrophosphorus	
$\frac{6114}{.72}$ = ...	8,491 pounds
Semi-anthracite coal per ton of heavy-media concentrate dephosphorized	
$\frac{8491}{23.7}$ = ...	358 pounds

Ferromanganese Reduction from the Dephosphorized Furnace Slag of the Preceding Operation:

It is suggested that the reader persue and note carefully the thermo-chemistry developed in the accompanying patent page No. 2,265,866.

Ferromanganese Furnace Burden:

The analysis of the dephosphorized slag from the selective reduction step is expected to be essentially:

MnO	50.9 per cent by weight
SiO_2	57.1 per cent by weight
Fe	1.0 per cent by weight

Limestone would be added to the extent that the basicity of the charge be not less than 1.5. That is the molal ratios of $CaO - MgO/SiO_2 - Al_2O_3$ would be one and one-half to one. The purpose of this high basicity would be to lower the critical reduction temperature of manganese and at the same time retard the reduction of silicon.

The manganese to iron ratio would be adjusted so that a ferromanganese of the following analysis would result.

Manganese	78.0 per cent by weight
Phosphorus	Nil
Silicon	1.25 per cent by weight
Carbon	6.0 per cent by wieght
Iron	14.75 per cent by weight

The iron would probably be added as scrap and would then require no carbon for reduction.

The burden of the furnace when producing ferromanganese would then be adjusted to the following analysis:

MnO	22.3 per cent by weight
Fe	2.8 per cent by weight
SiO_2	31.2 per cent by weight
CaO	43.7 per cent by weight
	100.0

The limestone ($CaCO_3$) requirement would then be 5.02 x 2000 x 43.7 x 1/43.7 or five tons of limestone per ton of ferromanganese.

Ferromanganese Slag to Metal Ratio:

Assuming that 90 per cent of the manganese in the burden is recovered in the form of ferromanganese, the "slag volume" becomes:

$\frac{74.9}{18.3}$ or 4.09 which is 8,180 pounds of slag to the ton (2000 lbs.) of metal.

Hearth Heat Requirements per ton of Ferromanganese:

The endothermic requirements for the reduction of each ton of ferromanganese are as follows:

1560 lbs. Mn as MnO @ 2110 Btu/lb.....	3,291,600 Btu
25 lbs. Si as SiO_2 @ 9600 Btu/lb.....	240,000 Btu
Total endothermic heat per ton of Ferromanganese	3,531,600 Btu

In order to satisfactorily lower the manganese content of the slag from this furnace operation, a

hearth temperature (observed exit temperature of slag and metal) of 3200° F. must be maintained. Assuming that the furnace burden reaches the smelting zone at the minimum free running temperature of 2200° Fahrenheit, the necessary super heat of metal and slag is 1000° F. The heat required for this super heat is then:

Ferromanganese, 2000 lbs. x 0.18 x 1000° F.....	360,000 Btu
Slag, 8180 lbs. x 0.286 x 1000° F.....	2,340,000 Btu
Total super heat	2,700,000 Btu
Adding endothermic heat of reaction	3,531,600 Btu
Total heat required at the hearth per ton of ferromanganese.	6,231,600 Btu

Unavailable and Available Hearth Heat:

With all the O_2 in the blast air converted to Co, the product gas is 1.209 times the original volume of air. Then the sensible heat of the gas leaving the hearth is:

$$\frac{74.87 \text{ cu.ft. air} \times 1.209 \times 3140^{\circ}\text{F.}}{47.38 \text{ (water pound equivalent)}}$$

or 5,969 Btu per pound CAT.

The net available heat at the hearth is then, per pound CAT:

Total thermal input	7,936 Btu
Add sensible heat of carbon reaching the hearth at 2200° F.....	700 Btu
Deduct unavailable hearth heat	5,969 Btu
Net available hearth heat per pound CAT	2,667 Btu

Carbon Burned at the Tuyeres:

Total heat required	6,231,000 Btu
Available net hearth heat per CAT	2,667 Btu

Which is 2,336 pounds CAT

Ferromanganese Capacity of Furnace Blowing 20,000 Cubic Feet of Wind a Minute:

The total volume of air blown in 24 hours, less 20 minutes off-time is

$$1420 \times 20{,}000 = 28{,}400{,}000 \text{ cubic feet.}$$

As 2336 pounds of carbon burned at the tuyeres will produce one ton of ferromanganese, and 74.87 cubic feet of standard air is required to burn one pound of carbon to CO, the furnace capacity is:

$$\frac{28{,}400{,}000}{74.87 \times 2336} \text{ or 162 net tons of ferromanganese.}$$

Ferromanganese Fuel Requirements:

The following calculations are in terms of pounds of carbon per net ton of ferromanganese. The analysis of the ferromanganese would be,

Manganese	78.0 per cent
Iron	14.75 per cent
Silicon	1.25 per cent
Carbon	6.0 per cent
Phosphorus	nil

CAT carbon burned to CO by dry air,
per ton ferromanganese ..... 2,336 pounds

Carbon reacting with moisture
in the blast air ..... 45 pounds

Carbon for direct reduction:
Manganese as MnO
$.78 \times 2000 \times \frac{12}{55}$ ..... 340 pounds

Silicon as SiO_2
$.0125 \times 2000 \times \frac{24}{28}$ ..... 21 pounds

Total carbon gasified per
ton ferromanganese ..... 2,742 pounds

Carbon for carbide (6 per cent) ..... 120 pounds

Total stockline carbon
per net ton ferromanganese ..... 2,862 pounds

The semi-anthracite requirement per ton of ferromanganese is as follows:

2862/0.72 = 3,975 pounds of coal

containing 72 per cent of fixed carbon.

Furnace Gas Volume:

The following gas computations are based upon the production of one net ton of ferromanganese.

Dry blast air per ton of ferro,
2,336 lbs x 74.87 cu.ft..... 174,896 cu.ft.

Nitrogen and inert gases,
0.79 x 174,896 cu.ft..... 138,167 cu.ft.

Carbon monoxide, pounds carbon gasified x 31.416,
2,740 x 31.416 ..... 86,063 cu.ft.

This volume of hydrogen is equal to the volume of water vapor in the humid blast. The blast air at 3½ grains per cubic foot generates, upon reacting with hot carbon, hydrogen,

$$\frac{0.30 \times 3.5 \times 174,896}{100} = 1,836 \text{ cu.ft.}$$

Hydrogen from coal at 2 per cent net,

$$\frac{0.02 \times 378 \times 3975}{100} = 14,876 \text{ cu.ft.}$$

Total hydrogen in furnace gas .....16,712 cu.ft.

Carbon dioxide from limestone,
10,000 x 0.1187 x 31.416 .....37,752 cu.ft.

Total volume dry blast furnace gas per ton of ferromanganese produced .....278,694 cu.ft.

The total daily gas volume from the proposed furnace having an output of 162 net tons of ferromanganese is: 162 x 278,694 = 45,148,428 cubic feet.

Furnace Gas Analysis and Heating Value:

Nitrogen	49.6 per cent
Carbon Monoxide	30.9 per cent
Hydrogen	6.0 per cent
Carbon Dioxide	13.5 per cent
	100.0 per cent

The low heating value of this furnace gas at 760 mm of mercury and 60° F. is,

(0.309 x 324) - (0.06 x 272) =

100.4 - 16.3 = 116.7 Btu per cubic foot of gas from the ferromanganese furnace operation.

The gas from the selective reduction operation would have no carbon dioxide and, therefore, would be 13.5 per cent less in volume and 1.16 times higher in Btu per cubic foot.

Furnace Gas Required for
Heating Blast Air to 3000° F.:

The hot moist blast air at 3000° F. has, as sensible heat, per ton of ferromanganese,

$$1.58 \times 2336 \text{ CAT} \times 3000^\circ \text{ F.} = 11{,}070{,}000 \text{ Btu.}$$

At 80 per cent efficiency for stoves and hot blast main, the Royster pebble stoves will require,

$$\frac{11{,}070{,}000 \text{ Btu}}{116.7 \times 0.80} = 112{,}150 \text{ cubic feet}$$

of furnace gas per ton of ferromanganese produced.

This is a requirement of 112,150/278,694 x 100, or 40.2 per cent of the total furnace gas. The balance of 59.8 per cent is available for steam power.

The burner rate is, per minute,

$$\frac{112{,}150 \times 162}{1440} = 15{,}500 \text{ cfm}$$

of furnace gas.

Gas Available for Steam Raising:

Beyond the requirement for heating the blast air, there is per ton of ferromanganese produced,

$$0.598 \times 116.7 \times 278{,}694 = 19{,}449{,}300 \text{ BTu}$$

which is $\frac{19{,}449{,}300 \times 162}{1440}$ or

2,160,200 Btu per minute.

Assuming an over-all heat rate as low as 20,000 Btu per horsepower-hour, the amount of plant steam power available is:

$$\frac{2{,}160{,}200 \times 60}{20{,}000} = 6{,}480 \text{ horsepower}$$

This is more than four times the total plant power requirement.

Draft Air for Hot Blast
Stoves and Flame Temperature:

The gas per minute for stove heating is,

$$\frac{112,150 \times 162}{1440} = 12,500 \text{ cfm at steady flow.}$$

The draft air required to burn this gas is,

$$\frac{12,500 \times (0.309 - 0.06)}{2 \times 0.21} = 11,000 \text{ cfm.}$$

The draft pressure drop is estimated at 5 psig maximum.

By preheating the draft air to 500° F., a flame temperature and stove dome temperature of 3200° F. could be regularly maintained.

Furnace and Appurtenances
Cooling Water Requirement:

The bosh and tuyere cooling heat loss is estimated as 600 Btu per CAT. Burners, valves, and other water cooling should not amount to more than 250 Btu per CAT. The total cooling water requirement, allowing a 40° F. rise in temperature for a furnace blowing 20,000 cfm is:

$$\frac{20{,}000 \times 850}{74.87 \times 40^{\circ}F. \times 8.3} = 684 \text{ gallons per minute}$$

Furnace Power Requirements:

At 72 per cent efficiency, 960 horsepower is required to blow 20,000 cfm of air against 10 psig pressure. The draft air blower will require about 300 horsepower. Incidental plant equipment is estimated at 250 horsepower.

The total installed furnace plant power is thus estimated at about 1500 horsepower.

ESTIMATES

Investment Requirements:

Further immediate exploration.....	$ 150,000
Access roads	100,000
Mining equipment	1,200,000
Heavy-media ore concentrating plants	900,000
Hauling equipment	210,000
Shaft furnace with stoves and blowing engines	960,000
Material hauling and storage	300,000
Steam generating boiler plant	100,000
Steam-electric equipment	80,000
Laboratory and equipment	60,000
Buildings	120,000
Miscellaneous equipment	120,000
Total Investment Account	$4,300,000

Time Estimate:

The proposed further exploration could be completed within six months.

Plant deisgn and selection of equipment could be accomplished in three months.

All equipment necessary to the project is obtainable within 12 months from date of order.

After procuring equipment and materials, all construction and installation could be completed within six months.

Estimate of Operating Costs:

	Cost per ton of Ferro-manganese
Exploration and development	$ 3.00
Mining 23 long tons of ore at $2.00 a ton	46.00
Crushing and heavy-media beneficiation of 23 tons @ 70¢ a ton	16.10
Hauling 3.64 tons of heavy-media concentrate 10 miles @ 12¢ a ton-mile	4.40
Furnace operation @ 125 long tons ferromanganese daily, labor and maintenance @ $2000	16.00
Fuel, 2¼ tons of semi-anthracite coal @ $10/ton	22.50
Limestone, 5 tons @ $5	25.00
Capital charges @ 20% a year of $4,300,000 investment	21.00
Property taxes	3.00
Administration	5.00
Total direct cost per ton of ferromanganese	$162.00

MARKETING OF PRODUCT

Ferro-grade manganese ore is traditionally required to contain at least 45 per cent of manganese, to have a manganese to iron ratio of 7 to 1, and have less than 0.10 per cent phosphorus and less than 10 per cent of silica plus alumina. In recent years, because of scarcity, these specifications have been relaxed somewhat, although one would have difficulty in disposing of manganese ore which contained less than 40 per cent of the metal, more than 12 or 15 per cent of silica and more than 0.12 per cent of phosphorus.

As ferro-grade ore, manganese now sells on the open market at $1.25 a long ton unit of manganese. (One long ton, 2,240 pounds of manganese ore analyzing 40 per cent of manganese, would contain 40 long ton units of manganese) The price is thus, 125/22.4 or 5.6 cents a pound of contained manganese. (A few politically dictated contracts are to be obtained from the Federal Stockpiling Agnocy for somewhat more than this.)

which ones?

The commercial form in which manganese is employed in the steel industry is ferromanganese, an alloy of nominally 78 per cent of manganese, 1.25 per cent of silicon, 6 per cent of carbon, less than 0.35 per cent of phosphorus, and the balance iron. The ceiling price per unit of manganese in this form is $225.00/.78 or $2.89 which is 12.9 cents a pound. This is an increase in value of 12.9/5.6 or 2.3 times which is 230 per cent.

The smelting of manganese ore into ferromanganese is a very simple and inexpensive operation provided that the apparatus be properly designed for the purpose.

To consider producing a highly beneficiated manganese ore for sale on the open market is ridiculous for both economic and metallurgical reasons. There is much more profit in the smelting of ferromanganese than in producing and marketing the ore itself, no matter how rich the ore deposit.

At the present time, no steel plant west of Pittsburgh smelts its own ferromanganese. About

50,000 tons a year is produced in Montana by a mining company. The balance of about 700,000 tons is made each year from ores purchased abroad.

The price of domestic ferromanganese is now fixed by the Government at $225 a gross ton. For two years, foreign ferromanganese has been offered at $350 a ton. In World War I, ferromanganese sold for $650 a ton. The writer believes the domestic price will match the foreign price within two years. This anticipated price rise is expected to follow the increased demand created by the current 20 per cent expansion of the steel industry.

The proposed Inland Mining Corporation production of ferromanganese is 41,000 gross tons annually. All of this can be disposed of to steel plants west of Chicago. The freight differential from Pittsburgh is favorable to Arkansas and the sale price should be at least the Pittsburgh price f.o.b. the Arkansas plant.

An important by-product of the proposed operation would be the recovery of about 350 to 400 tons

of metal annually of the following approximate analysis:

Iron	5.00 per cent
Copper	11.30 per cent
Cobalt	44.70 per cent
Nickel	39.00 per cent

Inasmuch as the ceiling price on cobalt is $4,800 a short ton, and nickel about $1,000 a ton, this alloy is worth in the neighborhood of $2,500 a ton, less the cost of electrolytic refining. This could amount to some $900,000 in additional yearly income.

The cobalt content of this alloy is of some strategic importance, since it might be as much as three per cent of our national requirement.

ESTIMATE OF NET YEARLY OPERATING INCOME

At an estimated annual production of 41,000 long tons of ferromanganese, the gross sales value at present prices f.o.b. plant is:

41,000 x $225, or $9,225,000

The direct operating cost is:

41,000 x $162, or 6,642,000

Net annual operating income without crediting sale of the by-products $2,583,000

FEDERAL TAX ASPECT

There is provision for the deduction from taxable income, 15 per cent of the gross metal sales, not to exceed 50 per cent of the net operating profit. This is the "depletion and reserve allowance".

At this time of writing, December, 1952, such a project as this would be allowed accelerated amortization probably to the extent of 80 per cent in five years.

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION
~~WASHINGTON 25, D. C.~~
Joplin, Missouri
September 29, 1952

Re: Docket DMEA-2299
Contract Idm-E280
Inland Mining Corp.

DEPARTMENT OF THE INTERIOR
Defense Minerals Administration
RECEIVED
OCT 1 1952

Memo

To: Operating Committee, DMEA

From: David Gallagher

Transmitted herewith are five sets of documents as explained in the accompanying letter to me from Cecil B. Chenoweth dated September 25, 1952.

As there are five copies of the contract other than my copy I am sending all five copies of these documents to you to distribute as you see fit.

David Gallagher

David Gallagher

DG/jd
Encs.

cc - C. B. Chenoweth

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION
WASHINGTON 25, D. C.

xxxxxxxxxxxxxx
Joplin, Missouri
September 29, 1952

Mr. Cecil B. Chenoweth
Vice-President
Inland Mining Corporation
523 Republic Bank Building
Dallas, Texas

Re: Docket DMEA-2299
Contract Idm-E280
Inland Mining Corp.

Dear Mr. Chenoweth:

This will acknowledge receipt of your letter of September 25, 1952 and the documents that accompanied it.

Your June account is still being held here awaiting word from Washington regarding the amendments concerned with additional land. Washington has, I believe, been unable to send me the necessary information pending receipt of the documents referred to above.

In a general way your suggestion for adjusting the billing for the month of June is correct, but even more extensive adjustments may be necessary depending upon Washington's determinations.

I strongly urge that no further work be done on lands other than those originally included in the original contract pending clarification from Washington.

All the documents received from you today, and referred to above have been forwarded today to the Operating Committee in DMEA in Washington.

Sincerely yours,

DG

David Gallagher
Executive Officer
DMEA Field Team, Region VI

DG/jd

co-Operating Committee

SEP 29 1952

Inland Mining Corporation

CECIL B. CHENOWETH
Vice-Pres. and Gen. Mgr.

523 Republic Bank Building
DALLAS, TEXAS

September 25, 1952

Mr. David Gallagher
Executive Officer
D.M.E.A. Field Team, Region VI
United States Department of the Interior
Joplin, Missouri

RE: Docket #DMEA-2299
Contract #Idm E280
Inland Mining Corporation

Dear Mr. Gallagher:

Your letter of September 11, 1952, caught up with me today, here in Dallas.

Enclosed you will please find five (5) sets each of the following documents, covering the "Boar Tusk Group," "New Find Group," and the "Hurricane Bill Group" of claims:

a. Subordination Agreement and Consent to Lien signed by all interested parties in each group,

b. Exhibit "A" for each group,

c. Mining Lease from original claim owners to myself as agent,

d. Mining Lease from myself as agent to Inland Mining Corporation.

You requested that I send these directly to Washington, but I am sending them to you, assuming that you will keep at least one set covering each group for your Joplin files and forward the correct number to Washington.

We still lack one signature on the "Coon Creek Group," which I expect to obtain within the next week or ten (10) days. The moment this is obtained, I will forward five copies of all proper papers to you.

In regard to the "Baloff Group" of claims, we are experiencing some difficulty in obtaining some of the signatures necessary on this group of claims. It may be that this group will have to be left out of our government contract. If so, a slight adjustment will have to be made for expenses as reflected in our monthly report of June to the government. Mr. McElwaine tells me that from his field notes and other information he can obtain accurate estimates of all costs incurred on these claims and submit this to your office on a percentage wise basis, which totals will then be subtracted from our billing to the government for the month of June.

Will this be the proper way to do this? We will appreciate your advising us as to the procedure to be followed in amending the costs as reflected in our June report, if we are unable to obtain the necessary signatures on this group of claims. Fortunately very little time and money was spent on this "Baloff Group" and I believe no drilling at all was done.

I am looking forward with pleasure to visiting you in your office in the near future.

Very truly yours,

Cecil B. Chenoweth

Cecil B. Chenoweth

CBC:mm
Encs.

cc: Operating Committee
D.M.E.A., Department of Interior
Washington 25, D. C.

cc: Mr. Estill S. Heyser, Jr., Dallas, Texas
cc: Mr. W. C. Jackson, Jr., Dallas, Texas
cc: Mr. S. A. Wier, Dallas, Texas

Form 2299X-10922

HURRICANE BILL GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This contract and lease made by and between Cecil B. Chenoweth, Agent, hereinafter called LESSOR, and Inland Mining Corporation, a corporation duly chartered under the laws of the State of Delaware, hereinafter called LESSEE,

W I T N E S S E T H:

WHEREAS, said LESSOR owns, controls, claims or holds under lease those certain mining claims situated in Polk County, Arkansas, described in the attached Exhibit "A", said exhibit being made a part hereof, and all of which claims are hereinafter known as "mining property"; and said LESSEE desires to obtain leasehold rights in said property;

NOW THEREFORE, in consideration of the sum of One ($1.00) Dollar, in hand paid by LESSEE to LESSOR, the receipt of which is hereby acknowledged, and the hereinafter recited reservations of interest in the property, and other good and sufficient consideration, including the mutual covenants and agreements herein contained, the LESSOR has leased, let and demised, and by these presents does lease, let and demise unto the said LESSEE the exclusive right to mine and operate solely for manganese and other metallic ores (together with all other materials necessarily removed in such mining), all of the mining property and claims described in said Exhibit "A", subject to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest and further subject to the reservations, conditions, terms, restrictions and agreements hereinafter set forth, to-wit:

(1) Subject to the other provisions hereof, the term of this lease shall be for five (5) years from the date hereof, and as long thereafter as manganese is produced or mined from said land by the LESSEE, its successors or assigns.

(2) LESSOR reserves unto himself absolutely all minerals other than metallic minerals lying on, in and under said mining property.

(3) LESSOR reserves unto himself and his respective heirs and assigns, as royalty, one-fourth (1/4) of all manganese and of all other metals, intending that such reservation shall cover and extend to all commercial materials produced, saved and made marketable from said mining property. Such royalty reservation in LESSOR is and shall be separate and apart and in addition to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest, and LESSEE assumes the obligations to pay and shall timely pay such original royalty or delay rentals of seven (7¢) cents per ton of raw manganese ore.

(4) LESSEE shall begin with reasonable promptness and continue thereafter with due diligence the exploration of said property in an orderly manner. LESSEE shall furnish reports to LESSOR, upon request, in appropriate written form, setting forth the information revealed by such exploration. LESSEE shall begin as early as practicable in accordance with its needs the mining of said property with the purpose and object of producing manganese therefrom, and shall continuously thereafter mine and remove from the property all ores commercially profitable for such purpose, and shall commercially process, clean, condition and concentrate all marketable products and by-products derived from such mining operations, all such commercially recovered materials, products and by-products produced and saved from said mining and processing being known herein as "products."

(5) LESSEE shall be obligated to process, clean, condition and concentrate all marketable products and by-products derived from mining operations on the mining properties and shall deliver over to LESSOR, his nominees and assigns, one-fourth (1/4) of all of the commercially recovered materials, products and by-products produced and saved from said mining and processing operations, as reserved royalty, free of all costs and expenses, and such deliveries shall be made in kind if LESSOR

so elects; if such election be not made, from time to time, with at least thirty (30) days notice in writing thereof, then LESSEE shall pay to LESSOR a sum in cash equal to the then established market value of such products. Delivery to LESSOR, his nominees or assigns of the said reserved royalty shall be made on or before the 20th day of each calendar month immediately following that month in which the same shall have been reduced to proper and acceptable commercial form, and shipped from the conditioning plant of LESSEE.

(6) LESSEE shall keep full and accurate records and books of account, showing the quantity of all ores mined and of all products derived therefrom, together with the market value of the latter, the amounts thereof shipped, the amounts thereof sold, and the sales volume thereof in money; and all such records and books shall be open to inspection by LESSOR and his agents at all reasonable business hours. Not later than the 20th day of each calendar month, LESSEE shall make reports in writing to LESSOR stating the quantity of ore mined, the quantity of ore processed, and the quantity, character and market value of all products derived therefrom and shipped during the calendar month immediately preceding the making of such report.

(7) LESSEE shall work and mine the leased property in the most effective, workmanlike and proper manner, according to the most approved and suitable methods and practices of modern mining and especially of modern strip mining, and in such manner as to ultimately recover the greatest amount of merchantable products reasonably recoverable from said property during the term of this lease; and during such term LESSEE shall allow to LESSOR full access to said property and to all mining operations thereon and also to all mills, plants and conditioning establishments processing ore from the leased property and operated by LESSEE or for its benefit wherever situated.

(8) LESSEE shall be privileged to build, erect, operate, remove, transport and employ any buildings, structures, bridges, dams, roads, machinery and equipment at any locations on the leased property as may be considered desirable, necessary or expedient thereby; and LESSEE may take from such property all materials and waters necessary in mining and processing ores removed therefrom.

(9) As part of the consideration for this lease and for the benefit of the LESSOR, LESSEE shall timely, fully and properly do all assessment work necessary and requisite by law and custom to adequately maintain in full force and effect all mining claims included in the leased property, and shall make and timely file full and complete statements and evidences of the assessment work done.

(10) At the option and election of LESSOR, this lease may be cancelled in the event that LESSEE is placed in receivership, or a petition in bankruptcy is filed against LESSEE, whether voluntary or involuntary, or if LESSEE makes a composition with creditors.

(11) This lease shall not be assigned by LESSEE unless permission for such assignment be given by LESSOR in writing; and LESSEE shall make no sub-lease or sub-leases concerning the mining property unless and until approval therefor has been given by LESSOR in writing.

(12) This lease shall inure to the benefit of and be binding upon the parties hereto and upon their respective heirs, assigns and successors.

WITNESS THE HANDS OF THE PARTIES on the 3rd day of June, 1952.

Cecil B. Chenoweth

Cecil B. Chenoweth, Agent LESSOR

INLAND MINING CORPORATION

ATTEST:

S. Albier

Secretary

By Cecil B. Chenoweth

LESSEE

EXHIBIT "A"

Mining Claim #1 and Mining Claim #2 of the Hurricane Bill Group located by S. A. Wier and filed for record in Book "I", Page 17, of the Mining Records of the Official Recorder of Polk County, Arkansas.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessor in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 3rd. day of June, 1952.

Elaine E. Decker
Notary Public

My commission expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this 3rd. day of June, 1952, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named Cecil B. Chenoweth, being the 1st. Vice President of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the 1st. Vice President of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this 3rd. day of June, 1952.

Elaine E. Decker
Notary Public

My comm. expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 195___, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named _____, being the _____ of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the _____ of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this _____ day of _____, 195____.

_____
Notary Public

Form 2299X-10921

HURRICANE DRILL GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This agreement made and entered into this 3rd day of June, 1952, by and between Cecil B. Chenoweth, Agent (hereinafter called LESSEE) and

S. A. Wier

(hereinafter called LESSOR(S)),

W I T N E S S E T H:

(1) That for and in consideration of the sum of One ($1.00) Dollar, receipt of which is hereby acknowledged, the mutual agreements hereinafter recited, and in further consideration of the royalties herein to be paid by the LESSEE, the LESSOR(S) Hereby let(s) and demise(s) unto the LESSEE the right to mine for manganese or other metallic ores (together with all other materials necessarily removed in said mining) the unpatented lode mining claims situated in the County of Polk, State of Arkansas, together with all appurtenances thereunto belonging, described on the instrument attached hereto designated as Exhibit "A" and made a part hereof and incorporated herein. To have and to hold unto the said LESSEE, his heirs and assigns for a term of five (5) years from the date hereof and as long thereafter as manganese ore is produced or mined from said claims by LESSEE, his heirs or assigns.

(2) LESSEE hereby agrees that during the term of this lease, he will do assessment work on the above described claim in compliance with statutory requirements for the benefit of the LESSOR(S) of at least One Hundred ($100.00) Dollars annually on or before June 30 of each year. The first assessment work under this lease shall be done on or before June 30, 1953. LESSEE further agrees to execute and file with the Circuit Clerk of the County in which the claim lies affidavits of assessment work done on the said mining claim for the benefit of the LESSOR(S). LESSEE may enter upon the said mining claims for exploratory and mining purposes and may take whatever steps he deems necessary in accordance with good mining practice to explore or mine said claim.

(3) In addition to doing the above mentioned assessment work, LESSEE agrees to pay to LESSOR(S) the sum of seven (7¢) cents per ton as royalty on all raw manganese ore removed from the said claims within sixty (60) days after said ore is removed; provided that it is hereby understood and agreed that as long as the aforementioned assessment work is done by the LESSEE that this lease shall remain in full force and effect and that LESSEE is under no obligation to mine the claim or to remove and sell the ore thereon.

(4) LESSEE agrees to furnish upon written request of LESSOR(S) records and accounts of the mining or exploratory activity on the said claims to the LESSOR(S).

(5) This lease may be terminated by the LESSEE at any time during the term thereof by giving notice of such termination to the LESSOR(S) at least sixty (60) days prior to the final date for doing the required assessment work for the mining year in which the lease is terminated. The words "mining year" as used in this paragraph shall be construed as commencing on July 1 and ending on June 30 and does not mean a calendar year.

(6) LESSOR(S) hereby agree(s) that the said LESSEE may assign this lease or sub-lease the mining claims under such terms as he sees fit; provided that the provisions of Paragraph (2) hereof shall be carried out by the said assignee or sub-lessee and provided further that if manganese ore is removed from the said mining claims that said

assignee or sub-lessee shall assume the obligation to pay and shall pay the seven (7¢) cents per ton royalty provided for in Paragraph (3) hereof.

(7) This agreement shall be binding upon the heirs, executors, administrators, successors and assigns of all parties hereto.

IN WITNESS WHEREOF the parties hereto have executed this agreement on this 3rd day of June, 1952.

Cecil B. Chenoweth, Agent, LESSEE

O. A. Wior

LESSORS

ACKNOWLEDGMENT

STATE OF ~~ARKANSAS~~ Texas
COUNTY OF DALLAS

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, O. A. Wior, to me well known to be the person(~~s~~) whose name(~~s~~) appear~~s~~ as Lessor(~~s~~) in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 29th day of August, 1952.

Maureen Massingill
Notary Public
(MAUREEN MASSINGILL)

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessee in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 3RD day of June, 1952.

Clarice E. Hooker
Notary Public

My com expires July 26, 1955.

EXHIBIT "A"

Mining Claim #1 and Mining Claim #2 of the Harrisburg Hill Group located by S. A. Wier and filed for record in Book "I", Page 17, of the Mining Records of the Official Recorder of Polk County, Arkansas.

LUTRICATE DIES GROUP

SUBORDINATION AGREEMENT AND CONSENT TO LIEN

KNOW ALL MEN BY THESE PRESENTS that:

WHEREAS, the "Undersigned" (as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller) have an interest in certain mining property in the State of Arkansas, County of Polk, hereinafter called "Property", said property being unpatented lode mining claims located on lands in the public domain; and the interest of the undersigned in said property includes the right to receive rentals and/or royalties on products mined and/or extracted therefrom; and the said property is the subject of a proposed Exploration Project Contract, hereinafter called "Contract", between the United States of America, hereinafter called the "Government", and Inland Mining Corporation, hereinafter called the "Operator"; and

WHEREAS, under certain provisions of said Contract which are set forth on the reverse side hereof, the Government will acquire certain rights and equities which do or may conflict with or be adverse to the interest of the undersigned in said property;

NOW THEREFORE, the undersigned, in consideration of said Contract and as an inducement to the Government and Operator to enter into same, undertakes and agrees as follows:

1. The Government's equity in and right to remove facilities, buildings, fixtures, and equipment, as provided in the Contract, shall prevail over and be prior and superior to any conflicting or adverse rights of the undersigned.

2. The Government's percentage royalty on net smelter returns or other net proceeds realized from ore, concentrates, or metal produced within ten (10) years from the date of the Contract, and the Government's lien for the payment of said percentage royalty shall attach to the mineral deposit and the production therefrom, in the amount of the Government's contribution, not in excess of $75,000.00, all upon the terms and conditions set forth in said Contract.

3. The undersigned shall commit no act nor assert any claim that may contravene or conflict with the lien, claim, or rights of the Government under the provisions of the said Contract. This agreement shall be binding upon the heirs, executors, administrators, successors, and assigns of the undersigned.

DATED this 3rd. day of June, 19 52; and
EXECUTED by the "Undersigned" as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller, thus:

S. A. Wier

Cecil B. Chenoweth
Cecil B. Chenoweth, Agent

INLAND MINING CORPORATION

By Cecil B. Chenoweth
1st. Vice President

No. 2299X-A-10919

Form 2299X-10922

HURRICANE BILL GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This contract and lease made by and between Cecil B. Chenoweth, Agent, hereinafter called LESSOR, and Inland Mining Corporation, a corporation duly chartered under the laws of the State of Delaware, hereinafter called LESSEE,

W I T N E S S E T H:

WHEREAS, said LESSOR owns, controls, claims or holds under lease those certain mining claims situated in Polk County, Arkansas, described in the attached Exhibit "A", said exhibit being made a part hereof, and all of which claims are hereinafter known as "mining property"; and said LESSEE desires to obtain leasehold rights in said property;

NOW THEREFORE, in consideration of the sum of One ($1.00) Dollar, in hand paid by LESSEE to LESSOR, the receipt of which is hereby acknowledged, and the hereinafter recited reservations of interest in the property, and other good and sufficient consideration, including the mutual covenants and agreements herein contained, the LESSOR has leased, let and demised, and by these presents does lease, let and demise unto the said LESSEE the exclusive right to mine and operate solely for manganese and other metallic ores (together with all other materials necessarily removed in such mining), all of the mining property and claims described in said Exhibit "A", subject to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest and further subject to the reservations, conditions, terms, restrictions and agreements hereinafter set forth, to-wit:

(1) Subject to the other provisions hereof, the term of this lease shall be for five (5) years from the date hereof, and as long thereafter as manganese is produced or mined from said land by the LESSEE, its successors or assigns.

(2) LESSOR reserves unto himself absolutely all minerals other than metallic minerals lying on, in and under said mining property.

(3) LESSOR reserves unto himself and his respective heirs and assigns, as royalty, one-fourth (1/4) of all manganese and of all other metals, intending that such reservation shall cover and extend to all commercial materials produced, saved and made marketable from said mining property. Such royalty reservation in LESSOR is and shall be separate and apart and in addition to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest, and LESSEE assumes the obligations to pay and shall timely pay such original royalty or delay rentals of seven (7¢) cents per ton of raw manganese ore.

(4) LESSEE shall begin with reasonable promptness and continue thereafter with due diligence the exploration of said property in an orderly manner. LESSEE shall furnish reports to LESSOR, upon request, in appropriate written form, setting forth the information revealed by such exploration. LESSEE shall begin as early as practicable in accordance with its needs the mining of said property with the purpose and object of producing manganese therefrom, and shall continuously thereafter mine and remove from the property all ores commercially profitable for such purpose, and shall commercially process, clean, condition and concentrate all marketable products and by-products derived from such mining operations, all such commercially recovered materials, products and by-products produced and saved from said mining and processing being known herein as "products."

(5) LESSEE shall be obligated to process, clean, condition and concentrate all marketable products and by-products derived from mining operations on the mining properties and shall deliver over to LESSOR, his nominees and assigns, one-fourth (1/4) of all of the commercially recovered materials, products and by-products produced and saved from said mining and processing operations, as reserved royalty, free of all costs and expenses, and such deliveries shall be made in kind if LESSOR

so elects; if such election be not made, from time to time, with at least thirty (30) days notice in writing thereof, then LESSEE shall pay to LESSOR a sum in cash equal to the then established market value of such products. Delivery to LESSOR, his nominees or assigns of the said reserved royalty shall be made on or before the 20th day of each calendar month immediately following that month in which the same shall have been reduced to proper and acceptable commercial form, and shipped from the conditioning plant of LESSEE.

(6) LESSEE shall keep full and accurate records and books of account, showing the quantity of all ores mined and of all products derived therefrom, together with the market value of the latter, the amounts thereof shipped, the amounts thereof sold, and the sales volume thereof in money; and all such records and books shall be open to inspection by LESSOR and his agents at all reasonable business hours. Not later than the 20th day of each calendar month, LESSEE shall make reports in writing to LESSOR stating the quantity of ore mined, the quantity of ore processed, and the quantity, character and market value of all products derived therefrom and shipped during the calendar month immediately preceding the making of such report.

(7) LESSEE shall work and mine the leased property in the most effective, workmanlike and proper manner, according to the most approved and suitable methods and practices of modern mining and especially of modern strip mining, and in such manner as to ultimately recover the greatest amount of merchantable products reasonably recoverable from said property during the term of this lease; and during such term LESSEE shall allow to LESSOR full access to said property and to all mining operations thereon and also to all mills, plants and conditioning establishments processing ore from the leased property and operated by LESSEE or for its benefit wherever situated.

(8) LESSEE shall be privileged to build, erect, operate, remove, transport and employ any buildings, structures, bridges, dams, roads, machinery and equipment at any locations on the leased property as may be considered desirable, necessary or expedient thereby; and LESSEE may take from such property all materials and waters necessary in mining and processing ores removed therefrom.

(9) As part of the consideration for this lease and for the benefit of the LESSOR, LESSEE shall timely, fully and properly do all assessment work necessary and requisite by law and custom to adequately maintain in full force and effect all mining claims included in the leased property, and shall make and timely file full and complete statements and evidences of the assessment work done.

(10) At the option and election of LESSOR, this lease may be cancelled in the event that LESSEE is placed in receivership, or a petition in bankruptcy is filed against LESSEE, whether voluntary or involuntary, or if LESSEE makes a composition with creditors.

(11) This lease shall not be assigned by LESSEE unless permission for such assignment be given by LESSOR in writing; and LESSEE shall make no sub-lease or sub-leases concerning the mining property unless and until approval therefor has been given by LESSOR in writing.

(12) This lease shall inure to the benefit of and be binding upon the parties hereto and upon their respective heirs, assigns and successors.

WITNESS THE HANDS OF THE PARTIES on the 3rd. day of June, 1952.

Cecil B. Chenoweth

Cecil B. Chenoweth, Agent LESSOR

INLAND MINING CORPORATION

By Cecil B. Chenoweth LESSEE

ATTEST:

Secretary

EXHIBIT "A"

Mining Claim #1 and Mining Claim #2 of the Hurricane Bill Group located by S. A. Wier and filed for record in Book "I", Page 17, of the Mining Records of the Official Recorder of Polk County, Arkansas.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessor in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 3rd. day of June, 1952.

Clarice E. Decker
Notary Public

My commission expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this 3rd. day of June, 1952, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named Cecil B. Chenoweth, being the 1st. Vice President of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the 1st. Vice President of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this 3rd. day of June, 1952.

Clarice E. Decker
Notary Public

My comm. expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 195___, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named _____, being the _____ of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the _____ of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this _____ day of _____, 195____.

_____
Notary Public

Form 2299X-10921

HURRICANE BILL GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This agreement made and entered into this 3rd. day of June, 1952, by and between Cecil B. Chenoweth, Agent (hereinafter called LESSEE) and

S. A. Wier

(hereinafter called LESSOR(S)),

W I T N E S S E T H:

(1) That for and in consideration of the sum of One ($1.00) Dollar, receipt of which is hereby acknowledged, the mutual agreements hereinafter recited, and in further consideration of the royalties herein to be paid by the LESSEE, the LESSOR(S) Hereby let(s) and demise(s) unto the LESSEE the right to mine for manganese or other metallic ores (together with all other materials necessarily removed in said mining) the unpatented lode mining claims situated in the County of Polk, State of Arkansas, together with all appurtenances thereunto belonging, described on the instrument attached hereto designated as Exhibit "A" and made a part hereof and incorporated herein. To have and to hold unto the said LESSEE, his heirs and assigns for a term of five (5) years from the date hereof and as long thereafter as manganese ore is produced or mined from said claims by LESSEE, his heirs or assigns.

(2) LESSEE hereby agrees that during the term of this lease, he will do assessment work on the above described claim in compliance with statutory requirements for the benefit of the LESSOR(S) of at least One Hundred ($100.00) Dollars annually on or before June 30 of each year. The first assessment work under this lease shall be done on or before June 30, 1953. LESSEE further agrees to execute and file with the Circuit Clerk of the County in which the claim lies affidavits of assessment work done on the said mining claim for the benefit of the LESSOR(S). LESSEE may enter upon the said mining claims for exploratory and mining purposes and may take whatever steps he deems necessary in accordance with good mining practice to explore or mine said claim.

(3) In addition to doing the above mentioned assessment work, LESSEE agrees to pay to LESSOR(S) the sum of seven (7¢) cents per ton as royalty on all raw manganese ore removed from the said claims within sixty (60) days after said ore is removed; provided that it is hereby understood and agreed that as long as the aforementioned assessment work is done by the LESSEE that this lease shall remain in full force and effect and that LESSEE is under no obligation to mine the claim or to remove and sell the ore thereon.

(4) LESSEE agrees to furnish upon written request of LESSOR(S) records and accounts of the mining or exploratory activity on the said claims to the LESSOR(S).

(5) This lease may be terminated by the LESSEE at any time during the term thereof by giving notice of such termination to the LESSOR(S) at least sixty (60) days prior to the final date for doing the required assessment work for the mining year in which the lease is terminated. The words "mining year" as used in this paragraph shall be construed as commencing on July 1 and ending on June 30 and does not mean a calendar year.

(6) LESSOR(S) hereby agree(s) that the said LESSEE may assign this lease or sub-lease the mining claims under such terms as he sees fit; provided that the provisions of Paragraph (2) hereof shall be carried out by the said assignee or sub-lessee and provided further that if manganese ore is removed from the said mining claims that said

assignee or sub-lessee shall assume the obligation to pay and shall pay the seven (7¢) cents per ton royalty provided for in Paragraph (3) hereof.

(7) This agreement shall be binding upon the heirs, executors, administrators, successors and assigns of all parties hereto.

IN WITNESS WHEREOF the parties hereto have executed this agreement on this 3rd. day of June, 1952.

Cecil B. Chenoweth

Cecil B. Chenoweth, Agent, LESSEE

S. A. Wier S. A. Wier

LESSORS

ACKNOWLEDGMENT

STATE OF ~~ARKANSAS~~ Texas
COUNTY OF DALLAS

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, S. A. Wier, to me well known to be the person(s) whose name(s) appears as Lessor(s) in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 29th day of August, 1952.

Maureen Massingill

Notary Public
(MAUREEN MASSINGILL)

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessee in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 3RD day of June, 1952.

Elaine E. Decker

Notary Public

My comm expires July 28, 1955.

EXHIBIT "A"

Mining Claim #1 and Mining Claim #2 of the Hurricane Bill Group located by S. A. Wier and filed for record in Book "I", Page 17, of the Mining Records of the Official Recorder of Polk County, Arkansas.

HURRICANE DILL GROUP

SUBORDINATION AGREEMENT AND CONSENT TO LIEN

KNOW ALL MEN BY THESE PRESENTS that:

WHEREAS, the "Undersigned" (as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller) have an interest in certain mining property in the State of Arkansas, County of Polk, hereinafter called "Property", said property being unpatented lode mining claims located on lands in the public domain; and the interest of the undersigned in said property includes the right to receive rentals and/or royalties on products mined and/or extracted therefrom; and the said property is the subject of a proposed Exploration Project Contract, hereinafter called "Contract", between the United States of America, hereinafter called the "Government", and Inland Mining Corporation, hereinafter called the "Operator"; and

WHEREAS, under certain provisions of said Contract which are set forth on the reverse side hereof, the Government will acquire certain rights and equities which do or may conflict with or be adverse to the interest of the undersigned in said property;

NOW THEREFORE, the undersigned, in consideration of said Contract and as an inducement to the Government and Operator to enter into same, undertakes and agrees as follows:

1. The Government's equity in and right to remove facilities, buildings, fixtures, and equipment, as provided in the Contract, shall prevail over and be prior and superior to any conflicting or adverse rights of the undersigned.

2. The Government's percentage royalty on net smelter returns or other net proceeds realized from ore, concentrates, or metal produced within ten (10) years from the date of the Contract, and the Government's lien for the payment of said percentage royalty shall attach to the mineral deposit and the production therefrom, in the amount of the Government's contribution, not in excess of $75,000.00, all upon the terms and conditions set forth in said Contract.

3. The undersigned shall commit no act nor assert any claim that may contravene or conflict with the lien, claim, or rights of the Government under the provisions of the said Contract. This agreement shall be binding upon the heirs, executors, administrators, successors, and assigns of the undersigned.

DATED this 3rd. day of June, 19 52; and
EXECUTED by the "Undersigned" as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller, thus:

S. A. Vier

Cecil B. Chenoweth, Agent

INLAND MINING CORPORATION

BY Cecil B. Chenoweth
1st. Vice President

No. 2299X-A-10919

Form 2299X-10922

HURRICANE BILL GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This contract and lease made by and between Cecil B. Chenoweth, Agent, hereinafter called LESSOR, and Inland Mining Corporation, a corporation duly chartered under the laws of the State of Delaware, hereinafter called LESSEE,

W I T N E S S E T H:

WHEREAS, said LESSOR owns, controls, claims or holds under lease those certain mining claims situated in Polk County, Arkansas, described in the attached Exhibit "A", said exhibit being made a part hereof, and all of which claims are hereinafter known as "mining property"; and said LESSEE desires to obtain leasehold rights in said property;

NOW THEREFORE, in consideration of the sum of One ($1.00) Dollar, in hand paid by LESSEE to LESSOR, the receipt of which is hereby acknowledged, and the hereinafter recited reservations of interest in the property, and other good and sufficient consideration, including the mutual covenants and agreements herein contained, the LESSOR has leased, let and demised, and by these presents does lease, let and demise unto the said LESSEE the exclusive right to mine and operate solely for manganese and other metallic ores (together with all other materials necessarily removed in such mining), all of the mining property and claims described in said Exhibit "A", subject to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest and further subject to the reservations, conditions, terms, restrictions and agreements hereinafter set forth, to-wit:

(1) Subject to the other provisions hereof, the term of this lease shall be for five (5) years from the date hereof, and as long thereafter as manganese is produced or mined from said land by the LESSEE, its successors or assigns.

(2) LESSOR reserves unto himself absolutely all minerals other than metallic minerals lying on, in and under said mining property.

(3) LESSOR reserves unto himself and his respective heirs and assigns, as royalty, one-fourth (1/4) of all manganese and of all other metals, intending that such reservation shall cover and extend to all commercial materials produced, saved and made marketable from said mining property. Such royalty reservation in LESSOR is and shall be separate and apart and in addition to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest, and LESSEE assumes the obligations to pay and shall timely pay such original royalty or delay rentals of seven (7¢) cents per ton of raw manganese ore.

(4) LESSEE shall begin with reasonable promptness and continue thereafter with due diligence the exploration of said property in an orderly manner. LESSEE shall furnish reports to LESSOR, upon request, in appropriate written form, setting forth the information revealed by such exploration. LESSEE shall begin as early as practicable in accordance with its needs the mining of said property with the purpose and object of producing manganese therefrom, and shall continuously thereafter mine and remove from the property all ores commercially profitable for such purpose, and shall commercially process, clean, condition and concentrate all marketable products and by-products derived from such mining operations, all such commercially recovered materials, products and by-products produced and saved from said mining and processing being known herein as "products."

(5) LESSEE shall be obligated to process, clean, condition and concentrate all marketable products and by-products derived from mining operations on the mining properties and shall deliver over to LESSOR, his nominees and assigns, one-fourth (1/4) of all of the commercially recovered materials, products and by-products produced and saved from said mining and processing operations, as reserved royalty, free of all costs and expenses, and such deliveries shall be made in kind if LESSOR

so elects; if such election be not made, from time to time, with at least thirty (30) days notice in writing thereof, then LESSEE shall pay to LESSOR a sum in cash equal to the then established market value of such products. Delivery to LESSOR, his nominees or assigns of the said reserved royalty shall be made on or before the 20th day of each calendar month immediately following that month in which the same shall have been reduced to proper and acceptable commercial form, and shipped from the conditioning plant of LESSEE.

(6) LESSEE shall keep full and accurate records and books of account, showing the quantity of all ores mined and of all products derived therefrom, together with the market value of the latter, the amounts thereof shipped, the amounts thereof sold, and the sales volume thereof in money; and all such records and books shall be open to inspection by LESSOR and his agents at all reasonable business hours. Not later than the 20th day of each calendar month, LESSEE shall make reports in writing to LESSOR stating the quantity of ore mined, the quantity of ore processed, and the quantity, character and market value of all products derived therefrom and shipped during the calendar month immediately preceding the making of such report.

(7) LESSEE shall work and mine the leased property in the most effective, workmanlike and proper manner, according to the most approved and suitable methods and practices of modern mining and especially of modern strip mining, and in such manner as to ultimately recover the greatest amount of merchantable products reasonably recoverable from said property during the term of this lease; and during such term LESSEE shall allow to LESSOR full access to said property and to all mining operations thereon and also to all mills, plants and conditioning establishments processing ore from the leased property and operated by LESSEE or for its benefit wherever situated.

(8) LESSEE shall be privileged to build, erect, operate, remove, transport and employ any buildings, structures, bridges, dams, roads, machinery and equipment at any locations on the leased property as may be considered desirable, necessary or expedient thereby; and LESSEE may take from such property all materials and waters necessary in mining and processing ores removed therefrom.

(9) As part of the consideration for this lease and for the benefit of the LESSOR, LESSEE shall timely, fully and properly do all assessment work necessary and requisite by law and custom to adequately maintain in full force and effect all mining claims included in the leased property, and shall make and timely file full and complete statements and evidences of the assessment work done.

(10) At the option and election of LESSOR, this lease may be cancelled in the event that LESSEE is placed in receivership, or a petition in bankruptcy is filed against LESSEE, whether voluntary or involuntary, or if LESSEE makes a composition with creditors.

(11) This lease shall not be assigned by LESSEE unless permission for such assignment be given by LESSOR in writing; and LESSEE shall make no sub-lease or sub-leases concerning the mining property unless and until approval therefor has been given by LESSOR in writing.

(12) This lease shall inure to the benefit of and be binding upon the parties hereto and upon their respective heirs, assigns and successors.

WITNESS THE HANDS OF THE PARTIES on the 3rd day of June, 1952.

Cecil B. Chenoweth

Cecil B. Chenoweth, Agent LESSOR

INLAND MINING CORPORATION

By Cecil B. Chenoweth LESSEE

ATTEST:

Secretary

EXHIBIT "A"

Mining Claim #1 and Mining Claim #2 of the Hurricane Bill Group located by S. A. Wier and filed for record in Book "I", Page 17, of the Mining Records of the Official Recorder of Polk County, Arkansas.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessor in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 3rd. day of June, 1952.

Elaine E. Decker
Notary Public

My commission expires July 31, 1955.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this 3rd. day of June, 1952, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named Cecil B. Chenoweth, being the 1st. Vice President of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the 1st. Vice President of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this 3rd. day of June, 1952.

Elaine E. Decker
Notary Public

My comm. expires July 31, 1955.

ACKNOWLEDGMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 195___, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named _____, being the _____ of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the _____ of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this _____ day of _____, 195____.

_____
Notary Public

Form 2299X-10921

HURRICANE BILL GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This agreement made and entered into this 3rd. day of June, 1952, by and between Cecil B. Chenoweth, Agent (hereinafter called LESSEE) and

S. A. Wier

(hereinafter called LESSOR(S)),

W I T N E S S E T H:

(1) That for and in consideration of the sum of One ($1.00) Dollar, receipt of which is hereby acknowledged, the mutual agreements hereinafter recited, and in further consideration of the royalties herein to be paid by the LESSEE, the LESSOR(S) Hereby let(s) and demise(s) unto the LESSEE the right to mine for manganese or other metallic ores (together with all other materials necessarily removed in said mining) the unpatented lode mining claims situated in the County of Polk, State of Arkansas, together with all appurtenances thereunto belonging, described on the instrument attached hereto designated as Exhibit "A" and made a part hereof and incorporated herein. To have and to hold unto the said LESSEE, his heirs and assigns for a term of five (5) years from the date hereof and as long thereafter as manganese ore is produced or mined from said claims by LESSEE, his heirs or assigns.

(2) LESSEE hereby agrees that during the term of this lease, he will do assessment work on the above described claim in compliance with statutory requirements for the benefit of the LESSOR(S) of at least One Hundred ($100.00) Dollars annually on or before June 30 of each year. The first assessment work under this lease shall be done on or before June 30, 1953. LESSEE further agrees to execute and file with the Circuit Clerk of the County in which the claim lies affidavits of assessment work done on the said mining claim for the benefit of the LESSOR(S). LESSEE may enter upon the said mining claims for exploratory and mining purposes and may take whatever steps he deems necessary in accordance with good mining practice to explore or mine said claim.

(3) In addition to doing the above mentioned assessment work, LESSEE agrees to pay to LESSOR(S) the sum of seven (7¢) cents per ton as royalty on all raw manganese ore removed from the said claims within sixty (60) days after said ore is removed; provided that it is hereby understood and agreed that as long as the aforementioned assessment work is done by the LESSEE that this lease shall remain in full force and effect and that LESSEE is under no obligation to mine the claim or to remove and sell the ore thereon.

(4) LESSEE agrees to furnish upon written request of LESSOR(S) records and accounts of the mining or exploratory activity on the said claims to the LESSOR(S).

(5) This lease may be terminated by the LESSEE at any time during the term thereof by giving notice of such termination to the LESSOR(S) at least sixty (60) days prior to the final date for doing the required assessment work for the mining year in which the lease is terminated. The words "mining year" as used in this paragraph shall be construed as commencing on July 1 and ending on June 30 and does not mean a calendar year.

(6) LESSOR(S) hereby agree(s) that the said LESSEE may assign this lease or sub-lease the mining claims under such terms as he sees fit; provided that the provisions of Paragraph (2) hereof shall be carried out by the said assignee or sub-lessee and provided further that if manganese ore is removed from the said mining claims that said

assignee or sub-lessee shall assume the obligation to pay and shall pay the seven (7¢) cents per ton royalty provided for in Paragraph (3) hereof.

(7) This agreement shall be binding upon the heirs, executors, administrators, successors and assigns of all parties hereto.

IN WITNESS WHEREOF the parties hereto have executed this agreement on this 3rd. day of June, 1952.

Cecil B. Chenoweth, Agent, LESSEE

S. A. Wier

LESSORS

ACKNOWLEDGMENT

STATE OF ~~ARKANSAS~~ Texas
COUNTY OF DALLAS

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, S. A. Wier, to me well known to be the person(s) whose name(s) appears as Lessor(s) in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 29th day of August, 1952.

Notary Public
(MAUREEN MASSINGILL)

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessee in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 3RD day of June, 1952.

Notary Public

My comm expires July 18, 1955.

EXHIBIT "A"

Mining Claim #1 and Mining Claim #2 of the Hurricane Bill Group located by S. A. Wier and filed for record in Book "I", Page 17, of the Mining Records of the Official Recorder of Polk County, Arkansas.

HURRICANE BILL GROUP

SUBORDINATION AGREEMENT AND CONSENT TO LIEN

KNOW ALL MEN BY THESE PRESENTS that:

WHEREAS, the "Undersigned" (as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller) have an interest in certain mining property in the State of Arkansas, County of Polk, hereinafter called "Property", said property being unpatented lode mining claims located on lands in the public domain; and the interest of the undersigned in said property includes the right to receive rentals and/or royalties on products mined and/or extracted therefrom; and the said property is the subject of a proposed Exploration Project Contract, hereinafter called "Contract", between the United States of America, hereinafter called the "Government", and Inland Mining Corporation, hereinafter called the "Operator"; and

WHEREAS, under certain provisions of said Contract which are set forth on the reverse side hereof, the Government will acquire certain rights and equities which do or may conflict with or be adverse to the interest of the undersigned in said property;

NOW THEREFORE, the undersigned, in consideration of said Contract and as an inducement to the Government and Operator to enter into same, undertakes and agrees as follows:

1. The Government's equity in and right to remove facilities, buildings, fixtures, and equipment, as provided in the Contract, shall prevail over and be prior and superior to any conflicting or adverse rights of the undersigned.

2. The Government's percentage royalty on net smelter returns or other net proceeds realized from ore, concentrates, or metal produced within ten (10) years from the date of the Contract, and the Government's lien for the payment of said percentage royalty shall attach to the mineral deposit and the production therefrom, in the amount of the Government's contribution, not in excess of $75,000.00, all upon the terms and conditions set forth in said Contract.

3. The undersigned shall commit no act nor assert any claim that may contravene or conflict with the lien, claim, or rights of the Government under the provisions of the said Contract. This agreement shall be binding upon the heirs, executors, administrators, successors, and assigns of the undersigned.

DATED this 3rd. day of June, 19 52; and
EXECUTED by the "Undersigned" as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller, thus:

S. A. Wier

Cecil B. Chenoweth, Agent

INLAND MINING CORPORATION

BY Cecil B. Chenoweth
1st. Vice President

No. 2299X-A-10919

RELEVANT CONTRACT PROVISIONS

Title to and disposition of property. All facilities, buildings, fixtures, equipment, or other items costing more than $50 each, paid for or purchased with funds contributed jointly by the Operator and the Government, shall belong to the Operator and the Government jointly, in proportion to their respective contributions, and upon the termination of the contract, if they have any salvage value, shall be disposed of for their joint account unless the Government, in writing, waives its interest in any such items. The Government may require the dismantling, severance from land, and removal of any such items in order to realize its interest in the salvage value thereof, and the cost of any such removal and of the disposal of the items shall be for the joint account of the parties in proportion to their respective interests.

Repayment by Operator. If, upon the completion of the exploration project or termination of the contract, the Government considers that a discovery or development has resulted from the work from which commercial production of ore may be made, the Government, within 6 months thereafter, shall so certify to the Operator, particularly describing and delimiting its estimate of the discovery or the development. Thereafter, if and as ore is produced as a result of such discovery or development, the Operator and his successor in interest shall be and become obligated to pay to the Government a percentage royalty on the net smelter returns or other net proceeds realized from such ore, concentrates, or metal produced within ten (10) years from the date of this contract, until the total amount contributed by the Government, without interest, is fully repaid or said 10 years have elapsed, whichever occurs first, as follows:

> Of net smelter returns or other net proceeds not in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent.
>
> Of net smelter returns or other net proceeds in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent, plus one-half ($\frac{1}{2}$) percent for each additional full fifty cents ($0.50) in excess of eight dollars ($8.00) per ton of ore, but not in excess of a maximum of five (5) percent.

This obligation to repay from net returns or proceeds shall be and remain a claim and lien upon the mineral deposit which is the subject of the exploration project and upon any production resulting from such discovery or development, in favor of the Government, until fully paid, or until said 10-year period has elapsed; and this claim and lien and the Government's right to repayment shall survive any termination of the contract, whether by completion of the exploration project or otherwise. This article is not to be construed as imposing any obligation on the Operator or his successor in interest to produce ore from any such discovery or development.

Form 2299X-10922

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This contract and lease made by and between Cecil B. Chenoweth, Agent, hereinafter called LESSOR, and Inland Mining Corporation, a corporation duly chartered under the laws of the State of Delaware, hereinafter called LESSEE,

W I T N E S S E T H:

WHEREAS, said LESSOR owns, controls, claims or holds under lease those certain mining claims situated in Polk County, Arkansas, described in the attached Exhibit "A", said exhibit being made a part hereof, and all of which claims are hereinafter known as "mining property"; and said LESSEE desires to obtain leasehold rights in said property;

NOW THEREFORE, in consideration of the sum of One ($1.00) Dollar, in hand paid by LESSEE to LESSOR, the receipt of which is hereby acknowledged, and the hereinafter recited reservations of interest in the property, and other good and sufficient consideration, including the mutual covenants and agreements herein contained, the LESSOR has leased, let and demised, and by these presents does lease, let and demise unto the said LESSEE the exclusive right to mine and operate solely for manganese and other metallic ores (together with all other materials necessarily removed in such mining), all of the mining property and claims described in said Exhibit "A", subject to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest and further subject to the reservations, conditions, terms, restrictions and agreements hereinafter set forth, to-wit:

(1) Subject to the other provisions hereof, the term of this lease shall be for five (5) years from the date hereof, and as long thereafter as manganese is produced or mined from said land by the LESSEE, its successors or assigns.

(2) LESSOR reserves unto himself absolutely all minerals other than metallic minerals lying on, in and under said mining property.

(3) LESSOR reserves unto himself and his respective heirs and assigns, as royalty, one-fourth (1/4) of all manganese and of all other metals, intending that such reservation shall cover and extend to all commercial materials produced, saved and made marketable from said mining property. Such royalty reservation in LESSOR is and shall be separate and apart and in addition to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest, and LESSEE assumes the obligations to pay and shall timely pay such original royalty or delay rentals of seven (7¢) cents per ton of raw manganese ore.

(4) LESSEE shall begin with reasonable promptness and continue thereafter with due diligence the exploration of said property in an orderly manner. LESSEE shall furnish reports to LESSOR, upon request, in appropriate written form, setting forth the information revealed by such exploration. LESSEE shall begin as early as practicable in accordance with its needs the mining of said property with the purpose and object of producing manganese therefrom, and shall continuously thereafter mine and remove from the property all ores commercially profitable for such purpose, and shall commercially process, clean, condition and concentrate all marketable products and by-products derived from such mining operations, all such commercially recovered materials, products and by-products produced and saved from said mining and processing being known herein as "products."

(5) LESSEE shall be obligated to process, clean, condition and concentrate all marketable products and by-products derived from mining operations on the mining properties and shall deliver over to LESSOR, his nominees and assigns, one-fourth (1/4) of all of the commercially recovered materials, products and by-products produced and saved from said mining and processing operations, as reserved royalty, free of all costs and expenses, and such deliveries shall be made in kind if LESSOR

so elects; if such election be not made, from time to time, with at least thirty (30) days notice in writing thereof, then LESSEE shall pay to LESSOR a sum in cash equal to the then established market value of such products. Delivery to LESSOR, his nominees or assigns of the said reserved royalty shall be made on or before the 20th day of each calendar month immediately following that month in which the same shall have been reduced to proper and acceptable commercial form, and shipped from the conditioning plant of LESSEE.

(6) LESSEE shall keep full and accurate records and books of account, showing the quantity of all ores mined and of all products derived therefrom, together with the market value of the latter, the amounts thereof shipped, the amounts thereof sold, and the sales volume thereof in money; and all such records and books shall be open to inspection by LESSOR and his agents at all reasonable business hours. Not later than the 20th day of each calendar month, LESSEE shall make reports in writing to LESSOR stating the quantity of ore mined, the quantity of ore processed, and the quantity, character and market value of all products derived therefrom and shipped during the calendar month immediately preceding the making of such report.

(7) LESSEE shall work and mine the leased property in the most effective, workmanlike and proper manner, according to the most approved and suitable methods and practices of modern mining and especially of modern strip mining, and in such manner as to ultimately recover the greatest amount of merchantable products reasonably recoverable from said property during the term of this lease; and during such term LESSEE shall allow to LESSOR full access to said property and to all mining operations thereon and also to all mills, plants and conditioning establishments processing ore from the leased property and operated by LESSEE or for its benefit wherever situated.

(8) LESSEE shall be privileged to build, erect, operate, remove, transport and employ any buildings, structures, bridges, dams, roads, machinery and equipment at any locations on the leased property as may be considered desirable, necessary or expedient thereby; and LESSEE may take from such property all materials and waters necessary in mining and processing ores removed therefrom.

(9) As part of the consideration for this lease and for the benefit of the LESSOR, LESSEE shall timely, fully and properly do all assessment work necessary and requisite by law and custom to adequately maintain in full force and effect all mining claims included in the leased property, and shall make and timely file full and complete statements and evidences of the assessment work done.

(10) At the option and election of LESSOR, this lease may be cancelled in the event that LESSEE is placed in receivership, or a petition in bankruptcy is filed against LESSEE, whether voluntary or involuntary, or if LESSEE makes a composition with creditors.

(11) This lease shall not be assigned by LESSEE unless permission for such assignment be given by LESSOR in writing; and LESSEE shall make no sub-lease or sub-leases concerning the mining property unless and until approval therefor has been given by LESSOR in writing.

(12) This lease shall inure to the benefit of and be binding upon the parties hereto and upon their respective heirs, assigns and successors.

WITNESS THE HANDS OF THE PARTIES on the 3rd day of June, 1952.

Cecil B. Chenoweth

Cecil B. Chenoweth, Agent LESSOR

INLAND MINING CORPORATION

By Cecil B. Chenoweth LESSEE

ATTEST:

Secretary

EXHIBIT "A"

Mining Claim #1 and Mining Claim #2 of the Hurricane Hill Group located by S. A. Wier and filed for record in Book "I", Page 17, of the Mining Records of the Official Recorder of Polk County, Arkansas.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessor in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 3rd. day of June, 1952.

Elaine E. Hecker
Notary Public

My commission expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this 3rd. day of June, 1952, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named Cecil B. Chenoweth, being the 1st. Vice President of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the 1st. Vice President of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this 3rd. day of June, 1952.

Elaine E. Hecker
Notary Public

My com. expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 195___, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named _____, being the _____ of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the _____ of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this _____ day of _____, 195___.

_____
Notary Public

Form 2299X-10921

HURRICANE BILL GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This agreement made and entered into this 3rd day of June, 1952, by and between Cecil B. Chenoweth, Agent (hereinafter called LESSEE) and

S. A. Wier

(hereinafter called LESSOR(S)),

W I T N E S S E T H:

(1) That for and in consideration of the sum of One ($1.00) Dollar, receipt of which is hereby acknowledged, the mutual agreements hereinafter recited, and in further consideration of the royalties herein to be paid by the LESSEE, the LESSOR(S) Hereby let(s) and demise(s) unto the LESSEE the right to mine for manganese or other metallic ores (together with all other materials necessarily removed in said mining) the unpatented lode mining claims situated in the County of Polk, State of Arkansas, together with all appurtenances thereunto belonging, described on the instrument attached hereto designated as Exhibit "A" and made a part hereof and incorporated herein. To have and to hold unto the said LESSEE, his heirs and assigns for a term of five (5) years from the date hereof and as long thereafter as manganese ore is produced or mined from said claims by LESSEE, his heirs or assigns.

(2) LESSEE hereby agrees that during the term of this lease, he will do assessment work on the above described claim in compliance with statutory requirements for the benefit of the LESSOR(S) of at least One Hundred ($100.00) Dollars annually on or before June 30 of each year. The first assessment work under this lease shall be done on or before June 30, 1953. LESSEE further agrees to execute and file with the Circuit Clerk of the County in which the claim lies affidavits of assessment work done on the said mining claim for the benefit of the LESSOR(S). LESSEE may enter upon the said mining claims for exploratory and mining purposes and may take whatever steps he deems necessary in accordance with good mining practice to explore or mine said claim.

(3) In addition to doing the above mentioned assessment work, LESSEE agrees to pay to LESSOR(S) the sum of seven (7¢) cents per ton as royalty on all raw manganese ore removed from the said claims within sixty (60) days after said ore is removed; provided that it is hereby understood and agreed that as long as the aforementioned assessment work is done by the LESSEE that this lease shall remain in full force and effect and that LESSEE is under no obligation to mine the claim or to remove and sell the ore thereon.

(4) LESSEE agrees to furnish upon written request of LESSOR(S) records and accounts of the mining or exploratory activity on the said claims to the LESSOR(S).

(5) This lease may be terminated by the LESSEE at any time during the term thereof by giving notice of such termination to the LESSOR(S) at least sixty (60) days prior to the final date for doing the required assessment work for the mining year in which the lease is terminated. The words "mining year" as used in this paragraph shall be construed as commencing on July 1 and ending on June 30 and does not mean a calendar year.

(6) LESSOR(S) hereby agree(s) that the said LESSEE may assign this lease or sub-lease the mining claims under such terms as he sees fit; provided that the provisions of Paragraph (2) hereof shall be carried out by the said assignee or sub-lessee and provided further that if manganese ore is removed from the said mining claims that said

assignee or sub-lessee shall assume the obligation to pay and shall pay the seven (7¢) cents per ton royalty provided for in Paragraph (3) hereof.

(7) This agreement shall be binding upon the heirs, executors, administrators, successors and assigns of all parties hereto.

IN WITNESS WHEREOF the parties hereto have executed this agreement on this 3rd. day of June, 1952.

Cecil B. Chenoweth
Cecil B. Chenoweth, Agent, LESSEE

S. A. Wier
S. A. Wier

LESSORS

ACKNOWLEDGMENT

STATE OF ~~ARKANSAS~~ Texas
COUNTY OF DALLAS

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, S. A. Wier, to me well known to be the person(~~s~~) whose name(~~s~~) appear~~s~~ as Lessor(~~s~~) in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 29th day of August, 1952.

Maureen Massingill
Notary Public
(MAUREEN MASSINGILL)

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessee in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 3RD day of June, 1952.

Elaine E. Hecker
Notary Public

My comm expires July 21, 1955.

EXHIBIT "A"

Mining Claim #1 and Mining Claim #2 of the Hurricane Bill Group located by S. A. Wier and filed for record in Book "I", Page 17, of the Mining Records of the Official Recorder of Polk County, Arkansas.

HURRICANE BILL GROUP

SUBORDINATION AGREEMENT AND CONSENT TO LIEN

KNOW ALL MEN BY THESE PRESENTS that:

WHEREAS, the "Undersigned" (as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller) have an interest in certain mining property in the State of Arkansas, County of Polk, hereinafter called "Property", said property being unpatented lode mining claims located on lands in the public domain; and the interest of the undersigned in said property includes the right to receive rentals and/or royalties on products mined and/or extracted therefrom; and the said property is the subject of a proposed Exploration Project Contract, hereinafter called "Contract", between the United States of America, hereinafter called the "Government", and Inland Mining Corporation, hereinafter called the "Operator"; and

WHEREAS, under certain provisions of said Contract which are set forth on the reverse side hereof, the Government will acquire certain rights and equities which do or may conflict with or be adverse to the interest of the undersigned in said property;

NOW THEREFORE, the undersigned, in consideration of said Contract and as an inducement to the Government and Operator to enter into same, undertakes and agrees as follows:

1. The Government's equity in and right to remove facilities, buildings, fixtures, and equipment, as provided in the Contract, shall prevail over and be prior and superior to any conflicting or adverse rights of the undersigned.

2. The Government's percentage royalty on net smelter returns or other net proceeds realized from ore, concentrates, or metal produced within ten (10) years from the date of the Contract, and the Government's lien for the payment of said percentage royalty shall attach to the mineral deposit and the production therefrom, in the amount of the Government's contribution, not in excess of $75,000.00, all upon the terms and conditions set forth in said Contract.

3. The undersigned shall commit no act nor assert any claim that may contravene or conflict with the lien, claim, or rights of the Government under the provisions of the said Contract. This agreement shall be binding upon the heirs, executors, administrators, successors, and assigns of the undersigned.

DATED this 3rd. day of June, 19 52; and
EXECUTED by the "Undersigned" as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller, thus:

S. A. Wier

Cecil B. Chenoweth, Agent

INLAND MINING CORPORATION

BY Cecil B. Chenoweth
1st. Vice President

No. 2299X-A-10919

RELEVANT CONTRACT PROVISIONS

Title to and disposition of property. All facilities, buildings, fixtures, equipment, or other items costing more than $50 each, paid for or purchased with funds contributed jointly by the Operator and the Government, shall belong to the Operator and the Government jointly, in proportion to their respective contributions, and upon the termination of the contract, if they have any salvage value, shall be disposed of for their joint account unless the Government, in writing, waives its interest in any such items. The Government may require the dismantling, severance from land, and removal of any such items in order to realize its interest in the salvage value thereof, and the cost of any such removal and of the disposal of the items shall be for the joint account of the parties in proportion to their respective interests.

Repayment by Operator. If, upon the completion of the exploration project or termination of the contract, the Government considers that a discovery or development has resulted from the work from which commercial production of ore may be made, the Government, within 6 months thereafter, shall so certify to the Operator, particularly describing and delimiting its estimate of the discovery or the development. Thereafter, if and as ore is produced as a result of such discovery or development, the Operator and his successor in interest shall be and become obligated to pay to the Government a percentage royalty on the net smelter returns or other net proceeds realized from such ore, concentrates, or metal produced within ten (10) years from the date of this contract, until the total amount contributed by the Government, without interest, is fully repaid or said 10 years have elapsed, whichever occurs first, as follows:

> Of net smelter returns or other net proceeds not in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent.
>
> Of net smelter returns or other net proceeds in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent, plus one-half ($\frac{1}{2}$) percent for each additional full fifty cents ($0.50) in excess of eight dollars ($8.00) per ton of ore, but not in excess of a maximum of five (5) percent.

This obligation to repay from net returns or proceeds shall be and remain a claim and lien upon the mineral deposit which is the subject of the exploration project and upon any production resulting from such discovery or development, in favor of the Government, until fully paid, or until said 10-year period has elapsed; and this claim and lien and the Government's right to repayment shall survive any termination of the contract, whether by completion of the exploration project or otherwise. This article is not to be construed as imposing any obligation on the Operator or his successor in interest to produce ore from any such discovery or development.

Form 2299X-10922

HURRICANE BILL GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This contract and lease made by and between Cecil B. Chenoweth, Agent, hereinafter called LESSOR, and Inland Mining Corporation, a corporation duly chartered under the laws of the State of Delaware, hereinafter called LESSEE,

W I T N E S S E T H:

WHEREAS, said LESSOR owns, controls, claims or holds under lease those certain mining claims situated in Polk County, Arkansas, described in the attached Exhibit "A", said exhibit being made a part hereof, and all of which claims are hereinafter known as "mining property"; and said LESSEE desires to obtain leasehold rights in said property;

NOW THEREFORE, in consideration of the sum of One ($1.00) Dollar, in hand paid by LESSEE to LESSOR, the receipt of which is hereby acknowledged, and the hereinafter recited reservations of interest in the property, and other good and sufficient consideration, including the mutual covenants and agreements herein contained, the LESSOR has leased, let and demised, and by these presents does lease, let and demise unto the said LESSEE the exclusive right to mine and operate solely for manganese and other metallic ores (together with all other materials necessarily removed in such mining), all of the mining property and claims described in said Exhibit "A", subject to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest and further subject to the reservations, conditions, terms, restrictions and agreements hereinafter set forth, to-wit:

(1) Subject to the other provisions hereof, the term of this lease shall be for five (5) years from the date hereof, and as long thereafter as manganese is produced or mined from said land by the LESSEE, its successors or assigns.

(2) LESSOR reserves unto himself absolutely all minerals other than metallic minerals lying on, in and under said mining property.

(3) LESSOR reserves unto himself and his respective heirs and assigns, as royalty, one-fourth (1/4) of all manganese and of all other metals, intending that such reservation shall cover and extend to all commercial materials produced, saved and made marketable from said mining property. Such royalty reservation in LESSOR is and shall be separate and apart and in addition to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest, and LESSEE assumes the obligations to pay and shall timely pay such original royalty or delay rentals of seven (7¢) cents per ton of raw manganese ore.

(4) LESSEE shall begin with reasonable promptness and continue thereafter with due diligence the exploration of said property in an orderly manner. LESSEE shall furnish reports to LESSOR, upon request, in appropriate written form, setting forth the information revealed by such exploration. LESSEE shall begin as early as practicable in accordance with its needs the mining of said property with the purpose and object of producing manganese therefrom, and shall continuously thereafter mine and remove from the property all ores commercially profitable for such purpose, and shall commercially process, clean, condition and concentrate all marketable products and by-products derived from such mining operations, all such commercially recovered materials, products and by-products produced and saved from said mining and processing being known herein as "products."

(5) LESSEE shall be obligated to process, clean, condition and concentrate all marketable products and by-products derived from mining operations on the mining properties and shall deliver over to LESSOR, his nominees and assigns, one-fourth (1/4) of all of the commercially recovered materials, products and by-products produced and saved from said mining and processing operations, as reserved royalty, free of all costs and expenses, and such deliveries shall be made in kind if LESSOR

so elects; if such election be not made, from time to time, with at least thirty (30) days notice in writing thereof, then LESSEE shall pay to LESSOR a sum in cash equal to the then established market value of such products. Delivery to LESSOR, his nominees or assigns of the said reserved royalty shall be made on or before the 20th day of each calendar month immediately following that month in which the same shall have been reduced to proper and acceptable commercial form, and shipped from the conditioning plant of LESSEE.

(6) LESSEE shall keep full and accurate records and books of account, showing the quantity of all ores mined and of all products derived therefrom, together with the market value of the latter, the amounts thereof shipped, the amounts thereof sold, and the sales volume thereof in money; and all such records and books shall be open to inspection by LESSOR and his agents at all reasonable business hours. Not later than the 20th day of each calendar month, LESSEE shall make reports in writing to LESSOR stating the quantity of ore mined, the quantity of ore processed, and the quantity, character and market value of all products derived therefrom and shipped during the calendar month immediately preceding the making of such report.

(7) LESSEE shall work and mine the leased property in the most effective, workmanlike and proper manner, according to the most approved and suitable methods and practices of modern mining and especially of modern strip mining, and in such manner as to ultimately recover the greatest amount of merchantable products reasonably recoverable from said property during the term of this lease; and during such term LESSEE shall allow to LESSOR full access to said property and to all mining operations thereon and also to all mills, plants and conditioning establishments processing ore from the leased property and operated by LESSEE or for its benefit wherever situated.

(8) LESSEE shall be privileged to build, erect, operate, remove, transport and employ any buildings, structures, bridges, dams, roads, machinery and equipment at any locations on the leased property as may be considered desirable, necessary or expedient thereby; and LESSEE may take from such property all materials and waters necessary in mining and processing ores removed therefrom.

(9) As part of the consideration for this lease and for the benefit of the LESSOR, LESSEE shall timely, fully and properly do all assessment work necessary and requisite by law and custom to adequately maintain in full force and effect all mining claims included in the leased property, and shall make and timely file full and complete statements and evidences of the assessment work done.

(10) At the option and election of LESSOR, this lease may be cancelled in the event that LESSEE is placed in receivership, or a petition in bankruptcy is filed against LESSEE, whether voluntary or involuntary, or if LESSEE makes a composition with creditors.

(11) This lease shall not be assigned by LESSEE unless permission for such assignment be given by LESSOR in writing; and LESSEE shall make no sub-lease or sub-leases concerning the mining property unless and until approval therefor has been given by LESSOR in writing.

(12) This lease shall inure to the benefit of and be binding upon the parties hereto and upon their respective heirs, assigns and successors.

WITNESS THE HANDS OF THE PARTIES on the 3rd. day of June, 1952.

Cecil B. Chenoweth

Cecil B. Chenoweth, Agent (LESSOR)

INLAND MINING CORPORATION

By Cecil B. Chenoweth (LESSEE)

ATTEST:

Secretary

EXHIBIT "A"

Mining Claim #1 and Mining Claim #2 of the Hurricane Hill Group located by S. A. Wier and filed for record in Book "I", Page 17, of the Mining Records of the Official Recorder of Polk County, Arkansas.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessor in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 3rd. day of June, 1952.

Elaine E. Decker
Notary Public

My comm. expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this #3rd. day of June, 1952, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named Cecil B. Chenoweth, being the 1st. Vice President of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the 1st. Vice President of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this 3rd. day of June, 1952.

Elaine E. Decker
Notary Public

My comm. expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 195___, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named _____, being the _____ of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the _____ of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this _____ day of _____, 195___.

_____
Notary Public

Form 2299X-10921

HURRICANE HILL GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This agreement made and entered into this 3rd. day of June, 1952, by and between Cecil B. Chenoweth, Agent (hereinafter called LESSEE) and

S. A. Wier

(hereinafter called LESSOR(S)),

W I T N E S S E T H:

(1) That for and in consideration of the sum of One ($1.00) Dollar, receipt of which is hereby acknowledged, the mutual agreements hereinafter recited, and in further consideration of the royalties herein to be paid by the LESSEE, the LESSOR(S) Hereby let(s) and demise(s) unto the LESSEE the right to mine for manganese or other metallic ores (together with all other materials necessarily removed in said mining) the unpatented lode mining claims situated in the County of Polk, State of Arkansas, together with all appurtenances thereunto belonging, described on the instrument attached hereto designated as Exhibit "A" and made a part hereof and incorporated herein. To have and to hold unto the said LESSEE, his heirs and assigns for a term of five (5) years from the date hereof and as long thereafter as manganese ore is produced or mined from said claims by LESSEE, his heirs or assigns.

(2) LESSEE hereby agrees that during the term of this lease, he will do assessment work on the above described claim in compliance with statutory requirements for the benefit of the LESSOR(S) of at least One Hundred ($100.00) Dollars annually on or before June 30 of each year. The first assessment work under this lease shall be done on or before June 30, 1953. LESSEE further agrees to execute and file with the Circuit Clerk of the County in which the claim lies affidavits of assessment work done on the said mining claim for the benefit of the LESSOR(S). LESSEE may enter upon the said mining claims for exploratory and mining purposes and may take whatever steps he deems necessary in accordance with good mining practice to explore or mine said claim.

(3) In addition to doing the above mentioned assessment work, LESSEE agrees to pay to LESSOR(S) the sum of seven (7¢) cents per ton as royalty on all raw manganese ore removed from the said claims within sixty (60) days after said ore is removed; provided that it is hereby understood and agreed that as long as the aforementioned assessment work is done by the LESSEE that this lease shall remain in full force and effect and that LESSEE is under no obligation to mine the claim or to remove and sell the ore thereon.

(4) LESSEE agrees to furnish upon written request of LESSOR(S) records and accounts of the mining or exploratory activity on the said claims to the LESSOR(S).

(5) This lease may be terminated by the LESSEE at any time during the term thereof by giving notice of such termination to the LESSOR(S) at least sixty (60) days prior to the final date for doing the required assessment work for the mining year in which the lease is terminated. The words "mining year" as used in this paragraph shall be construed as commencing on July 1 and ending on June 30 and does not mean a calendar year.

(6) LESSOR(S) hereby agree(s) that the said LESSEE may assign this lease or sub-lease the mining claims under such terms as he sees fit; provided that the provisions of Paragraph (2) hereof shall be carried out by the said assignee or sub-lessee and provided further that if manganese ore is removed from the said mining claims that said

assignee or sub-lessee shall assume the obligation to pay and shall pay the seven (7¢) cents per ton royalty provided for in Paragraph (3) hereof.

(7) This agreement shall be binding upon the heirs, executors, administrators, successors and assigns of all parties hereto.

IN WITNESS WHEREOF the parties hereto have executed this agreement on this 3rd. day of June, 1952.

Cecil B. Chenoweth, Agent, LESSEE

S. A. Wier

LESSORS

ACKNOWLEDGMENT

STATE OF ~~ARKANSAS~~ TEXAS
COUNTY OF DALLAS

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, S. A. Wier, to me well known to be the person(s) whose name(s) appear as Lessor(s) in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 29th day of August, 1952.

Maureen Massingill
Notary Public
(MAUREEN MASSINGILL)

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessee in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 3rd. day of June, 1952.

Elaine E. Hecker
Notary Public

My commission expires July 21, 1955.

EXHIBIT "A"

Mining Claim #1 and Mining Claim #2 of the Hurricane Bill Group located by S. A. Wier and filed for record in Book "I", Page 17, of the Mining Records of the Official Recorder of Polk County, Arkansas.

AMERICAN DRILL GROUP

SUBORDINATION AGREEMENT AND CONSENT TO LIEN

KNOW ALL MEN BY THESE PRESENTS that:

WHEREAS, the "Undersigned" (as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller) have an interest in certain mining property in the State of Arkansas, County of Polk, hereinafter called "Property", said property being unpatented lode mining claims located on lands in the public domain; and the interest of the undersigned in said property includes the right to receive rentals and/or royalties on products mined and/or extracted therefrom; and the said property is the subject of a proposed Exploration Project Contract, hereinafter called "Contract", between the United States of America, hereinafter called the "Government", and Inland Mining Corporation, hereinafter called the "Operator"; and

WHEREAS, under certain provisions of said Contract which are set forth on the reverse side hereof, the Government will acquire certain rights and equities which do or may conflict with or be adverse to the interest of the undersigned in said property;

NOW THEREFORE, the undersigned, in consideration of said Contract and as an inducement to the Government and Operator to enter into same, undertakes and agrees as follows:

1. The Government's equity in and right to remove facilities, buildings, fixtures, and equipment, as provided in the Contract, shall prevail over and be prior and superior to any conflicting or adverse rights of the undersigned.

2. The Government's percentage royalty on net smelter returns or other net proceeds realized from ore, concentrates, or metal produced within ten (10) years from the date of the Contract, and the Government's lien for the payment of said percentage royalty shall attach to the mineral deposit and the production therefrom, in the amount of the Government's contribution, not in excess of $75,000.00, all upon the terms and conditions set forth in said Contract.

3. The undersigned shall commit no act nor assert any claim that may contravene or conflict with the lien, claim, or rights of the Government under the provisions of the said Contract. This agreement shall be binding upon the heirs, executors, administrators, successors, and assigns of the undersigned.

DATED this 3rd day of June, 1952; and
EXECUTED by the "Undersigned" as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller, thus:

Cecil B. Chenoweth
Cecil B. Chenoweth, Agent

INLAND MINING CORPORATION

BY Cecil B. Chenoweth
1st Vice President

No. 2299X-A-10919

RELEVANT CONTRACT PROVISIONS

Title to and disposition of property. All facilities, buildings, fixtures, equipment, or other items costing more than $50 each, paid for or purchased with funds contributed jointly by the Operator and the Government, shall belong to the Operator and the Government jointly, in proportion to their respective contributions, and upon the termination of the contract, if they have any salvage value, shall be disposed of for their joint account unless the Government, in writing, waives its interest in any such items. The Government may require the dismantling, severance from land, and removal of any such items in order to realize its interest in the salvage value thereof, and the cost of any such removal and of the disposal of the items shall be for the joint account of the parties in proportion to their respective interests.

Repayment by Operator. If, upon the completion of the exploration project or termination of the contract, the Government considers that a discovery or development has resulted from the work from which commercial production of ore may be made, the Government, within 6 months thereafter, shall so certify to the Operator, particularly describing and delimiting its estimate of the discovery or the development. Thereafter, if and as ore is produced as a result of such discovery or development, the Operator and his successor in interest shall be and become obligated to pay to the Government a percentage royalty on the net smelter returns or other net proceeds realized from such ore, concentrates, or metal produced within ten (10) years from the date of this contract, until the total amount contributed by the Government, without interest, is fully repaid or said 10 years have elapsed, whichever occurs first, as follows:

> Of net smelter returns or other net proceeds not in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent.
>
> Of net smelter returns or other net proceeds in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent, plus one-half ($\frac{1}{2}$) percent for each additional full fifty cents ($0.50) in excess of eight dollars ($8.00) per ton of ore, but not in excess of a maximum of five (5) percent.

This obligation to repay from net returns or proceeds shall be and remain a claim and lien upon the mineral deposit which is the subject of the exploration project and upon any production resulting from such discovery or development, in favor of the Government, until fully paid, or until said 10-year period has elapsed; and this claim and lien and the Government's right to repayment shall survive any termination of the contract, whether by completion of the exploration project or otherwise. This article is not to be construed as imposing any obligation on the Operator or his successor in interest to produce ore from any such discovery or development.

Form 2299X-10922

NEW FIND GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This contract and lease made by and between Cecil B. Chenoweth, Agent, hereinafter called LESSOR, and Inland Mining Corporation, a corporation duly chartered under the laws of the State of Delaware, hereinafter called LESSEE,

W I T N E S S E T H:

WHEREAS, said LESSOR owns, controls, claims or holds under lease those certain mining claims situated in Polk County, Arkansas, described in the attached Exhibit "A", said exhibit being made a part hereof, and all of which claims are hereinafter known as "mining property"; and said LESSEE desires to obtain leasehold rights in said property;

NOW THEREFORE, in consideration of the sum of One ($1.00) Dollar, in hand paid by LESSEE to LESSOR, the receipt of which is hereby acknowledged, and the hereinafter recited reservations of interest in the property, and other good and sufficient consideration, including the mutual covenants and agreements herein contained, the LESSOR has leased, let and demised, and by these presents does lease, let and demise unto the said LESSEE the exclusive right to mine and operate solely for manganese and other metallic ores (together with all other materials necessarily removed in such mining), all of the mining property and claims described in said Exhibit "A", subject to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest and further subject to the reservations, conditions, terms, restrictions and agreements hereinafter set forth, to-wit:

(1) Subject to the other provisions hereof, the term of this lease shall be for five (5) years from the date hereof, and as long thereafter as manganese is produced or mined from said land by the LESSEE, its successors or assigns.

(2) LESSOR reserves unto himself absolutely all minerals other than metallic minerals lying on, in and under said mining property.

(3) LESSOR reserves unto himself and his respective heirs and assigns, as royalty, one-fourth (1/4) of all manganese and of all other metals, intending that such reservation shall cover and extend to all commercial materials produced, saved and made marketable from said mining property. Such royalty reservation in LESSOR is and shall be separate and apart and in addition to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest, and LESSEE assumes the obligations to pay and shall timely pay such original royalty or delay rentals of seven (7¢) cents per ton of raw manganese ore.

(4) LESSEE shall begin with reasonable promptness and continue thereafter with due diligence the exploration of said property in an orderly manner. LESSEE shall furnish reports to LESSOR, upon request, in appropriate written form, setting forth the information revealed by such exploration. LESSEE shall begin as early as practicable in accordance with its needs the mining of said property with the purpose and object of producing manganese therefrom, and shall continuously thereafter mine and remove from the property all ores commercially profitable for such purpose, and shall commercially process, clean, condition and concentrate all marketable products and by-products derived from such mining operations, all such commercially recovered materials, products and by-products produced and saved from said mining and processing being known herein as "products."

(5) LESSEE shall be obligated to process, clean, condition and concentrate all marketable products and by-products derived from mining operations on the mining properties and shall deliver over to LESSOR, his nominees and assigns, one-fourth (1/4) of all of the commercially recovered materials, products and by-products produced and saved from said mining and processing operations, as reserved royalty, free of all costs and expenses, and such deliveries shall be made in kind if LESSOR

so elects; if such election be not made, from time to time, with at least thirty (30) days notice in writing thereof, then LESSEE shall pay to LESSOR a sum in cash equal to the then established market value of such products. Delivery to LESSOR, his nominees or assigns of the said reserved royalty shall be made on or before the 20th day of each calendar month immediately following that month in which the same shall have been reduced to proper and acceptable commercial form, and shipped from the conditioning plant of LESSEE.

(6) LESSEE shall keep full and accurate records and books of account, showing the quantity of all ores mined and of all products derived therefrom, together with the market value of the latter, the amounts thereof shipped, the amounts thereof sold, and the sales volume thereof in money; and all such records and books shall be open to inspection by LESSOR and his agents at all reasonable business hours. Not later than the 20th day of each calendar month, LESSEE shall make reports in writing to LESSOR stating the quantity of ore mined, the quantity of ore processed, and the quantity, character and market value of all products derived therefrom and shipped during the calendar month immediately preceding the making of such report.

(7) LESSEE shall work and mine the leased property in the most effective, workmanlike and proper manner, according to the most approved and suitable methods and practices of modern mining and especially of modern strip mining, and in such manner as to ultimately recover the greatest amount of merchantable products reasonably recoverable from said property during the term of this lease; and during such term LESSEE shall allow to LESSOR full access to said property and to all mining operations thereon and also to all mills, plants and conditioning establishments processing ore from the leased property and operated by LESSEE or for its benefit wherever situated.

(8) LESSEE shall be privileged to build, erect, operate, remove, transport and employ any buildings, structures, bridges, dams, roads, machinery and equipment at any locations on the leased property as may be considered desirable, necessary or expedient thereby; and LESSEE may take from such property all materials and waters necessary in mining and processing ores removed therefrom.

(9) As part of the consideration for this lease and for the benefit of the LESSOR, LESSEE shall timely, fully and properly do all assessment work necessary and requisite by law and custom to adequately maintain in full force and effect all mining claims included in the leased property, and shall make and timely file full and complete statements and evidences of the assessment work done.

(10) At the option and election of LESSOR, this lease may be cancelled in the event that LESSEE is placed in receivership, or a petition in bankruptcy is filed against LESSEE, whether voluntary or involuntary, or if LESSEE makes a composition with creditors.

(11) This lease shall not be assigned by LESSEE unless permission for such assignment be given by LESSOR in writing; and LESSEE shall make no sub-lease or sub-leases concerning the mining property unless and until approval therefor has been given by LESSOR in writing.

(12) This lease shall inure to the benefit of and be binding upon the parties hereto and upon their respective heirs, assigns and successors.

WITNESS THE HANDS OF THE PARTIES on the 8th day of June, 1952.

Cecil B. Chenoweth

Cecil B. Chenoweth, Agent LESSOR

INLAND MINING CORPORATION

By Cecil B. Chenoweth LESSEE

ATTEST:

Secretary

EXHIBIT "A"

Mining Claim #1 of the New Find Group located by Wendell L. Neil and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

Mining Claim #2 of the New Find Group located by I. R. Whisenhunt and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessor in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 8th day of June, 1952.

Elaine E. Hecker
Notary Public

My commission expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this 8th day of June, 1952, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named Cecil B. Chenoweth, being the 1st. Vice President of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the 1st. Vice President of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this 8th day of June, 1952.

Elaine E. Hecker
Notary Public

My commission expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 195___, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named _____, being the _____ of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the _____ of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this _____ day of _____, 195____.

_____
Notary Public

Form 2299X-10921

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This agreement made and entered into this 22 day of May, 1952, by and between Cecil B. Chenoweth, Agent (hereinafter called LESSEE) and

J. Dean Scott
R. Whisenhunt
W. L. Neil

(hereinafter called LESSOR(S)),

W I T N E S S E T H:

(1) That for and in consideration of the sum of One ($1.00) Dollar, receipt of which is hereby acknowledged, the mutual agreements hereinafter recited, and in further consideration of the royalties herein to be paid by the LESSEE, the LESSOR(S) Hereby let(s) and demise(s) unto the LESSEE the right to mine for manganese or other metallic ores (together with all other materials necessarily removed in said mining) the unpatented lode mining claims situated in the County of Polk, State of Arkansas, together with all appurtenances thereunto belonging, described on the instrument attached hereto designated as Exhibit "A" and made a part hereof and incorporated herein. To have and to hold unto the said LESSEE, his heirs and assigns for a term of five (5) years from the date hereof and as long thereafter as manganese ore is produced or mined from said claims by LESSEE, his heirs or assigns.

(2) LESSEE hereby agrees that during the term of this lease, he will do assessment work on the above described claim in compliance with statutory requirements for the benefit of the LESSOR(S) of at least One Hundred ($100.00) Dollars annually on or before June 30 of each year. The first assessment work under this lease shall be done on or before June 30, 1953. LESSEE further agrees to execute and file with the Circuit Clerk of the County in which the claim lies affidavits of assessment work done on the said mining claim for the benefit of the LESSOR(S). LESSEE may enter upon the said mining claims for exploratory and mining purposes and may take whatever steps he deems necessary in accordance with good mining practice to explore or mine said claim.

(3) In addition to doing the above mentioned assessment work, LESSEE agrees to pay to LESSOR(S) the sum of seven (7¢) cents per ton as royalty on all raw manganese ore removed from the said claims within sixty (60) days after said ore is removed; provided that it is hereby understood and agreed that as long as the aforementioned assessment work is done by the LESSEE that this lease shall remain in full force and effect and that LESSEE is under no obligation to mine the claim or to remove and sell the ore thereon.

(4) LESSEE agrees to furnish upon written request of LESSOR(S) records and accounts of the mining or exploratory activity on the said claims to the LESSOR(S).

(5) This lease may be terminated by the LESSEE at any time during the term thereof by giving notice of such termination to the LESSOR(S) at least sixty (60) days prior to the final date for doing the required assessment work for the mining year in which the lease is terminated. The words "mining year" as used in this paragraph shall be construed as commencing on July 1 and ending on June 30 and does not mean a calendar year.

(6) LESSOR(S) hereby agree(s) that the said LESSEE may assign this lease or sub-lease the mining claims under such terms as he sees fit; provided that the provisions of Paragraph (2) hereof shall be carried out by the said assignee or sub-lessee and provided further that if manganese ore is removed from the said mining claims that said

assignee or sub-lessee shall assume the obligation to pay and shall pay the seven (7¢) cents per ton royalty provided for in Paragraph (3) hereof.

(7) This agreement shall be binding upon the heirs, executors, administrators, successors and assigns of all parties hereto.

IN WITNESS WHEREOF the parties hereto have executed this agreement on this 22nd day of May, 1952.

Cecil B. Chenoweth

Cecil B. Chenoweth, Agent, LESSEE

J. Dow Scott

I R Whisenhunt

W L Neil

LESSORS

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, J. Dow Scott, I. R. Whisenhunt and Wendell L. Neil, to me well known to be the person(s) whose name(s) appear as Lessor(s) in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 22nd. day of May, 1952.

Clarice E. Decker

Notary Public

My Commission Expires July 28, 1955

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessee in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 22nd day of May, 1952.

Clarice E. Decker

Notary Public

My Commission Expires July 28, 1955

SUBORDINATION AGREEMENT AND CONSENT TO LIEN

KNOW ALL MEN BY THESE PRESENTS that:

WHEREAS, the "Undersigned" (as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller) have an interest in certain mining property in the State of Arkansas, County of Polk, hereinafter called "Property", said property being unpatented lode mining claims located on lands in the public domain; and the interest of the undersigned in said property includes the right to receive rentals and/or royalties on products mined and/or extracted therefrom; and the said property is the subject of a proposed Exploration Project Contract, hereinafter called "Contract", between the United States of America, hereinafter called the "Government", and Inland Mining Corporation, hereinafter called the "Operator"; and

WHEREAS, under certain provisions of said Contract which are set forth on the reverse side hereof, the Government will acquire certain rights and equities which do or may conflict with or be adverse to the interest of the undersigned in said property;

NOW THEREFORE, the undersigned, in consideration of said Contract and as an inducement to the Government and Operator to enter into same, undertakes and agrees as follows:

1. The Government's equity in and right to remove facilities, buildings, fixtures, and equipment, as provided in the Contract, shall prevail over and be prior and superior to any conflicting or adverse rights of the undersigned.

2. The Government's percentage royalty on net smelter returns or other net proceeds realized from ore, concentrates, or metal produced within ten (10) years from the date of the Contract, and the Government's lien for the payment of said percentage royalty shall attach to the mineral deposit and the production therefrom, in the amount of the Government's contribution, not in excess of $75,000.00, all upon the terms and conditions set forth in said Contract.

3. The undersigned shall commit no act nor assert any claim that may contravene or conflict with the lien, claim, or rights of the Government under the provisions of the said Contract. This agreement shall be binding upon the heirs, executors, administrators, successors, and assigns of the undersigned.

DATED this 22nd day of May, 1952; and
EXECUTED by the "Undersigned" as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller, thus:

J. Dew Scott
J. R. Whisenhunt
W. L. Neil

Cecil B. Pokenowith

INLAND MINING CORPORATION

By Cecil B. Pokenowith
1st. Vice President

No. 2299X-A-10919

RELEVANT CONTRACT PROVISIONS

Title to and disposition of property. All facilities, buildings, fixtures, equipment, or other items costing more than $50 each, paid for or purchased with funds contributed jointly by the Operator and the Government, shall belong to the Operator and the Government jointly, in proportion to their respective contributions, and upon the termination of the contract, if they have any salvage value, shall be disposed of for their joint account unless the Government, in writing, waives its interest in any such items. The Government may require the dismantling, severance from land, and removal of any such items in order to realize its interest in the salvage value thereof, and the cost of any such removal and of the disposal of the items shall be for the joint account of the parties in proportion to their respective interests.

Repayment by Operator. If, upon the completion of the exploration project or termination of the contract, the Government considers that a discovery or development has resulted from the work from which commercial production of ore may be made, the Government, within 6 months thereafter, shall so certify to the Operator, particularly describing and delimiting its estimate of the discovery or the development. Thereafter, if and as ore is produced as a result of such discovery or development, the Operator and his successor in interest shall be and become obligated to pay to the Government a percentage royalty on the net smelter returns or other net proceeds realized from such ore, concentrates, or metal produced within ten (10) years from the date of this contract, until the total amount contributed by the Government, without interest, is fully repaid or said 10 years have elapsed, whichever occurs first, as follows:

> Of net smelter returns or other net proceeds not in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent.
>
> Of net smelter returns or other net proceeds in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent, plus one-half ($\frac{1}{2}$) percent for each additional full fifty cents ($0.50) in excess of eight dollars ($8.00) per ton of ore, but not in excess of a maximum of five (5) percent.

This obligation to repay from net returns or proceeds shall be and remain a claim and lien upon the mineral deposit which is the subject of the exploration project and upon any production resulting from such discovery or development, in favor of the Government, until fully paid, or until said 10-year period has elapsed; and this claim and lien and the Government's right to repayment shall survive any termination of the contract, whether by completion of the exploration project or otherwise. This article is not to be construed as imposing any obligation on the Operator or his successor in interest to produce ore from any such discovery or development.

EXHIBIT "A"

Mining Claim #1 of the New Find Group located by Wendell L. Neil and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

Mining Claim #2 of the New Find Group located by I. R. Whisenhunt and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

Form 2299X-10922

NEW FIND GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This contract and lease made by and between Cecil B. Chenoweth, Agent, hereinafter called LESSOR, and Inland Mining Corporation, a corporation duly chartered under the laws of the State of Delaware, hereinafter called LESSEE,

W I T N E S S E T H:

WHEREAS, said LESSOR owns, controls, claims or holds under lease those certain mining claims situated in Polk County, Arkansas, described in the attached Exhibit "A", said exhibit being made a part hereof, and all of which claims are hereinafter known as "mining property"; and said LESSEE desires to obtain leasehold rights in said property;

NOW THEREFORE, in consideration of the sum of One ($1.00) Dollar, in hand paid by LESSEE to LESSOR, the receipt of which is hereby acknowledged, and the hereinafter recited reservations of interest in the property, and other good and sufficient consideration, including the mutual covenants and agreements herein contained, the LESSOR has leased, let and demised, and by these presents does lease, let and demise unto the said LESSEE the exclusive right to mine and operate solely for manganese and other metallic ores (together with all other materials necessarily removed in such mining), all of the mining property and claims described in said Exhibit "A", subject to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest and further subject to the reservations, conditions, terms, restrictions and agreements hereinafter set forth, to-wit:

(1) Subject to the other provisions hereof, the term of this lease shall be for five (5) years from the date hereof, and as long thereafter as manganese is produced or mined from said land by the LESSEE, its successors or assigns.

(2) LESSOR reserves unto himself absolutely all minerals other than metallic minerals lying on, in and under said mining property.

(3) LESSOR reserves unto himself and his respective heirs and assigns, as royalty, one-fourth (1/4) of all manganese and of all other metals, intending that such reservation shall cover and extend to all commercial materials produced, saved and made marketable from said mining property. Such royalty reservation in LESSOR is and shall be separate and apart and in addition to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest, and LESSEE assumes the obligations to pay and shall timely pay such original royalty or delay rentals of seven (7¢) cents per ton of raw manganese ore.

(4) LESSEE shall begin with reasonable promptness and continue thereafter with due diligence the exploration of said property in an orderly manner. LESSEE shall furnish reports to LESSOR, upon request, in appropriate written form, setting forth the information revealed by such exploration. LESSEE shall begin as early as practicable in accordance with its needs the mining of said property with the purpose and object of producing manganese therefrom, and shall continuously thereafter mine and remove from the property all ores commercially profitable for such purpose, and shall commercially process, clean, condition and concentrate all marketable products and by-products derived from such mining operations, all such commercially recovered materials, products and by-products produced and saved from said mining and processing being known herein as "products."

(5) LESSEE shall be obligated to process, clean, condition and concentrate all marketable products and by-products derived from mining operations on the mining properties and shall deliver over to LESSOR, his nominees and assigns, one-fourth (1/4) of all of the commercially recovered materials, products and by-products produced and saved from said mining and processing operations, as reserved royalty, free of all costs and expenses, and such deliveries shall be made in kind if LESSOR

so elects; if such election be not made, from time to time, with at least thirty (30) days notice in writing thereof, then LESSEE shall pay to LESSOR a sum in cash equal to the then established market value of such products. Delivery to LESSOR, his nominees or assigns of the said reserved royalty shall be made on or before the 20th day of each calendar month immediately following that month in which the same shall have been reduced to proper and acceptable commercial form, and shipped from the conditioning plant of LESSEE.

(6) LESSEE shall keep full and accurate records and books of account, showing the quantity of all ores mined and of all products derived therefrom, together with the market value of the latter, the amounts thereof shipped, the amounts thereof sold, and the sales volume thereof in money; and all such records and books shall be open to inspection by LESSOR and his agents at all reasonable business hours. Not later than the 20th day of each calendar month, LESSEE shall make reports in writing to LESSOR stating the quantity of ore mined, the quantity of ore processed, and the quantity, character and market value of all products derived therefrom and shipped during the calendar month immediately preceding the making of such report.

(7) LESSEE shall work and mine the leased property in the most effective, workmanlike and proper manner, according to the most approved and suitable methods and practices of modern mining and especially of modern strip mining, and in such manner as to ultimately recover the greatest amount of merchantable products reasonably recoverable from said property during the term of this lease; and during such term LESSEE shall allow to LESSOR full access to said property and to all mining operations thereon and also to all mills, plants and conditioning establishments processing ore from the leased property and operated by LESSEE or for its benefit wherever situated.

(8) LESSEE shall be privileged to build, erect, operate, remove, transport and employ any buildings, structures, bridges, dams, roads, machinery and equipment at any locations on the leased property as may be considered desirable, necessary or expedient thereby; and LESSEE may take from such property all materials and waters necessary in mining and processing ores removed therefrom.

(9) As part of the consideration for this lease and for the benefit of the LESSOR, LESSEE shall timely, fully and properly do all assessment work necessary and requisite by law and custom to adequately maintain in full force and effect all mining claims included in the leased property, and shall make and timely file full and complete statements and evidences of the assessment work done.

(10) At the option and election of LESSOR, this lease may be cancelled in the event that LESSEE is placed in receivership, or a petition in bankruptcy is filed against LESSEE, whether voluntary or involuntary, or if LESSEE makes a composition with creditors.

(11) This lease shall not be assigned by LESSEE unless permission for such assignment be given by LESSOR in writing; and LESSEE shall make no sub-lease or sub-leases concerning the mining property unless and until approval therefor has been given by LESSOR in writing.

(12) This lease shall inure to the benefit of and be binding upon the parties hereto and upon their respective heirs, assigns and successors.

WITNESS THE HANDS OF THE PARTIES on the 8th day of June, 1952.

Cecil B. Chenoweth

Cecil B. Chenoweth, Agent LESSOR

INLAND MINING CORPORATION

By Cecil B. Chenoweth

LESSEE

ATTEST:

Secretary

EXHIBIT "A"

Mining Claim #1 of the New Find Group located by Wendell L. Neil and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

Mining Claim #2 of the New Find Group located by I. R. Whisenhunt and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessor in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 8th day of June, 1952.

Clarice E. Decker
Notary Public

My commission expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this 8th day of June, 1952, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named Cecil B. Chenoweth, being the 1st. Vice President of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the 1st. Vice President of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this 8th day of June, 1952.

Clarice E. Decker
Notary Public

My commission expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 195___, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named _____, being the _____ of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the _____ of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this _____ day of _____, 195____.

_____
Notary Public

Form 2299X-10921

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This agreement made and entered into this 22nd day of May, 1952, by and between Cecil B. Chenoweth, Agent (hereinafter called LESSEE) and

J Don Scott
B R Whisenhunt
W L Neil

(hereinafter called LESSOR(S)),

W I T N E S S E T H:

(1) That for and in consideration of the sum of One ($1.00) Dollar, receipt of which is hereby acknowledged, the mutual agreements hereinafter recited, and in further consideration of the royalties herein to be paid by the LESSEE, the LESSOR(S) Hereby let(s) and demise(s) unto the LESSEE the right to mine for manganese or other metallic ores (together with all other materials necessarily removed in said mining) the unpatented lode mining claims situated in the County of Polk, State of Arkansas, together with all appurtenances thereunto belonging, described on the instrument attached hereto designated as Exhibit "A" and made a part hereof and incorporated herein. To have and to hold unto the said LESSEE, his heirs and assigns for a term of five (5) years from the date hereof and as long thereafter as manganese ore is produced or mined from said claims by LESSEE, his heirs or assigns.

(2) LESSEE hereby agrees that during the term of this lease, he will do assessment work on the above described claim in compliance with statutory requirements for the benefit of the LESSOR(S) of at least One Hundred ($100.00) Dollars annually on or before June 30 of each year. The first assessment work under this lease shall be done on or before June 30, 1953. LESSEE further agrees to execute and file with the Circuit Clerk of the County in which the claim lies affidavits of assessment work done on the said mining claim for the benefit of the LESSOR(S). LESSEE may enter upon the said mining claims for exploratory and mining purposes and may take whatever steps he deems necessary in accordance with good mining practice to explore or mine said claim.

(3) In addition to doing the above mentioned assessment work, LESSEE agrees to pay to LESSOR(S) the sum of seven (7¢) cents per ton as royalty on all raw manganese ore removed from the said claims within sixty (60) days after said ore is removed; provided that it is hereby understood and agreed that as long as the aforementioned assessment work is done by the LESSEE that this lease shall remain in full force and effect and that LESSEE is under no obligation to mine the claim or to remove and sell the ore thereon.

(4) LESSEE agrees to furnish upon written request of LESSOR(S) records and accounts of the mining or exploratory activity on the said claims to the LESSOR(S).

(5) This lease may be terminated by the LESSEE at any time during the term thereof by giving notice of such termination to the LESSOR(S) at least sixty (60) days prior to the final date for doing the required assessment work for the mining year in which the lease is terminated. The words "mining year" as used in this paragraph shall be construed as commencing on July 1 and ending on June 30 and does not mean a calendar year.

(6) LESSOR(S) hereby agree(s) that the said LESSEE may assign this lease or sub-lease the mining claims under such terms as he sees fit; provided that the provisions of Paragraph (2) hereof shall be carried out by the said assignee or sub-lessee and provided further that if manganese ore is removed from the said mining claims that said

assignee or sub-lessee shall assume the obligation to pay and shall pay the seven (7¢) cents per ton royalty provided for in Paragraph (3) hereof.

(7) This agreement shall be binding upon the heirs, executors, administrators, successors and assigns of all parties hereto.

IN WITNESS WHEREOF the parties hereto have executed this agreement on this 22nd day of May, 1952.

Cecil B. Chenoweth

Cecil B. Chenoweth, Agent, LESSEE

J. Dow Scott

I. R. Whisenhunt

W. L. Neil

LESSORS

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, J. Dow Scott, I. R. Whisenhunt and Wendell L. Neil, to me well known to be the person(s) whose name(s) appear as Lessor(s) in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 22nd. day of May, 1952.

Clarice E. Decker

Notary Public

My Commission Expires July 28, 1955

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessee in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 22nd day of May, 1952.

Clarice E. Decker

Notary Public

My Commission Expires July 28, 1955

SUBORDINATION AGREEMENT AND CONSENT TO LIEN

KNOW ALL MEN BY THESE PRESENTS that:

WHEREAS, the "Undersigned" (as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller) have an interest in certain mining property in the State of Arkansas, County of Polk, hereinafter called "Property", said property being unpatented lode mining claims located on lands in the public domain; and the interest of the undersigned in said property includes the right to receive rentals and/or royalties on products mined and/or extracted therefrom; and the said property is the subject of a proposed Exploration Project Contract, hereinafter called "Contract", between the United States of America, hereinafter called the "Government", and Inland Mining Corporation, hereinafter called the "Operator"; and

WHEREAS, under certain provisions of said Contract which are set forth on the reverse side hereof, the Government will acquire certain rights and equities which do or may conflict with or be adverse to the interest of the undersigned in said property;

NOW THEREFORE, the undersigned, in consideration of said Contract and as an inducement to the Government and Operator to enter into same, undertakes and agrees as follows:

1. The Government's equity in and right to remove facilities, buildings, fixtures, and equipment, as provided in the Contract, shall prevail over and be prior and superior to any conflicting or adverse rights of the undersigned.

2. The Government's percentage royalty on net smelter returns or other net proceeds realized from ore, concentrates, or metal produced within ten (10) years from the date of the Contract, and the Government's lien for the payment of said percentage royalty shall attach to the mineral deposit and the production therefrom, in the amount of the Government's contribution, not in excess of $75,000.00, all upon the terms and conditions set forth in said Contract.

3. The undersigned shall commit no act nor assert any claim that may contravene or conflict with the lien, claim, or rights of the Government under the provisions of the said Contract. This agreement shall be binding upon the heirs, executors, administrators, successors, and assigns of the undersigned.

DATED this 22nd day of May, 1952; and
EXECUTED by the "Undersigned" as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller, thus:

J. Dave Scott
J. R. Wasinhurst
W. L. Neil

Cecil B. Pohenwith

INLAND MINING CORPORATION

By Cecil B. Pohenwith
1st. Vice President

No. 2299X-A-10919

RELEVANT CONTRACT PROVISIONS

Title to and disposition of property. All facilities, buildings, fixtures, equipment, or other items costing more than $50 each, paid for or purchased with funds contributed jointly by the Operator and the Government, shall belong to the Operator and the Government jointly, in proportion to their respective contributions, and upon the termination of the contract, if they have any salvage value, shall be disposed of for their joint account unless the Government, in writing, waives its interest in any such items. The Government may require the dismantling, severance from land, and removal of any such items in order to realize its interest in the salvage value thereof, and the cost of any such removal and of the disposal of the items shall be for the joint account of the parties in proportion to their respective interests.

Repayment by Operator. If, upon the completion of the exploration project or termination of the contract, the Government considers that a discovery or development has resulted from the work from which commercial production of ore may be made, the Government, within 6 months thereafter, shall so certify to the Operator, particularly describing and delimiting its estimate of the discovery or the development. Thereafter, if and as ore is produced as a result of such discovery or development, the Operator and his successor in interest shall be and become obligated to pay to the Government a percentage royalty on the net smelter returns or other net proceeds realized from such ore, concentrates, or metal produced within ten (10) years from the date of this contract, until the total amount contributed by the Government, without interest, is fully repaid or said 10 years have elapsed, whichever occurs first, as follows:

> Of net smelter returns or other net proceeds not in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent.
>
> Of net smelter returns or other net proceeds in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent, plus one-half ($\frac{1}{2}$) percent for each additional full fifty cents ($0.50) in excess of eight dollars ($8.00) per ton of ore, but not in excess of a maximum of five (5) percent.

This obligation to repay from net returns or proceeds shall be and remain a claim and lien upon the mineral deposit which is the subject of the exploration project and upon any production resulting from such discovery or development, in favor of the Government, until fully paid, or until said 10-year period has elapsed; and this claim and lien and the Government's right to repayment shall survive any termination of the contract, whether by completion of the exploration project or otherwise. This article is not to be construed as imposing any obligation on the Operator or his successor in interest to produce ore from any such discovery or development.

EXHIBIT "A"

Mining Claim #1 of the New Find Group located by Wendell L. Neil and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

Mining Claim #2 of the New Find Group located by I. R. Whisenhunt and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

Form 2299X-10922

NEW FIND GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This contract and lease made by and between Cecil B. Chenoweth, Agent, hereinafter called LESSOR, and Inland Mining Corporation, a corporation duly chartered under the laws of the State of Delaware, hereinafter called LESSEE,

W I T N E S S E T H:

WHEREAS, said LESSOR owns, controls, claims or holds under lease those certain mining claims situated in Polk County, Arkansas, described in the attached Exhibit "A", said exhibit being made a part hereof, and all of which claims are hereinafter known as "mining property"; and said LESSEE desires to obtain leasehold rights in said property;

NOW THEREFORE, in consideration of the sum of One ($1.00) Dollar, in hand paid by LESSEE to LESSOR, the receipt of which is hereby acknowledged, and the hereinafter recited reservations of interest in the property, and other good and sufficient consideration, including the mutual covenants and agreements herein contained, the LESSOR has leased, let and demised, and by these presents does lease, let and demise unto the said LESSEE the exclusive right to mine and operate solely for manganese and other metallic ores (together with all other materials necessarily removed in such mining), all of the mining property and claims described in said Exhibit "A", subject to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest and further subject to the reservations, conditions, terms, restrictions and agreements hereinafter set forth, to-wit:

(1) Subject to the other provisions hereof, the term of this lease shall be for five (5) years from the date hereof, and as long thereafter as manganese is produced or mined from said land by the LESSEE, its successors or assigns.

(2) LESSOR reserves unto himself absolutely all minerals other than metallic minerals lying on, in and under said mining property.

(3) LESSOR reserves unto himself and his respective heirs and assigns, as royalty, one-fourth (1/4) of all manganese and of all other metals, intending that such reservation shall cover and extend to all commercial materials produced, saved and made marketable from said mining property. Such royalty reservation in LESSOR is and shall be separate and apart and in addition to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest, and LESSEE assumes the obligations to pay and shall timely pay such original royalty or delay rentals of seven (7¢) cents per ton of raw manganese ore.

(4) LESSEE shall begin with reasonable promptness and continue thereafter with due diligence the exploration of said property in an orderly manner. LESSEE shall furnish reports to LESSOR, upon request, in appropriate written form, setting forth the information revealed by such exploration. LESSEE shall begin as early as practicable in accordance with its needs the mining of said property with the purpose and object of producing manganese therefrom, and shall continuously thereafter mine and remove from the property all ores commercially profitable for such purpose, and shall commercially process, clean, condition and concentrate all marketable products and by-products derived from such mining operations, all such commercially recovered materials, products and by-products produced and saved from said mining and processing being known herein as "products."

(5) LESSEE shall be obligated to process, clean, condition and concentrate all marketable products and by-products derived from mining operations on the mining properties and shall deliver over to LESSOR, his nominees and assigns, one-fourth (1/4) of all of the commercially recovered materials, products and by-products produced and saved from said mining and processing operations, as reserved royalty, free of all costs and expenses, and such deliveries shall be made in kind if LESSOR

so elects; if such election be not made, from time to time, with at least thirty (30) days notice in writing thereof, then LESSEE shall pay to LESSOR a sum in cash equal to the then established market value of such products. Delivery to LESSOR, his nominees or assigns of the said reserved royalty shall be made on or before the 20th day of each calendar month immediately following that month in which the same shall have been reduced to proper and acceptable commercial form, and shipped from the conditioning plant of LESSEE.

(6) LESSEE shall keep full and accurate records and books of account, showing the quantity of all ores mined and of all products derived therefrom, together with the market value of the latter, the amounts thereof shipped, the amounts thereof sold, and the sales volume thereof in money; and all such records and books shall be open to inspection by LESSOR and his agents at all reasonable business hours. Not later than the 20th day of each calendar month, LESSEE shall make reports in writing to LESSOR stating the quantity of ore mined, the quantity of ore processed, and the quantity, character and market value of all products derived therefrom and shipped during the calendar month immediately preceding the making of such report.

(7) LESSEE shall work and mine the leased property in the most effective, workmanlike and proper manner, according to the most approved and suitable methods and practices of modern mining and especially of modern strip mining, and in such manner as to ultimately recover the greatest amount of merchantable products reasonably recoverable from said property during the term of this lease; and during such term LESSEE shall allow to LESSOR full access to said property and to all mining operations thereon and also to all mills, plants and conditioning establishments processing ore from the leased property and operated by LESSEE or for its benefit wherever situated.

(8) LESSEE shall be privileged to build, erect, operate, remove, transport and employ any buildings, structures, bridges, dams, roads, machinery and equipment at any locations on the leased property as may be considered desirable, necessary or expedient thereby; and LESSEE may take from such property all materials and waters necessary in mining and processing ores removed therefrom.

(9) As part of the consideration for this lease and for the benefit of the LESSOR, LESSEE shall timely, fully and properly do all assessment work necessary and requisite by law and custom to adequately maintain in full force and effect all mining claims included in the leased property, and shall make and timely file full and complete statements and evidences of the assessment work done.

(10) At the option and election of LESSOR, this lease may be cancelled in the event that LESSEE is placed in receivership, or a petition in bankruptcy is filed against LESSEE, whether voluntary or involuntary, or if LESSEE makes a composition with creditors.

(11) This lease shall not be assigned by LESSEE unless permission for such assignment be given by LESSOR in writing; and LESSEE shall make no sub-lease or sub-leases concerning the mining property unless and until approval therefor has been given by LESSOR in writing.

(12) This lease shall inure to the benefit of and be binding upon the parties hereto and upon their respective heirs, assigns and successors.

WITNESS THE HANDS OF THE PARTIES on the 8th day of June, 1952.

Cecil B. Chenoweth

Cecil B. Chenoweth, Agent LESSOR

INLAND MINING CORPORATION

By Cecil B. Chenoweth LESSEE

ATTEST:

Secretary

EXHIBIT "A"

Mining Claim #1 of the New Find Group located by Wendell L. Neil and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

Mining Claim #2 of the New Find Group located by I. R. Whisenhunt and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessor in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 8th day of June, 1952.

Elaine E. Decker
Notary Public

My commission expires July 28 1955.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this 8th day of June, 1952, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named Cecil B. Chenoweth, being the 1st. Vice President of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the 1st. Vice President of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this 8th day of June, 1952.

Elaine E. Decker
Notary Public

My comm. expires July 28, 1955

ACKNOWLEDGMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 195___, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named _____, being the _____ of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the _____ of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this _____ day of _____, 195____.

_____
Notary Public

Form 2299X-10921

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This agreement made and entered into this 22nd day of May, 195 2, by and between Cecil B. Chenoweth, Agent (hereinafter called LESSEE) and

J. Dean Scott _____ _____

S B Weinkauff _____ _____

W L Neil _____ _____

(hereinafter called LESSOR(S)),

W I T N E S S E T H:

(1) That for and in consideration of the sum of One ($1.00) Dollar, receipt of which is hereby acknowledged, the mutual agreements hereinafter recited, and in further consideration of the royalties herein to be paid by the LESSEE, the LESSOR(S) Hereby let(s) and demise(s) unto the LESSEE the right to mine for manganese or other metallic ores (together with all other materials necessarily removed in said mining) the unpatented lode mining claims situated in the County of Polk, State of Arkansas, together with all appurtenances thereunto belonging, described on the instrument attached hereto designated as Exhibit "A" and made a part hereof and incorporated herein. To have and to hold unto the said LESSEE, his heirs and assigns for a term of five (5) years from the date hereof and as long thereafter as manganese ore is produced or mined from said claims by LESSEE, his heirs or assigns.

(2) LESSEE hereby agrees that during the term of this lease, he will do assessment work on the above described claim in compliance with statutory requirements for the benefit of the LESSOR(S) of at least One Hundred ($100.00) Dollars annually on or before June 30 of each year. The first assessment work under this lease shall be done on or before June 30, 195 2. LESSEE further agrees to execute and file with the Circuit Clerk of the County in which the claim lies affidavits of assessment work done on the said mining claim for the benefit of the LESSOR(S). LESSEE may enter upon the said mining claims for exploratory and mining purposes and may take whatever steps he deems necessary in accordance with good mining practice to explore or mine said claim.

(3) In addition to doing the above mentioned assessment work, LESSEE agrees to pay to LESSOR(S) the sum of seven (7¢) cents per ton as royalty on all raw manganese ore removed from the said claims within sixty (60) days after said ore is removed; provided that it is hereby understood and agreed that as long as the aforementioned assessment work is done by the LESSEE that this lease shall remain in full force and effect and that LESSEE is under no obligation to mine the claim or to remove and sell the ore thereon.

(4) LESSEE agrees to furnish upon written request of LESSOR(S) records and accounts of the mining or exploratory activity on the said claims to the LESSOR(S).

(5) This lease may be terminated by the LESSEE at any time during the term thereof by giving notice of such termination to the LESSOR(S) at least sixty (60) days prior to the final date for doing the required assessment work for the mining year in which the lease is terminated. The words "mining year" as used in this paragraph shall be construed as commencing on July 1 and ending on June 30 and does not mean a calendar year.

(6) LESSOR(S) hereby agree(s) that the said LESSEE may assign this lease or sub-lease the mining claims under such terms as he sees fit; provided that the provisions of Paragraph (2) hereof shall be carried out by the said assignee or sub-lessee and provided further that if manganese ore is removed from the said mining claims that said

assignee or sub-lessee shall assume the obligation to pay and shall pay the seven (7¢) cents per ton royalty provided for in Paragraph (3) hereof.

(7) This agreement shall be binding upon the heirs, executors, administrators, successors and assigns of all parties hereto.

IN WITNESS WHEREOF the parties hereto have executed this agreement on this 22nd day of May, 1952.

Cecil B. Chenoweth

Cecil B. Chenoweth, Agent, LESSEE

J. Dow Scott

I R Whisenhunt

W L Neil

LESSORS

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, J. Dow Scott, I. R. Whisenhunt and Wendell L. Neil, to me well known to be the person(s) whose name(s) appear as Lessor(s) in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 22nd day of May, 1952.

Clarice E. Hicker

Notary Public

My Commission Expires July 28, 1955

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessee in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 22nd day of May, 1952.

Clarice E. Hicker

Notary Public

My Commission Expires July 28, 1955

SUBORDINATION AGREEMENT AND CONSENT TO LIEN

KNOW ALL MEN BY THESE PRESENTS that:

WHEREAS, the "Undersigned" (as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller) have an interest in certain mining property in the State of Arkansas, County of Polk, hereinafter called "Property", said property being unpatented lode mining claims located on lands in the public domain; and the interest of the undersigned in said property includes the right to receive rentals and/or royalties on products mined and/or extracted therefrom; and the said property is the subject of a proposed Exploration Project Contract, hereinafter called "Contract", between the United States of America, hereinafter called the "Government", and Inland Mining Corporation, hereinafter called the "Operator"; and

WHEREAS, under certain provisions of said Contract which are set forth on the reverse side hereof, the Government will acquire certain rights and equities which do or may conflict with or be adverse to the interest of the undersigned in said property;

NOW THEREFORE, the undersigned, in consideration of said Contract and as an inducement to the Government and Operator to enter into same, undertakes and agrees as follows:

1. The Government's equity in and right to remove facilities, buildings, fixtures, and equipment, as provided in the Contract, shall prevail over and be prior and superior to any conflicting or adverse rights of the undersigned.

2. The Government's percentage royalty on net smelter returns or other net proceeds realized from ore, concentrates, or metal produced within ten (10) years from the date of the Contract, and the Government's lien for the payment of said percentage royalty shall attach to the mineral deposit and the production therefrom, in the amount of the Government's contribution, not in excess of $75,000.00, all upon the terms and conditions set forth in said Contract.

3. The undersigned shall commit no act nor assert any claim that may contravene or conflict with the lien, claim, or rights of the Government under the provisions of the said Contract. This agreement shall be binding upon the heirs, executors, administrators, successors, and assigns of the undersigned.

DATED this 22nd day of May, 1952; and
EXECUTED by the "Undersigned" as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller, thus;

J. Don Scott
T R Whisenhunt
W L Neil

Cecil B. Pehnowith

INLAND MINING CORPORATION

By Cecil B. Pehnowith
Pres. Vice President

No. 2299X-A-10919

RELEVANT CONTRACT PROVISIONS

Title to and disposition of property. All facilities, buildings, fixtures, equipment, or other items costing more than $50 each, paid for or purchased with funds contributed jointly by the Operator and the Government, shall belong to the Operator and the Government jointly, in proportion to their respective contributions, and upon the termination of the contract, if they have any salvage value, shall be disposed of for their joint account unless the Government, in writing, waives its interest in any such items. The Government may require the dismantling, severance from land, and removal of any such items in order to realize its interest in the salvage value thereof, and the cost of any such removal and of the disposal of the items shall be for the joint account of the parties in proportion to their respective interests.

Repayment by Operator. If, upon the completion of the exploration project or termination of the contract, the Government considers that a discovery or development has resulted from the work from which commercial production of ore may be made, the Government, within 6 months thereafter, shall so certify to the Operator, particularly describing and delimiting its estimate of the discovery or the development. Thereafter, if and as ore is produced as a result of such discovery or development, the Operator and his successor in interest shall be and become obligated to pay to the Government a percentage royalty on the net smelter returns or other net proceeds realized from such ore, concentrates, or metal produced within ten (10) years from the date of this contract, until the total amount contributed by the Government, without interest, is fully repaid or said 10 years have elapsed, whichever occurs first, as follows:

> Of net smelter returns or other net proceeds not in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent.
>
> Of net smelter returns or other net proceeds in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent, plus one-half ($\frac{1}{2}$) percent for each additional full fifty cents ($0.50) in excess of eight dollars ($8.00) per ton of ore, but not in excess of a maximum of five (5) percent.

This obligation to repay from net returns or proceeds shall be and remain a claim and lien upon the mineral deposit which is the subject of the exploration project and upon any production resulting from such discovery or development, in favor of the Government, until fully paid, or until said 10-year period has elapsed; and this claim and lien and the Government's right to repayment shall survive any termination of the contract, whether by completion of the exploration project or otherwise. This article is not to be construed as imposing any obligation on the Operator or his successor in interest to produce ore from any such discovery or development.

EXHIBIT "A"

Mining Claim #1 of the New Find Group located by Wendell L. Neil and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

Mining Claim #2 of the New Find Group located by I. R. Whisenhunt and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

Form 2299X-10922

NEW FIND GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This contract and lease made by and between Cecil B. Chenoweth, Agent, hereinafter called LESSOR, and Inland Mining Corporation, a corporation duly chartered under the laws of the State of Delaware, hereinafter called LESSEE,

W I T N E S S E T H:

WHEREAS, said LESSOR owns, controls, claims or holds under lease those certain mining claims situated in Polk County, Arkansas, described in the attached Exhibit "A", said exhibit being made a part hereof, and all of which claims are hereinafter known as "mining property"; and said LESSEE desires to obtain leasehold rights in said property;

NOW THEREFORE, in consideration of the sum of One ($1.00) Dollar, in hand paid by LESSEE to LESSOR, the receipt of which is hereby acknowledged, and the hereinafter recited reservations of interest in the property, and other good and sufficient consideration, including the mutual covenants and agreements herein contained, the LESSOR has leased, let and demised, and by these presents does lease, let and demise unto the said LESSEE the exclusive right to mine and operate solely for manganese and other metallic ores (together with all other materials necessarily removed in such mining), all of the mining property and claims described in said Exhibit "A", subject to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest and further subject to the reservations, conditions, terms, restrictions and agreements hereinafter set forth, to-wit:

(1) Subject to the other provisions hereof, the term of this lease shall be for five (5) years from the date hereof, and as long thereafter as manganese is produced or mined from said land by the LESSEE, its successors or assigns.

(2) LESSOR reserves unto himself absolutely all minerals other than metallic minerals lying on, in and under said mining property.

(3) LESSOR reserves unto himself and his respective heirs and assigns, as royalty, one-fourth (1/4) of all manganese and of all other metals, intending that such reservation shall cover and extend to all commercial materials produced, saved and made marketable from said mining property. Such royalty reservation in LESSOR is and shall be separate and apart and in addition to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest, and LESSEE assumes the obligations to pay and shall timely pay such original royalty or delay rentals of seven (7¢) cents per ton of raw manganese ore.

(4) LESSEE shall begin with reasonable promptness and continue thereafter with due diligence the exploration of said property in an orderly manner. LESSEE shall furnish reports to LESSOR, upon request, in appropriate written form, setting forth the information revealed by such exploration. LESSEE shall begin as early as practicable in accordance with its needs the mining of said property with the purpose and object of producing manganese therefrom, and shall continuously thereafter mine and remove from the property all ores commercially profitable for such purpose, and shall commercially process, clean, condition and concentrate all marketable products and by-products derived from such mining operations, all such commercially recovered materials, products and by-products produced and saved from said mining and processing being known herein as "products."

(5) LESSEE shall be obligated to process, clean, condition and concentrate all marketable products and by-products derived from mining operations on the mining properties and shall deliver over to LESSOR, his nominees and assigns, one-fourth (1/4) of all of the commercially recovered materials, products and by-products produced and saved from said mining and processing operations, as reserved royalty, free of all costs and expenses, and such deliveries shall be made in kind if LESSOR

so elects; if such election be not made, from time to time, with at least thirty (30) days notice in writing thereof, then LESSEE shall pay to LESSOR a sum in cash equal to the then established market value of such products. Delivery to LESSOR, his nominees or assigns of the said reserved royalty shall be made on or before the 20th day of each calendar month immediately following that month in which the same shall have been reduced to proper and acceptable commercial form, and shipped from the conditioning plant of LESSEE.

(6) LESSEE shall keep full and accurate records and books of account, showing the quantity of all ores mined and of all products derived therefrom, together with the market value of the latter, the amounts thereof shipped, the amounts thereof sold, and the sales volume thereof in money; and all such records and books shall be open to inspection by LESSOR and his agents at all reasonable business hours. Not later than the 20th day of each calendar month, LESSEE shall make reports in writing to LESSOR stating the quantity of ore mined, the quantity of ore processed, and the quantity, character and market value of all products derived therefrom and shipped during the calendar month immediately preceding the making of such report.

(7) LESSEE shall work and mine the leased property in the most effective, workmanlike and proper manner, according to the most approved and suitable methods and practices of modern mining and especially of modern strip mining, and in such manner as to ultimately recover the greatest amount of merchantable products reasonably recoverable from said property during the term of this lease; and during such term LESSEE shall allow to LESSOR full access to said property and to all mining operations thereon and also to all mills, plants and conditioning establishments processing ore from the leased property and operated by LESSEE or for its benefit wherever situated.

(8) LESSEE shall be privileged to build, erect, operate, remove, transport and employ any buildings, structures, bridges, dams, roads, machinery and equipment at any locations on the leased property as may be considered desirable, necessary or expedient thereby; and LESSEE may take from such property all materials and waters necessary in mining and processing ores removed therefrom.

(9) As part of the consideration for this lease and for the benefit of the LESSOR, LESSEE shall timely, fully and properly do all assessment work necessary and requisite by law and custom to adequately maintain in full force and effect all mining claims included in the leased property, and shall make and timely file full and complete statements and evidences of the assessment work done.

(10) At the option and election of LESSOR, this lease may be cancelled in the event that LESSEE is placed in receivership, or a petition in bankruptcy is filed against LESSEE, whether voluntary or involuntary, or if LESSEE makes a composition with creditors.

(11) This lease shall not be assigned by LESSEE unless permission for such assignment be given by LESSOR in writing; and LESSEE shall make no sub-lease or sub-leases concerning the mining property unless and until approval therefor has been given by LESSOR in writing.

(12) This lease shall inure to the benefit of and be binding upon the parties hereto and upon their respective heirs, assigns and successors.

WITNESS THE HANDS OF THE PARTIES on the 8th day of June, 1952.

Cecil B. Chenoweth

Cecil B. Chenoweth, Agent LESSOR

INLAND MINING CORPORATION

By Cecil B. Chenoweth LESSEE

ATTEST:

Secretary

EXHIBIT "A"

Mining Claim #1 of the New Find Group located by Wendell L. Neil and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

Mining Claim #2 of the New Find Group located by I. R. Whisenhunt and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessor in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 8th day of June, 1952.

Clarice E. Dicker
Notary Public

My commission expires July 28 19 55.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this 8th day of June, 1952, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named Cecil B. Chenoweth, being the 1st. Vice President of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the 1st. Vice President of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this 8th day of June, 1952.

Clarice E. Dicker
Notary Public

My comm. expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 195___, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named _____, being the _____ of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the _____ of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this _____ day of _____, 195____.

_____
Notary Public

Form 2299X-10921

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This agreement made and entered into this 22nd day of May, 1952, by and between Cecil B. Chenoweth, Agent (hereinafter called LESSEE) and

J. Dave Scott
J. N. Whisenhunt
W. L. Neil

(hereinafter called LESSOR(S)),

W I T N E S S E T H:

(1) That for and in consideration of the sum of One ($1.00) Dollar, receipt of which is hereby acknowledged, the mutual agreements hereinafter recited, and in further consideration of the royalties herein to be paid by the LESSEE, the LESSOR(S) Hereby let(s) and demise(s) unto the LESSEE the right to mine for manganese or other metallic ores (together with all other materials necessarily removed in said mining) the unpatented lode mining claims situated in the County of Polk, State of Arkansas, together with all appurtenances thereunto belonging, described on the instrument attached hereto designated as Exhibit "A" and made a part hereof and incorporated herein. To have and to hold unto the said LESSEE, his heirs and assigns for a term of five (5) years from the date hereof and as long thereafter as manganese ore is produced or mined from said claims by LESSEE, his heirs or assigns.

(2) LESSEE hereby agrees that during the term of this lease, he will do assessment work on the above described claim in compliance with statutory requirements for the benefit of the LESSOR(S) of at least One Hundred ($100.00) Dollars annually on or before June 30 of each year. The first assessment work under this lease shall be done on or before June 30, 1953. LESSEE further agrees to execute and file with the Circuit Clerk of the County in which the claim lies affidavits of assessment work done on the said mining claim for the benefit of the LESSOR(S). LESSEE may enter upon the said mining claims for exploratory and mining purposes and may take whatever steps he deems necessary in accordance with good mining practice to explore or mine said claim.

(3) In addition to doing the above mentioned assessment work, LESSEE agrees to pay to LESSOR(S) the sum of seven (7¢) cents per ton as royalty on all raw manganese ore removed from the said claims within sixty (60) days after said ore is removed; provided that it is hereby understood and agreed that as long as the aforementioned assessment work is done by the LESSEE that this lease shall remain in full force and effect and that LESSEE is under no obligation to mine the claim or to remove and sell the ore thereon.

(4) LESSEE agrees to furnish upon written request of LESSOR(S) records and accounts of the mining or exploratory activity on the said claims to the LESSOR(S).

(5) This lease may be terminated by the LESSEE at any time during the term thereof by giving notice of such termination to the LESSOR(S) at least sixty (60) days prior to the final date for doing the required assessment work for the mining year in which the lease is terminated. The words "mining year" as used in this paragraph shall be construed as commencing on July 1 and ending on June 30 and does not mean a calendar year.

(6) LESSOR(S) hereby agree(s) that the said LESSEE may assign this lease or sub-lease the mining claims under such terms as he sees fit; provided that the provisions of Paragraph (2) hereof shall be carried out by the said assignee or sub-lessee and provided further that if manganese ore is removed from the said mining claims that said

assignee or sub-lessee shall assume the obligation to pay and shall pay the seven (7¢) cents per ton royalty provided for in Paragraph (3) hereof.

(7) This agreement shall be binding upon the heirs, executors, administrators, successors and assigns of all parties hereto.

IN WITNESS WHEREOF the parties hereto have executed this agreement on this 22nd day of May, 1952.

Cecil B. Chenoweth
Cecil B. Chenoweth, Agent, LESSEE

J. Dow Scott
I. R. Whisenhunt
W. L. Neil

LESSORS

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, J. Dow Scott, I. R. Whisenhunt and Wendell L. Neil, to me well known to be the person(s) whose name(s) appear as Lessor(s) in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 22nd day of May, 1952.

Clarie E. Decker
Notary Public

My Commission Expires July 28, 1955

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessee in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 22nd day of May, 1952.

Clarie E. Decker
Notary Public

My Commission Expires July 28, 1955

SUBORDINATION AGREEMENT AND CONSENT TO LIEN

KNOW ALL MEN BY THESE PRESENTS that:

WHEREAS, the "Undersigned" (as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller) have an interest in certain mining property in the State of Arkansas, County of Polk, hereinafter called "Property", said property being unpatented lode mining claims located on lands in the public domain; and the interest of the undersigned in said property includes the right to receive rentals and/or royalties on products mined and/or extracted therefrom; and the said property is the subject of a proposed Exploration Project Contract, hereinafter called "Contract", between the United States of America, hereinafter called the "Government", and Inland Mining Corporation, hereinafter called the "Operator"; and

WHEREAS, under certain provisions of said Contract which are set forth on the reverse side hereof, the Government will acquire certain rights and equities which do or may conflict with or be adverse to the interest of the undersigned in said property;

NOW THEREFORE, the undersigned, in consideration of said Contract and as an inducement to the Government and Operator to enter into same, undertakes and agrees as follows:

1. The Government's equity in and right to remove facilities, buildings, fixtures, and equipment, as provided in the Contract, shall prevail over and be prior and superior to any conflicting or adverse rights of the undersigned.

2. The Government's percentage royalty on net smelter returns or other net proceeds realized from ore, concentrates, or metal produced within ten (10) years from the date of the Contract, and the Government's lien for the payment of said percentage royalty shall attach to the mineral deposit and the production therefrom, in the amount of the Government's contribution, not in excess of $75,000.00, all upon the terms and conditions set forth in said Contract.

3. The undersigned shall commit no act nor assert any claim that may contravene or conflict with the lien, claim, or rights of the Government under the provisions of the said Contract. This agreement shall be binding upon the heirs, executors, administrators, successors, and assigns of the undersigned.

DATED this 22nd day of May, 19 52; and
EXECUTED by the "Undersigned" as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller, thus:

J. Don Scott
J. R. Weisenhunt
W. L. Neil

Percil B. Pehenowith

INLAND MINING CORPORATION

BY Percil B. Pehenowith
1st Vice Pres., & Gen. Mgr.

No. 2299X-A-10919

RELEVANT CONTRACT PROVISIONS

Title to and disposition of property. All facilities, buildings, fixtures, equipment, or other items costing more than $50 each, paid for or purchased with funds contributed jointly by the Operator and the Government, shall belong to the Operator and the Government jointly, in proportion to their respective contributions, and upon the termination of the contract, if they have any salvage value, shall be disposed of for their joint account unless the Government, in writing, waives its interest in any such items. The Government may require the dismantling, severance from land, and removal of any such items in order to realize its interest in the salvage value thereof, and the cost of any such removal and of the disposal of the items shall be for the joint account of the parties in proportion to their respective interests.

Repayment by Operator. If, upon the completion of the exploration project or termination of the contract, the Government considers that a discovery or development has resulted from the work from which commercial production of ore may be made, the Government, within 6 months thereafter, shall so certify to the Operator, particularly describing and delimiting its estimate of the discovery or the development. Thereafter, if and as ore is produced as a result of such discovery or development, the Operator and his successor in interest shall be and become obligated to pay to the Government a percentage royalty on the net smelter returns or other net proceeds realized from such ore, concentrates, or metal produced within ten (10) years from the date of this contract, until the total amount contributed by the Government, without interest, is fully repaid or said 10 years have elapsed, whichever occurs first, as follows:

> Of net smelter returns or other net proceeds not in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent.
>
> Of net smelter returns or other net proceeds in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent, plus one-half ($\frac{1}{2}$) percent for each additional full fifty cents ($0.50) in excess of eight dollars ($8.00) per ton of ore, but not in excess of a maximum of five (5) percent.

This obligation to repay from net returns or proceeds shall be and remain a claim and lien upon the mineral deposit which is the subject of the exploration project and upon any production resulting from such discovery or development, in favor of the Government, until fully paid, or until said 10-year period has elapsed; and this claim and lien and the Government's right to repayment shall survive any termination of the contract, whether by completion of the exploration project or otherwise. This article is not to be construed as imposing any obligation on the Operator or his successor in interest to produce ore from any such discovery or development.

EXHIBIT "A"

Mining Claim #1 of the New Find Group located by Wendell L. Neil and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

Mining Claim #2 of the New Find Group located by I. R. Whisenhunt and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

Dallas Office Copy

Form 2299X-10922

NEW FIND GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This contract and lease made by and between Cecil B. Chenoweth, Agent, hereinafter called LESSOR, and Inland Mining Corporation, a corporation duly chartered under the laws of the State of Delaware, hereinafter called LESSEE,

W I T N E S S E T H:

WHEREAS, said LESSOR owns, controls, claims or holds under lease those certain mining claims situated in Polk County, Arkansas, described in the attached Exhibit "A", said exhibit being made a part hereof, and all of which claims are hereinafter known as "mining property"; and said LESSEE desires to obtain leasehold rights in said property;

NOW THEREFORE, in consideration of the sum of One ($1.00) Dollar, in hand paid by LESSEE to LESSOR, the receipt of which is hereby acknowledged, and the hereinafter recited reservations of interest in the property, and other good and sufficient consideration, including the mutual covenants and agreements herein contained, the LESSOR has leased, let and demised, and by these presents does lease, let and demise unto the said LESSEE the exclusive right to mine and operate solely for manganese and other metallic ores (together with all other materials necessarily removed in such mining), all of the mining property and claims described in said Exhibit "A", subject to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest and further subject to the reservations, conditions, terms, restrictions and agreements hereinafter set forth, to-wit:

(1) Subject to the other provisions hereof, the term of this lease shall be for five (5) years from the date hereof, and as long thereafter as manganese is produced or mined from said land by the LESSEE, its successors or assigns.

(2) LESSOR reserves unto himself absolutely all minerals other than metallic minerals lying on, in and under said mining property.

(3) LESSOR reserves unto himself and his respective heirs and assigns, as royalty, one-fourth (1/4) of all manganese and of all other metals, intending that such reservation shall cover and extend to all commercial materials produced, saved and made marketable from said mining property. Such royalty reservation in LESSOR is and shall be separate and apart and in addition to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest, and LESSEE assumes the obligations to pay and shall timely pay such original royalty or delay rentals of seven (7¢) cents per ton of raw manganese ore.

(4) LESSEE shall begin with reasonable promptness and continue thereafter with due diligence the exploration of said property in an orderly manner. LESSEE shall furnish reports to LESSOR, upon request, in appropriate written form, setting forth the information revealed by such exploration. LESSEE shall begin as early as practicable in accordance with its needs the mining of said property with the purpose and object of producing manganese therefrom, and shall continuously thereafter mine and remove from the property all ores commercially profitable for such purpose, and shall commercially process, clean, condition and concentrate all marketable products and by-products derived from such mining operations, all such commercially recovered materials, products and by-products produced and saved from said mining and processing being known herein as "products."

(5) LESSEE shall be obligated to process, clean, condition and concentrate all marketable products and by-products derived from mining operations on the mining properties and shall deliver over to LESSOR, his nominees and assigns, one-fourth (1/4) of all of the commercially recovered materials, products and by-products produced and saved from said mining and processing operations, as reserved royalty, free of all costs and expenses, and such deliveries shall be made in kind if LESSOR

so elects; if such election be not made, from time to time, with at least thirty (30) days notice in writing thereof, then LESSEE shall pay to LESSOR a sum in cash equal to the then established market value of such products. Delivery to LESSOR, his nominees or assigns of the said reserved royalty shall be made on or before the 20th day of each calendar month immediately following that month in which the same shall have been reduced to proper and acceptable commercial form, and shipped from the conditioning plant of LESSEE.

(6) LESSEE shall keep full and accurate records and books of account, showing the quantity of all ores mined and of all products derived therefrom, together with the market value of the latter, the amounts thereof shipped, the amounts thereof sold, and the sales volume thereof in money; and all such records and books shall be open to inspection by LESSOR and his agents at all reasonable business hours. Not later than the 20th day of each calendar month, LESSEE shall make reports in writing to LESSOR stating the quantity of ore mined, the quantity of ore processed, and the quantity, character and market value of all products derived therefrom and shipped during the calendar month immediately preceding the making of such report.

(7) LESSEE shall work and mine the leased property in the most effective, workmanlike and proper manner, according to the most approved and suitable methods and practices of modern mining and especially of modern strip mining, and in such manner as to ultimately recover the greatest amount of merchantable products reasonably recoverable from said property during the term of this lease; and during such term LESSEE shall allow to LESSOR full access to said property and to all mining operations thereon and also to all mills, plants and conditioning establishments processing ore from the leased property and operated by LESSEE or for its benefit wherever situated.

(8) LESSEE shall be privileged to build, erect, operate, remove, transport and employ any buildings, structures, bridges, dams, roads, machinery and equipment at any locations on the leased property as may be considered desirable, necessary or expedient thereby; and LESSEE may take from such property all materials and waters necessary in mining and processing ores removed therefrom.

(9) As part of the consideration for this lease and for the benefit of the LESSOR, LESSEE shall timely, fully and properly do all assessment work necessary and requisite by law and custom to adequately maintain in full force and effect all mining claims included in the leased property, and shall make and timely file full and complete statements and evidences of the assessment work done.

(10) At the option and election of LESSOR, this lease may be cancelled in the event that LESSEE is placed in receivership, or a petition in bankruptcy is filed against LESSEE, whether voluntary or involuntary, or if LESSEE makes a composition with creditors.

(11) This lease shall not be assigned by LESSEE unless permission for such assignment be given by LESSOR in writing; and LESSEE shall make no sub-lease or sub-leases concerning the mining property unless and until approval therefor has been given by LESSOR in writing.

(12) This lease shall inure to the benefit of and be binding upon the parties hereto and upon their respective heirs, assigns and successors.

WITNESS THE HANDS OF THE PARTIES on the 8th day of June, 1952.

Cecil B. Chenoweth

Cecil B. Chenoweth, Agent LESSOR

INLAND MINING CORPORATION

By Cecil B. Chenoweth LESSEE

ATTEST:

Secretary

EXHIBIT "A"

Mining Claim #1 of the New Find Group located by Wendell L. Neil and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

Mining Claim #2 of the New Find Group located by I. R. Whisenhunt and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessor in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 8th day of June, 1952.

Clarice E. Decker
Notary Public

My commission expires July 28 1955.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this 8th day of June, 1952, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named Cecil B. Chenoweth, being the 1st. Vice President of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the 1st. Vice President of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this 8th day of June, 1952.

Clarice E. Decker
Notary Public

My comm. expired July 28, 1955

ACKNOWLEDGMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 195___, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named _____, being the _____ of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the _____ of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this _____ day of _____, 195____.

_____
Notary Public

Form 2299X-10921

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This agreement made and entered into this 22nd day of May, 1952, by and between Cecil B. Chenoweth, Agent (hereinafter called LESSEE) and

J. Don Scott
J R Whisenhunt
W L Neil

(hereinafter called LESSOR(S)),

W I T N E S S E T H:

(1) That for and in consideration of the sum of One ($1.00) Dollar, receipt of which is hereby acknowledged, the mutual agreements hereinafter recited, and in further consideration of the royalties herein to be paid by the LESSEE, the LESSOR(S) Hereby let(s) and demise(s) unto the LESSEE the right to mine for manganese or other metallic ores (together with all other materials necessarily removed in said mining) the unpatented lode mining claims situated in the County of Polk, State of Arkansas, together with all appurtenances thereunto belonging, described on the instrument attached hereto designated as Exhibit "A" and made a part hereof and incorporated herein. To have and to hold unto the said LESSEE, his heirs and assigns for a term of five (5) years from the date hereof and as long thereafter as manganese ore is produced or mined from said claims by LESSEE, his heirs or assigns.

(2) LESSEE hereby agrees that during the term of this lease, he will do assessment work on the above described claim in compliance with statutory requirements for the benefit of the LESSOR(S) of at least One Hundred ($100.00) Dollars annually on or before June 30 of each year. The first assessment work under this lease shall be done on or before June 30, 1953. LESSEE further agrees to execute and file with the Circuit Clerk of the County in which the claim lies affidavits of assessment work done on the said mining claim for the benefit of the LESSOR(S). LESSEE may enter upon the said mining claims for exploratory and mining purposes and may take whatever steps he deems necessary in accordance with good mining practice to explore or mine said claim.

(3) In addition to doing the above mentioned assessment work, LESSEE agrees to pay to LESSOR(S) the sum of seven (7¢) cents per ton as royalty on all raw manganese ore removed from the said claims within sixty (60) days after said ore is removed; provided that it is hereby understood and agreed that as long as the aforementioned assessment work is done by the LESSEE that this lease shall remain in full force and effect and that LESSEE is under no obligation to mine the claim or to remove and sell the ore thereon.

(4) LESSEE agrees to furnish upon written request of LESSOR(S) records and accounts of the mining or exploratory activity on the said claims to the LESSOR(S).

(5) This lease may be terminated by the LESSEE at any time during the term thereof by giving notice of such termination to the LESSOR(S) at least sixty (60) days prior to the final date for doing the required assessment work for the mining year in which the lease is terminated. The words "mining year" as used in this paragraph shall be construed as commencing on July 1 and ending on June 30 and does not mean a calendar year.

(6) LESSOR(S) hereby agree(s) that the said LESSEE may assign this lease or sub-lease the mining claims under such terms as he sees fit; provided that the provisions of Paragraph (2) hereof shall be carried out by the said assignee or sub-lessee and provided further that if manganese ore is removed from the said mining claims that said

RELEVANT CONTRACT PROVISIONS

Title to and disposition of property. All facilities, buildings, fixtures, equipment, or other items costing more than $50 each, paid for or purchased with funds contributed jointly by the Operator and the Government, shall belong to the Operator and the Government jointly, in proportion to their respective contributions, and upon the termination of the contract, if they have any salvage value, shall be disposed of for their joint account unless the Government, in writing, waives its interest in any such items. The Government may require the dismantling, severance from land, and removal of any such items in order to realize its interest in the salvage value thereof, and the cost of any such removal and of the disposal of the items shall be for the joint account of the parties in proportion to their respective interests.

Repayment by Operator. If, upon the completion of the exploration project or termination of the contract, the Government considers that a discovery or development has resulted from the work from which commercial production of ore may be made, the Government, within 6 months thereafter, shall so certify to the Operator, particularly describing and delimiting its estimate of the discovery or the development. Thereafter, if and as ore is produced as a result of such discovery or development, the Operator and his successor in interest shall be and become obligated to pay to the Government a percentage royalty on the net smelter returns or other net proceeds realized from such ore, concentrates, or metal produced within ten (10) years from the date of this contract, until the total amount contributed by the Government, without interest, is fully repaid or said 10 years have elapsed, whichever occurs first, as follows:

> Of net smelter returns or other net proceeds not in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent.
>
> Of net smelter returns or other net proceeds in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent, plus one-half ($\frac{1}{2}$) percent for each additional full fifty cents ($0.50) in excess of eight dollars ($8.00) per ton of ore, but not in excess of a maximum of five (5) percent.

This obligation to repay from net returns or proceeds shall be and remain a claim and lien upon the mineral deposit which is the subject of the exploration project and upon any production resulting from such discovery or development, in favor of the Government, until fully paid, or until said 10-year period has elapsed; and this claim and lien and the Government's right to repayment shall survive any termination of the contract, whether by completion of the exploration project or otherwise. This article is not to be construed as imposing any obligation on the Operator or his successor in interest to produce ore from any such discovery or development.

assignee or sub-lessee shall assume the obligation to pay and shall pay the seven (7¢) cents per ton royalty provided for in Paragraph (3) hereof.

(7) This agreement shall be binding upon the heirs, executors, administrators, successors and assigns of all parties hereto.

IN WITNESS WHEREOF the parties hereto have executed this agreement on this 22nd day of May, 1952.

Cecil B. Chenoweth

Cecil B. Chenoweth, Agent, LESSEE

J. Dow Scott

I. R. Whisenhunt

W. L. Neil

LESSORS

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, J. Dow Scott, I. R. Whisenhunt, Wendell L. Neil, to me well known to be the person(s) whose name(s) appear as Lessor(s) in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 22nd day of May, 1952.

Clarice E. Decker

Notary Public

My Commission Expires July 28, 1955

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessee in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 22nd day of May, 1952.

Clarice E. Decker

Notary Public

My Commission Expires July 28, 1955

SUBORDINATION AGREEMENT AND CONSENT TO LIEN

KNOW ALL MEN BY THESE PRESENTS that:

WHEREAS, the "Undersigned" (as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller) have an interest in certain mining property in the State of Arkansas, County of Polk, hereinafter called "Property", said property being unpatented lode mining claims located on lands in the public domain; and the interest of the undersigned in said property includes the right to receive rentals and/or royalties on products mined and/or extracted therefrom; and the said property is the subject of a proposed Exploration Project Contract, hereinafter called "Contract", between the United States of America, hereinafter called the "Government", and Inland Mining Corporation, hereinafter called the "Operator"; and

WHEREAS, under certain provisions of said Contract which are set forth on the reverse side hereof, the Government will acquire certain rights and equities which do or may conflict with or be adverse to the interest of the undersigned in said property;

NOW THEREFORE, the undersigned, in consideration of said Contract and as an inducement to the Government and Operator to enter into same, undertakes and agrees as follows:

1. The Government's equity in and right to remove facilities, buildings, fixtures, and equipment, as provided in the Contract, shall prevail over and be prior and superior to any conflicting or adverse rights of the undersigned.

2. The Government's percentage royalty on net smelter returns or other net proceeds realized from ore, concentrates, or metal produced within ten (10) years from the date of the Contract, and the Government's lien for the payment of said percentage royalty shall attach to the mineral deposit and the production therefrom, in the amount of the Government's contribution, not in excess of $75,000.00, all upon the terms and conditions set forth in said Contract.

3. The undersigned shall commit no act nor assert any claim that may contravene or conflict with the lien, claim, or rights of the Government under the provisions of the said Contract. This agreement shall be binding upon the heirs, executors, administrators, successors, and assigns of the undersigned.

DATED this 22nd day of May, 1952; and
EXECUTED by the "Undersigned" as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller, thus:

J. Dean Scott
D R Mauerhurst
W L Neil

Pearl B. Rhenovath

INLAND MINING CORPORATION

By Pearl B. Rhenovath
1st. Vice President

No. 2299X-A-10919

RELEVANT CONTRACT PROVISIONS

Title to and disposition of property. All facilities, buildings, fixtures, equipment, or other items costing more than $50 each, paid for or purchased with funds contributed jointly by the Operator and the Government, shall belong to the Operator and the Government jointly, in proportion to their respective contributions, and upon the termination of the contract, if they have any salvage value, shall be disposed of for their joint account unless the Government, in writing, waives its interest in any such items. The Government may require the dismantling, severance from land, and removal of any such items in order to realize its interest in the salvage value thereof, and the cost of any such removal and of the disposal of the items shall be for the joint account of the parties in proportion to their respective interests.

Repayment by Operator. If, upon the completion of the exploration project or termination of the contract, the Government considers that a discovery or development has resulted from the work from which commercial production of ore may be made, the Government, within 6 months thereafter, shall so certify to the Operator, particularly describing and delimiting its estimate of the discovery or the development. Thereafter, if and as ore is produced as a result of such discovery or development, the Operator and his successor in interest shall be and become obligated to pay to the Government a percentage royalty on the net smelter returns or other net proceeds realized from such ore, concentrates, or metal produced within ten (10) years from the date of this contract, until the total amount contributed by the Government, without interest, is fully repaid or said 10 years have elapsed, whichever occurs first, as follows:

> Of net smelter returns or other net proceeds not in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent.
>
> Of net smelter returns or other net proceeds in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent, plus one-half ($\frac{1}{2}$) percent for each additional full fifty cents ($0.50) in excess of eight dollars ($8.00) per ton of ore, but not in excess of a maximum of five (5) percent.

This obligation to repay from net returns or proceeds shall be and remain a claim and lien upon the mineral deposit which is the subject of the exploration project and upon any production resulting from such discovery or development, in favor of the Government, until fully paid, or until said 10-year period has elapsed; and this claim and lien and the Government's right to repayment shall survive any termination of the contract, whether by completion of the exploration project or otherwise. This article is not to be construed as imposing any obligation on the Operator or his successor in interest to produce ore from any such discovery or development.

EXHIBIT "A"

Mining Claim #1 of the New Find Group located by Wendell L. Neil and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

Mining Claim #2 of the New Find Group located by I. R. Whisenhunt and filed for record in Book "H", Page 385 of the Mining Records of the Official Recorder of Polk County, Arkansas.

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION
~~WASHINGTON 25, D.C.~~
Joplin, Missouri
October 6, 1952

Re: Docket DMEA-2299
Contract Idm-E280
Inland Mining Corp.

Memo

To: Operating Committee, DMEA

From: David Gallagher, Executive Officer, Field Team Region VI

Transmitted herewith are five sets of documents as explained in the accompanying letter to me from Cecil B. Chenoweth dated September 30, 1952.

As there are five copies of the contract other than my copy I am sending all five copies of these documents to you to distribute as you see fit.

As some parts of the costs may be disallowed, depending upon your decisions, we have attempted to review the past expenditures in the hope of allocating appropriate parts of the costs to each of the various working places. We find that the available records are not sufficiently detailed or specific to make such an allocation possible.

Therefore, when a decision has been reached as to what working places are to be allowed or disallowed, it will probably be necessary for an auditor to work with the personnel of the operator to reconstruct new records as a basis for revised MF-104s.

First, your decisions are necessary, and then it will be possible to revise the records accordingly.

David Gallagher

David Gallagher

/jd

cc - C. B. Chenoweth

Defense Minerals Administration
RECEIVED
OCT 8 1952

MF-500

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION

REFERENCE SLIP

REFERRED TO: DATE 10-8-52

1. ~~Mr. Berry, Chief Geol.~~
2. ~~Selfridge, Rm. 3538~~
3. ~~Mr. Hoffland, Rm. 4627~~
4. ~~Mr. Chambers, Rm. 2616~~
5. ~~Mr. Selfridge, Rm. 3538~~
6. H. Berry.

FOR:

- ---------- Action
- ---------- Approval
- ---------- Comment
- ---------- Conference
- ---------- Consideration
- ---------- Filing
- ---------- Instr...
- ---------- Recommendation
- ---------- Record of ----------
- ---------- Referring to ----------
- ---------- Reply for signa-... of ----------

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION
WASHINGTON 25, D. C.

xxxxxxxxxxxxxxx

Joplin, Missouri
October 6, 1952

Mr. Cecil B. Chenoweth
Vice-President
Inland Mining Corporation
P. O. Box 71
Mena, Arkansas

Re: Docket DMEA-2299
Contract Idm-E280
Inland Mining Corp.

Dear Mr. Chenoweth:

This will acknowledge receipt of your letter of September 30, 1952 and the documents that accompanied it.

All documents received from you, and referred to above have been forwarded today to the Operating Committee in DMEA in Washington.

Enclosed is a carbon copy of a letter to the Operating Committee that I think answers your question about revising the June MF-104. No revision is practical until we hear from Washington.

Sincerely yours,

David Gallagher
Executive Officer
DMEA Field Team, Region VI

/jd

cc - Operating Committee

OCT 1 1952

Inland Mining Corporation

CECIL B. CHENOWETH
Vice Pres. and Gen. Mgr.

Mena, Arkansas

Executive Offices
523 Republic Bank Building
Dallas, Texas

September 30, 1952

DEPARTMENT OF THE INTERIOR
Bureau of Land Management
RECEIVED
OCT 8 1952

Mr. David Gallagher,
Executive Officer
D. M. E. A. Field Team, Region VI
United States Department of the Interior
221 W. 3rd. Street,
Joplin, Missouri

Re: Docket #DMEA-2299
Contract #Idm E280
Inland Mining Corp.

Dear Mr. Gallagher:

Enclosed please find five (5) sets of the following documents, covering the "Coon Creek Group" of claims:

(a) Subordination Agreement and Consent to Lien,

(b) Exhibit "A",

(c) Mining Lease from the original claim owner to myself as Agent,

(d) Mining Lease from myself as Agent to Inland Mining Corporation.

I am also enclosing two (2) sketch maps showing the Baloff Group of claims marked out in red pencil and the Parsons Claim No. 3 in the Coon Creek Group marked in the same manner. We are withdrawing our request that these claims (Four (4) claims in the Baloff Group and Parsons Claim in the Coon Creek Group) be made a part of our Contract due to the fact that our Attorneys are not satisfied with title to these claims and we are unable to obtain the necessary signatures to make good title for these properties.

Shall we revise our June Report insofor as costs are concerned? Also would you like an Amendment, or statement of some sort, from Mr. McElwaine as to costs incurred on these claims and also his narrative section as reflected in our June Report?

In other words it now appears that we spent some time and money as reflected in our June Report on the Baloff and Coon Creek Groups which we are not entitled to receive compensation from the Government. We are anxious to amend our June Report accordingly, just as soon as possible. We await your instructions as to the procedure we should follow.

Very truly yours,

Cecil B. Chenoweth

CBC/cd ccs-S. Austin Wier
W. C. Jackson, Jr., E. S. Heyser, Jr.

COON CREEK GROUP

SUBORDINATION AGREEMENT AND CONSENT TO LIEN

KNOW ALL MEN BY THESE PRESENTS that:

WHEREAS, the "Undersigned" (as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller) have an interest in certain mining property in the State of Arkansas, County of Polk, hereinafter called "Property", said property being unpatented lode mining claims located on lands in the public domain; and the interest of the undersigned in said property includes the right to receive rentals and/or royalties on products mined and/or extracted therefrom; and the said property is the subject of a proposed Exploration Project Contract, hereinafter called "Contract", between the United States of America, hereinafter called the "Government", and Inland Mining Corporation, hereinafter called the "Operator"; and

WHEREAS, under certain provisions of said Contract which are set forth on the reverse side hereof, the Government will acquire certain rights and equities which do or may conflict with or be adverse to the interest of the undersigned in said property;

NOW THEREFORE, the undersigned, in consideration of said Contract and as an inducement to the Government and Operator to enter into same, undertakes and agrees as follows:

1. The Government's equity in and right to remove facilities, buildings, fixtures, and equipment, as provided in the Contract, shall prevail over and be prior and superior to any conflicting or adverse rights of the undersigned.

2. The Government's percentage royalty on net smelter returns or other net proceeds realized from ore, concentrates, or metal produced within ten (10) years from the date of the Contract, and the Government's lien for the payment of said percentage royalty shall attach to the mineral deposit and the production therefrom, in the amount of the Government's contribution, not in excess of $75,000.00, all upon the terms and conditions set forth in said Contract.

3. The undersigned shall commit no act nor assert any claim that may contravene or conflict with the lien, claim, or rights of the Government under the provisions of the said Contract. This agreement shall be binding upon the heirs, executors, administrators, successors, and assigns of the undersigned.

DATED this 1st. day of July, 1952; and
EXECUTED by the "Undersigned" as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller, thus:

W. S. Parsons

Cecil B. Chenoweth, Agent

S. A. Wier

INLAND MINING CORPORATION
By Cecil B. Chenoweth
Vice President

No. 2299X-A-10919

79 8100

RELEVANT CONTRACT PROVISIONS

Title to and disposition of property. All facilities, buildings, fixtures, equipment, or other items costing more than $50 each, paid for or purchased with funds contributed jointly by the Operator and the Government, shall belong to the Operator and the Government jointly, in proportion to their respective contributions, and upon the termination of the contract, if they have any salvage value, shall be disposed of for their joint account unless the Government, in writing, waives its interest in any such items. The Government may require the dismantling, severance from land, and removal of any such items in order to realize its interest in the salvage value thereof, and the cost of any such removal and of the disposal of the items shall be for the joint account of the parties in proportion to their respective interests.

Repayment by Operator. If, upon the completion of the exploration project or termination of the contract, the Government considers that a discovery or development has resulted from the work from which commercial production of ore may be made, the Government, within 6 months thereafter, shall so certify to the Operator, particularly describing and delimiting its estimate of the discovery or the development. Thereafter, if and as ore is produced as a result of such discovery or development, the Operator and his successor in interest shall be and become obligated to pay to the Government a percentage royalty on the net smelter returns or other net proceeds realized from such ore, concentrates, or metal produced within ten (10) years from the date of this contract, until the total amount contributed by the Government, without interest, is fully repaid or said 10 years have elapsed, whichever occurs first, as follows:

> Of net smelter returns or other net proceeds not in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent.
>
> Of net smelter returns or other net proceeds in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent, plus one-half ($\frac{1}{2}$) percent for each additional full fifty cents ($0.50) in excess of eight dollars ($8.00) per ton of ore, but not in excess of a maximum of five (5) percent.

This obligation to repay from net returns or proceeds shall be and remain a claim and lien upon the mineral deposit which is the subject of the exploration project and upon any production resulting from such discovery or development, in favor of the Government, until fully paid, or until said 10-year period has elapsed; and this claim and lien and the Government's right to repayment shall survive any termination of the contract, whether by completion of the exploration project or otherwise. This article is not to be construed as imposing any obligation on the Operator or his successor in interest to produce ore from any such discovery or development.

EXHIBIT "A"

Mining claim #1 of the Coon Creek Group located by S. A. Wier and recorded in the Official Mining Records of the Recorder of Polk County, Arkansas in Book "I", Page 18.

Form 2299X-10921

COON CREEK GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This agreement made and entered into this 5 day of June, 195 2, by and between Cecil B. Chenoweth, Agent (hereinafter called LESSEE) and

S.A. Wier

(hereinafter called LESSOR(S)),

W I T N E S S E T H:

(1) That for and in consideration of the sum of One ($1.00) Dollar, receipt of which is hereby acknowledged, the mutual agreements hereinafter recited, and in further consideration of the royalties herein to be paid by the LESSEE, the LESSOR(S) Hereby let(s) and demise(s) unto the LESSEE the right to mine for manganese or other metallic ores (together with all other materials necessarily removed in said mining) the unpatented lode mining claims situated in the County of Polk, State of Arkansas, together with all appurtenances thereunto belonging, described on the instrument attached hereto designated as Exhibit "A" and made a part hereof and incorporated herein. To have and to hold unto the said LESSEE, his heirs and assigns for a term of five (5) years from the date hereof and as long thereafter as manganese ore is produced or mined from said claims by LESSEE, his heirs or assigns.

(2) LESSEE hereby agrees that during the term of this lease, he will do assessment work on the above described claim in compliance with statutory requirements for the benefit of the LESSOR(S) of at least One Hundred ($100.00) Dollars annually on or before June 30 of each year. The first assessment work under this lease shall be done on or before June 30, 195 3. LESSEE further agrees to execute and file with the Circuit Clerk of the County in which the claim lies affidavits of assessment work done on the said mining claim for the benefit of the LESSOR(S). LESSEE may enter upon the said mining claims for exploratory and mining purposes and may take whatever steps he deems necessary in accordance with good mining practice to explore or mine said claim.

(3) In addition to doing the above mentioned assessment work, LESSEE agrees to pay to LESSOR(S) the sum of seven (7¢) cents per ton as royalty on all raw manganese ore removed from the said claims within sixty (60) days after said ore is removed; provided that it is hereby understood and agreed that as long as the aforementioned assessment work is done by the LESSEE that this lease shall remain in full force and effect and that LESSEE is under no obligation to mine the claim or to remove and sell the ore thereon.

(4) LESSEE agrees to furnish upon written request of LESSOR(S) records and accounts of the mining or exploratory activity on the said claims to the LESSOR(S).

(5) This lease may be terminated by the LESSEE at any time during the term thereof by giving notice of such termination to the LESSOR(S) at least sixty (60) days prior to the final date for doing the required assessment work for the mining year in which the lease is terminated. The words "mining year" as used in this paragraph shall be construed as commencing on July 1 and ending on June 30 and does not mean a calendar year.

(6) LESSOR(S) hereby agree(s) that the said LESSEE may assign this lease or sub-lease the mining claims under such terms as he sees fit; provided that the provisions of Paragraph (2) hereof shall be carried out by the said assignee or sub-lessee and provided further that if manganese ore is removed from the said mining claims that said

assignee or sub-lessee shall assume the obligation to pay and shall pay the seven (7¢) cents per ton royalty provided for in Paragraph (3) hereof.

(7) This agreement shall be binding upon the heirs, executors, administrators, successors and assigns of all parties hereto.

IN WITNESS WHEREOF the parties hereto have executed this agreement on this 5th. day of June, 1952.

Cecil B. Chenoweth, Agent, LESSEE

S. A. Wier

LESSORS

ACKNOWLEDGMENT

STATE OF ~~ARKANSAS~~ TEXAS
COUNTY OF DALLAS

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, S. A. Wier, to me well known to be the person(~~s~~) whose name(~~s~~) appears as Lessor(~~s~~) in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 29th day of August, 1952.

Maureen Massingill
Notary Public
(MAUREEN MASSINGILL)

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessee in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 5th. day of June, 1952.

Claire E. Decker
Notary Public

My comm. expires July 28, 1955.

Form 2299X-10922

COON CREEK GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This contract and lease made by and between Cecil B. Chenoweth, Agent, hereinafter called LESSOR, and Inland Mining Corporation, a corporation duly chartered under the laws of the State of Delaware, hereinafter called LESSEE,

W I T N E S S E T H:

WHEREAS, said LESSOR owns, controls, claims or holds under lease those certain mining claims situated in Polk County, Arkansas, described in the attached Exhibit "A", said exhibit being made a part hereof, and all of which claims are hereinafter known as "mining property"; and said LESSEE desires to obtain leasehold rights in said property;

NOW THEREFORE, in consideration of the sum of One ($1.00) Dollar, in hand paid by LESSEE to LESSOR, the receipt of which is hereby acknowledged, and the hereinafter recited reservations of interest in the property, and other good and sufficient consideration, including the mutual covenants and agreements herein contained, the LESSOR has leased, let and demised, and by these presents does lease, let and demise unto the said LESSEE the exclusive right to mine and operate solely for manganese and other metallic ores (together with all other materials necessarily removed in such mining), all of the mining property and claims described in said Exhibit "A", subject to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest and further subject to the reservations, conditions, terms, restrictions and agreements hereinafter set forth, to-wit:

(1) Subject to the other provisions hereof, the term of this lease shall be for five (5) years from the date hereof, and as long thereafter as manganese is produced or mined from said land by the LESSEE, its successors or assigns.

(2) LESSOR reserves unto himself absolutely all minerals other than metallic minerals lying on, in and under said mining property.

(3) LESSOR reserves unto himself and his respective heirs and assigns, as royalty, one-fourth (1/4) of all manganese and of all other metals, intending that such reservation shall cover and extend to all commercial materials produced, saved and made marketable from said mining property. Such royalty reservation in LESSOR is and shall be separate and apart and in addition to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest, and LESSEE assumes the obligations to pay and shall timely pay such original royalty or delay rentals of seven (7¢) cents per ton of raw manganese ore.

(4) LESSEE shall begin with reasonable promptness and continue thereafter with due diligence the exploration of said property in an orderly manner. LESSEE shall furnish reports to LESSOR, upon request, in appropriate written form, setting forth the information revealed by such exploration. LESSEE shall begin as early as practicable in accordance with its needs the mining of said property with the purpose and object of producing manganese therefrom, and shall continuously thereafter mine and remove from the property all ores commercially profitable for such purpose, and shall commercially process, clean, condition and concentrate all marketable products and by-products derived from such mining operations, all such commercially recovered materials, products and by-products produced and saved from said mining and processing being known herein as "products."

(5) LESSEE shall be obligated to process, clean, condition and concentrate all marketable products and by-products derived from mining operations on the mining properties and shall deliver over to LESSOR, his nominees and assigns, one-fourth (1/4) of all of the commercially recovered materials, products and by-products produced and saved from said mining and processing operations, as reserved royalty, free of all costs and expenses, and such deliveries shall be made in kind if LESSOR

so elects; if such election be not made, from time to time, with at least thirty (30) days notice in writing thereof, then LESSEE shall pay to LESSOR a sum in cash equal to the then established market value of such products. Delivery to LESSOR, his nominees or assigns of the said reserved royalty shall be made on or before the 20th day of each calendar month immediately following that month in which the same shall have been reduced to proper and acceptable commercial form, and shipped from the conditioning plant of LESSEE.

(6) LESSEE shall keep full and accurate records and books of account, showing the quantity of all ores mined and of all products derived therefrom, together with the market value of the latter, the amounts thereof shipped, the amounts thereof sold, and the sales volume thereof in money; and all such records and books shall be open to inspection by LESSOR and his agents at all reasonable business hours. Not later than the 20th day of each calendar month, LESSEE shall make reports in writing to LESSOR stating the quantity of ore mined, the quantity of ore processed, and the quantity, character and market value of all products derived therefrom and shipped during the calendar month immediately preceding the making of such report.

(7) LESSEE shall work and mine the leased property in the most effective, workmanlike and proper manner, according to the most approved and suitable methods and practices of modern mining and especially of modern strip mining, and in such manner as to ultimately recover the greatest amount of merchantable products reasonably recoverable from said property during the term of this lease; and during such term LESSEE shall allow to LESSOR full access to said property and to all mining operations thereon and also to all mills, plants and conditioning establishments processing ore from the leased property and operated by LESSEE or for its benefit wherever situated.

(8) LESSEE shall be privileged to build, erect, operate, remove, transport and employ any buildings, structures, bridges, dams, roads, machinery and equipment at any locations on the leased property as may be considered desirable, necessary or expedient thereby; and LESSEE may take from such property all materials and waters necessary in mining and processing ores removed therefrom.

(9) As part of the consideration for this lease and for the benefit of the LESSOR, LESSEE shall timely, fully and properly do all assessment work necessary and requisite by law and custom to adequately maintain in full force and effect all mining claims included in the leased property, and shall make and timely file full and complete statements and evidences of the assessment work done.

(10) At the option and election of LESSOR, this lease may be cancelled in the event that LESSEE is placed in receivership, or a petition in bankruptcy is filed against LESSEE, whether voluntary or involuntary, or if LESSEE makes a composition with creditors.

(11) This lease shall not be assigned by LESSEE unless permission for such assignment be given by LESSOR in writing; and LESSEE shall make no sub-lease or sub-leases concerning the mining property unless and until approval therefor has been given by LESSOR in writing.

(12) This lease shall inure to the benefit of and be binding upon the parties hereto and upon their respective heirs, assigns and successors.

WITNESS THE HANDS OF THE PARTIES on the 5th day of June, 1952.

Cecil B. Chenoweth

Cecil B. Chenoweth, Agent LESSOR

INLAND MINING CORPORATION

By Cecil B. Chenoweth

Vice Pres., & Gen. Mgr. LESSEE

ATTEST: S. A. Wier

S.A. Wier Secretary

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessor in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 5th. day of June, 1952.

Clarice E. Decker
Notary Public

My comm. expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this 5th day of June, 1952, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named Cecil B. Chenoweth, being the 1st. Vice President of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the 1st. Vice President of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this 5th. day of June, 1952.

Clarice E. Decker
Notary Public

My comm. expires July 28 1955.

ACKNOWLEDGMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 195___, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named _____, being the _____ of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the _____ of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this _____ day of _____, 195____.

_____
Notary Public

COON CREEK GROUP

SUBORDINATION AGREEMENT AND CONSENT TO LIEN

KNOW ALL MEN BY THESE PRESENTS that:

WHEREAS, the "Undersigned" (as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller) have an interest in certain mining property in the State of Arkansas, County of Polk, hereinafter called "Property", said property being unpatented lode mining claims located on lands in the public domain; and the interest of the undersigned in said property includes the right to receive rentals and/or royalties on products mined and/or extracted therefrom; and the said property is the subject of a proposed Exploration Project Contract, hereinafter called "Contract", between the United States of America, hereinafter called the "Government", and Inland Mining Corporation, hereinafter called the "Operator"; and

WHEREAS, under certain provisions of said Contract which are set forth on the reverse side hereof, the Government will acquire certain rights and equities which do or may conflict with or be adverse to the interest of the undersigned in said property;

NOW THEREFORE, the undersigned, in consideration of said Contract and as an inducement to the Government and Operator to enter into same, undertakes and agrees as follows:

1. The Government's equity in and right to remove facilities, buildings, fixtures, and equipment, as provided in the Contract, shall prevail over and be prior and superior to any conflicting or adverse rights of the undersigned.

2. The Government's percentage royalty on net smelter returns or other net proceeds realized from ore, concentrates, or metal produced within ten (10) years from the date of the Contract, and the Government's lien for the payment of said percentage royalty shall attach to the mineral deposit and the production therefrom, in the amount of the Government's contribution, not in excess of $75,000.00, all upon the terms and conditions set forth in said Contract.

3. The undersigned shall commit no act nor assert any claim that may contravene or conflict with the lien, claim, or rights of the Government under the provisions of the said Contract. This agreement shall be binding upon the heirs, executors, administrators, successors, and assigns of the undersigned.

DATED this _____ day of _____, 19___; and
EXECUTED by the "Undersigned" as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller, thus:

	Cecil B. Chenoweth Cecil B. Chenoweth, Agent
~~W. S. Parsons~~	
S. A. Wier S. A. Wier	INLAND MINING CORPORATION By Cecil B. Chenoweth Vice President

No. 2299X-A-10919

OCT 8 1952
DEPARTMENT OF THE INTERIOR
Defense Materials Administration
RECEIVED

RELEVANT CONTRACT PROVISIONS

Title to and disposition of property. All facilities, buildings, fixtures, equipment, or other items costing more than $50 each, paid for or purchased with funds contributed jointly by the Operator and the Government, shall belong to the Operator and the Government jointly, in proportion to their respective contributions, and upon the termination of the contract, if they have any salvage value, shall be disposed of for their joint account unless the Government, in writing, waives its interest in any such items. The Government may require the dismantling, severance from land, and removal of any such items in order to realize its interest in the salvage value thereof, and the cost of any such removal and of the disposal of the items shall be for the joint account of the parties in proportion to their respective interests.

Repayment by Operator. If, upon the completion of the exploration project or termination of the contract, the Government considers that a discovery or development has resulted from the work from which commercial production of ore may be made, the Government, within 6 months thereafter, shall so certify to the Operator, particularly describing and delimiting its estimate of the discovery or the development. Thereafter, if and as ore is produced as a result of such discovery or development, the Operator and his successor in interest shall be and become obligated to pay to the Government a percentage royalty on the net smelter returns or other net proceeds realized from such ore, concentrates, or metal produced within ten (10) years from the date of this contract, until the total amount contributed by the Government, without interest, is fully repaid or said 10 years have elapsed, whichever occurs first, as follows:

> Of net smelter returns or other net proceeds not in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent.
>
> Of net smelter returns or other net proceeds in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent, plus one-half ($\frac{1}{2}$) percent for each additional full fifty cents ($0.50) in excess of eight dollars ($8.00) per ton of ore, but not in excess of a maximum of five (5) percent.

This obligation to repay from net returns or proceeds shall be and remain a claim and lien upon the mineral deposit which is the subject of the exploration project and upon any production resulting from such discovery or development, in favor of the Government, until fully paid, or until said 10-year period has elapsed; and this claim and lien and the Government's right to repayment shall survive any termination of the contract, whether by completion of the exploration project or otherwise. This article is not to be construed as imposing any obligation on the Operator or his successor in interest to produce ore from any such discovery or development.

EXHIBIT "A"

Mining claim #1 of the Coon Creek Group located by S. A. Wier and recorded in the Official Mining Records of the Recorder of Polk County, Arkansas in Book "I", Page 18.

Form 2299X-10921

COON CREEK GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This agreement made and entered into this 5th day of June, 195~~2~~, by and between Cecil B. Chenoweth, Agent (hereinafter called LESSEE) and

S. A. Wier

(hereinafter called LESSOR(S)),

W I T N E S S E T H:

(1) That for and in consideration of the sum of One ($1.00) Dollar, receipt of which is hereby acknowledged, the mutual agreements hereinafter recited, and in further consideration of the royalties herein to be paid by the LESSEE, the LESSOR(S) Hereby let(s) and demise(s) unto the LESSEE the right to mine for manganese or other metallic ores (together with all other materials necessarily removed in said mining) the unpatented lode mining claims situated in the County of Polk, State of Arkansas, together with all appurtenances thereunto belonging, described on the instrument attached hereto designated as Exhibit "A" and made a part hereof and incorporated herein. To have and to hold unto the said LESSEE, his heirs and assigns for a term of five (5) years from the date hereof and as long thereafter as manganese ore is produced or mined from said claims by LESSEE, his heirs or assigns.

(2) LESSEE hereby agrees that during the term of this lease, he will do assessment work on the above described claim in compliance with statutory requirements for the benefit of the LESSOR(S) of at least One Hundred ($100.00) Dollars annually on or before June 30 of each year. The first assessment work under this lease shall be done on or before June 30, 195~~3~~. LESSEE further agrees to execute and file with the Circuit Clerk of the County in which the claim lies affidavits of assessment work done on the said mining claim for the benefit of the LESSOR(S). LESSEE may enter upon the said mining claims for exploratory and mining purposes and may take whatever steps he deems necessary in accordance with good mining practice to explore or mine said claim.

(3) In addition to doing the above mentioned assessment work, LESSEE agrees to pay to LESSOR(S) the sum of seven (7¢) cents per ton as royalty on all raw manganese ore removed from the said claims within sixty (60) days after said ore is removed; provided that it is hereby understood and agreed that as long as the aforementioned assessment work is done by the LESSEE that this lease shall remain in full force and effect and that LESSEE is under no obligation to mine the claim or to remove and sell the ore thereon.

(4) LESSEE agrees to furnish upon written request of LESSOR(S) records and accounts of the mining or exploratory activity on the said claims to the LESSOR(S).

(5) This lease may be terminated by the LESSEE at any time during the term thereof by giving notice of such termination to the LESSOR(S) at least sixty (60) days prior to the final date for doing the required assessment work for the mining year in which the lease is terminated. The words "mining year" as used in this paragraph shall be construed as commencing on July 1 and ending on June 30 and does not mean a calendar year.

(6) LESSOR(S) hereby agree(s) that the said LESSEE may assign this lease or sub-lease the mining claims under such terms as he sees fit; provided that the provisions of Paragraph (2) hereof shall be carried out by the said assignee or sub-lessee and provided further that if manganese ore is removed from the said mining claims that said

assignee or sub-lessee shall assume the obligation to pay and shall pay the seven (7¢) cents per ton royalty provided for in Paragraph (3) hereof.

(7) This agreement shall be binding upon the heirs, executors, administrators, successors and assigns of all parties hereto.

IN WITNESS WHEREOF the parties hereto have executed this agreement on this 5TH day of June, 1952.

Cecil B. Chenoweth, Agent, LESSEE

S. A. Wier

LESSORS

ACKNOWLEDGMENT

STATE OF ~~ARKANSAS~~ TEXAS
COUNTY OF DALLAS

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, S. A. Wier, to me well known to be the person(s) whose name(s) appears as Lessor(s) in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 29th day of August, 1952.

Maureen Massingill
Notary Public
(MAUREEN MASSINGILL)

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessee in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 5 day of June, 1952.

Clarice E. Decker
Notary Public

My comm. expires July 28, 1955.

Form 2299X-10922

COON CREEK GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This contract and lease made by and between Cecil B. Chenoweth, Agent, hereinafter called LESSOR, and Inland Mining Corporation, a corporation duly chartered under the laws of the State of Delaware, hereinafter called LESSEE,

W I T N E S S E T H:

WHEREAS, said LESSOR owns, controls, claims or holds under lease those certain mining claims situated in Polk County, Arkansas, described in the attached Exhibit "A", said exhibit being made a part hereof, and all of which claims are hereinafter known as "mining property"; and said LESSEE desires to obtain leasehold rights in said property;

NOW THEREFORE, in consideration of the sum of One ($1.00) Dollar, in hand paid by LESSEE to LESSOR, the receipt of which is hereby acknowledged, and the hereinafter recited reservations of interest in the property, and other good and sufficient consideration, including the mutual covenants and agreements herein contained, the LESSOR has leased, let and demised, and by these presents does lease, let and demise unto the said LESSEE the exclusive right to mine and operate solely for manganese and other metallic ores (together with all other materials necessarily removed in such mining), all of the mining property and claims described in said Exhibit "A", subject to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest and further subject to the reservations, conditions, terms, restrictions and agreements hereinafter set forth, to-wit:

(1) Subject to the other provisions hereof, the term of this lease shall be for five (5) years from the date hereof, and as long thereafter as manganese is produced or mined from said land by the LESSEE, its successors or assigns.

(2) LESSOR reserves unto himself absolutely all minerals other than metallic minerals lying on, in and under said mining property.

(3) LESSOR reserves unto himself and his respective heirs and assigns, as royalty, one-fourth (1/4) of all manganese and of all other metals, intending that such reservation shall cover and extend to all commercial materials produced, saved and made marketable from said mining property. Such royalty reservation in LESSOR is and shall be separate and apart and in addition to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest, and LESSEE assumes the obligations to pay and shall timely pay such original royalty or delay rentals of seven (7¢) cents per ton of raw manganese ore.

(4) LESSEE shall begin with reasonable promptness and continue thereafter with due diligence the exploration of said property in an orderly manner. LESSEE shall furnish reports to LESSOR, upon request, in appropriate written form, setting forth the information revealed by such exploration. LESSEE shall begin as early as practicable in accordance with its needs the mining of said property with the purpose and object of producing manganese therefrom, and shall continuously thereafter mine and remove from the property all ores commercially profitable for such purpose, and shall commercially process, clean, condition and concentrate all marketable products and by-products derived from such mining operations, all such commercially recovered materials, products and by-products produced and saved from said mining and processing being known herein as "products."

(5) LESSEE shall be obligated to process, clean, condition and concentrate all marketable products and by-products derived from mining operations on the mining properties and shall deliver over to LESSOR, his nominees and assigns, one-fourth (1/4) of all of the commercially recovered materials, products and by-products produced and saved from said mining and processing operations, as reserved royalty, free of all costs and expenses, and such deliveries shall be made in kind if LESSOR

so elects; if such election be not made, from time to time, with at least thirty (30) days notice in writing thereof, then LESSEE shall pay to LESSOR a sum in cash equal to the then established market value of such products. Delivery to LESSOR, his nominees or assigns of the said reserved royalty shall be made on or before the 20th day of each calendar month immediately following that month in which the same shall have been reduced to proper and acceptable commercial form, and shipped from the conditioning plant of LESSEE.

(6) LESSEE shall keep full and accurate records and books of account, showing the quantity of all ores mined and of all products derived therefrom, together with the market value of the latter, the amounts thereof shipped, the amounts thereof sold, and the sales volume thereof in money; and all such records and books shall be open to inspection by LESSOR and his agents at all reasonable business hours. Not later than the 20th day of each calendar month, LESSEE shall make reports in writing to LESSOR stating the quantity of ore mined, the quantity of ore processed, and the quantity, character and market value of all products derived therefrom and shipped during the calendar month immediately preceding the making of such report.

(7) LESSEE shall work and mine the leased property in the most effective, workmanlike and proper manner, according to the most approved and suitable methods and practices of modern mining and especially of modern strip mining, and in such manner as to ultimately recover the greatest amount of merchantable products reasonably recoverable from said property during the term of this lease; and during such term LESSEE shall allow to LESSOR full access to said property and to all mining operations thereon and also to all mills, plants and conditioning establishments processing ore from the leased property and operated by LESSEE or for its benefit wherever situated.

(8) LESSEE shall be privileged to build, erect, operate, remove, transport and employ any buildings, structures, bridges, dams, roads, machinery and equipment at any locations on the leased property as may be considered desirable, necessary or expedient thereby; and LESSEE may take from such property all materials and waters necessary in mining and processing ores removed therefrom.

(9) As part of the consideration for this lease and for the benefit of the LESSOR, LESSEE shall timely, fully and properly do all assessment work necessary and requisite by law and custom to adequately maintain in full force and effect all mining claims included in the leased property, and shall make and timely file full and complete statements and evidences of the assessment work done.

(10) At the option and election of LESSOR, this lease may be cancelled in the event that LESSEE is placed in receivership, or a petition in bankruptcy is filed against LESSEE, whether voluntary or involuntary, or if LESSEE makes a composition with creditors.

(11) This lease shall not be assigned by LESSEE unless permission for such assignment be given by LESSOR in writing; and LESSEE shall make no sub-lease or sub-leases concerning the mining property unless and until approval therefor has been given by LESSOR in writing.

(12) This lease shall inure to the benefit of and be binding upon the parties hereto and upon their respective heirs, assigns and successors.

WITNESS THE HANDS OF THE PARTIES on the 5th day of June, 1952.

Cecil B. Chenoweth

Cecil B. Chenoweth, Agent LESSOR

INLAND MINING CORPORATION

By Cecil B. Chenoweth

Vice Pres., & Gen. Mgr. LESSEE

ATTEST:

S.A. Wier

S.A. Wier- Secretary

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessor in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 5th. day of June, 1952.

Clarice E. Decker
Notary Public

My comm. expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this 5th day of June, 1952, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named Cecil B. Chenoweth, being the 1st. Vice President of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the 1st. Vice President of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this 5th. day of June, 1952.

Clarice E. Decker
Notary Public

My comm. expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 195___, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named _____, being the _____ of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the _____ of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this _____ day of _____, 195____.

_____
Notary Public

COPY

SUBORDINATION AGREEMENT AND CONSENT TO LIEN

KNOW ALL MEN BY THESE PRESENTS that:

WHEREAS, the "Undersigned" (as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller) have an interest in certain mining property in the State of Arkansas, County of Polk, hereinafter called "Property", said property being unpatented lode mining claims located on lands in the public domain; and the interest of the undersigned in said property includes the right to receive rentals and/or royalties on products mined and/or extracted therefrom; and the said property is the subject of a proposed Exploration Project Contract, hereinafter called "Contract", between the United States of America, hereinafter called the "Government", and Inland Mining Corporation, hereinafter called the "Operator"; and

WHEREAS, under certain provisions of said Contract which are set forth on the reverse side hereof, the Government will acquire certain rights and equities which do or may conflict with or be adverse to the interest of the undersigned in said property;

NOW THEREFORE, the undersigned, in consideration of said Contract and as an inducement to the Government and Operator to enter into same, undertakes and agrees as follows:

1. The Government's equity in and right to remove facilities, buildings, fixtures, and equipment, as provided in the Contract, shall prevail over and be prior and superior to any conflicting or adverse rights of the undersigned.

2. The Government's percentage royalty on net smelter returns or other net proceeds realized from ore, concentrates, or metal produced within ten (10) years from the date of the Contract, and the Government's lien for the payment of said percentage royalty shall attach to the mineral deposit and the production therefrom, in the amount of the Government's contribution, not in excess of $75,000.00, all upon the terms and conditions set forth in said Contract.

3. The undersigned shall commit no act nor assert any claim that may contravene or conflict with the lien, claim, or rights of the Government under the provisions of the said Contract. This agreement shall be binding upon the heirs, executors, administrators, successors, and assigns of the undersigned.

DATED this 1st day of July, 19[illegible]; and
EXECUTED by the "Undersigned" as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller, thus:

~~W. G. Parsons~~	Cecil B. Chenoweth, Agent
S. A. Wier	INLAND MINING CORPORATION By Cecil B. Chenoweth Vice President

No. 2299X-A-10919

OCT 8 1950
DEPARTMENT OF THE INTERIOR
Defense Materials Administration
RECEIVED

RELEVANT CONTRACT PROVISIONS

Title to and disposition of property. All facilities, buildings, fixtures, equipment, or other items costing more than $50 each, paid for or purchased with funds contributed jointly by the Operator and the Government, shall belong to the Operator and the Government jointly, in proportion to their respective contributions, and upon the termination of the contract, if they have any salvage value, shall be disposed of for their joint account unless the Government, in writing, waives its interest in any such items. The Government may require the dismantling, severance from land, and removal of any such items in order to realize its interest in the salvage value thereof, and the cost of any such removal and of the disposal of the items shall be for the joint account of the parties in proportion to their respective interests.

Repayment by Operator. If, upon the completion of the exploration project or termination of the contract, the Government considers that a discovery or development has resulted from the work from which commercial production of ore may be made, the Government, within 6 months thereafter, shall so certify to the Operator, particularly describing and delimiting its estimate of the discovery or the development. Thereafter, if and as ore is produced as a result of such discovery or development, the Operator and his successor in interest shall be and become obligated to pay to the Government a percentage royalty on the net smelter returns or other net proceeds realized from such ore, concentrates, or metal produced within ten (10) years from the date of this contract, until the total amount contributed by the Government, without interest, is fully repaid or said 10 years have elapsed, whichever occurs first, as follows:

> Of net smelter returns or other net proceeds not in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent.
>
> Of net smelter returns or other net proceeds in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent, plus one-half ($\frac{1}{2}$) percent for each additional full fifty cents ($0.50) in excess of eight dollars ($8.00) per ton of ore, but not in excess of a maximum of five (5) percent.

This obligation to repay from net returns or proceeds shall be and remain a claim and lien upon the mineral deposit which is the subject of the exploration project and upon any production resulting from such discovery or development, in favor of the Government, until fully paid, or until said 10-year period has elapsed; and this claim and lien and the Government's right to repayment shall survive any termination of the contract, whether by completion of the exploration project or otherwise. This article is not to be construed as imposing any obligation on the Operator or his successor in interest to produce ore from any such discovery or development.

EXHIBIT "A"

Mining claim #1 of the Coon Creek Group located by S. A. Wier and recorded in the Official Mining Records of the Recorder of Polk County, Arkansas in Book "I", Page 18.

Form 2299X-10921

COON CREEK GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This agreement made and entered into this 5th. day of June, 1952, by and between Cecil B. Chenoweth, Agent (hereinafter called LESSEE) and

S. A. Wier

(hereinafter called LESSOR(S)),

W I T N E S S E T H:

(1) That for and in consideration of the sum of One ($1.00) Dollar, receipt of which is hereby acknowledged, the mutual agreements hereinafter recited, and in further consideration of the royalties herein to be paid by the LESSEE, the LESSOR(S) Hereby let(s) and demise(s) unto the LESSEE the right to mine for manganese or other metallic ores (together with all other materials necessarily removed in said mining) the unpatented lode mining claims situated in the County of Polk, State of Arkansas, together with all appurtenances thereunto belonging, described on the instrument attached hereto designated as Exhibit "A" and made a part hereof and incorporated herein. To have and to hold unto the said LESSEE, his heirs and assigns for a term of five (5) years from the date hereof and as long thereafter as manganese ore is produced or mined from said claims by LESSEE, his heirs or assigns.

(2) LESSEE hereby agrees that during the term of this lease, he will do assessment work on the above described claim in compliance with statutory requirements for the benefit of the LESSOR(S) of at least One Hundred ($100.00) Dollars annually on or before June 30 of each year. The first assessment work under this lease shall be done on or before June 30, 1953. LESSEE further agrees to execute and file with the Circuit Clerk of the County in which the claim lies affidavits of assessment work done on the said mining claim for the benefit of the LESSOR(S). LESSEE may enter upon the said mining claims for exploratory and mining purposes and may take whatever steps he deems necessary in accordance with good mining practice to explore or mine said claim.

(3) In addition to doing the above mentioned assessment work, LESSEE agrees to pay to LESSOR(S) the sum of seven (7¢) cents per ton as royalty on all raw manganese ore removed from the said claims within sixty (60) days after said ore is removed; provided that it is hereby understood and agreed that as long as the aforementioned assessment work is done by the LESSEE that this lease shall remain in full force and effect and that LESSEE is under no obligation to mine the claim or to remove and sell the ore thereon.

(4) LESSEE agrees to furnish upon written request of LESSOR(S) records and accounts of the mining or exploratory activity on the said claims to the LESSOR(S).

(5) This lease may be terminated by the LESSEE at any time during the term thereof by giving notice of such termination to the LESSOR(S) at least sixty (60) days prior to the final date for doing the required assessment work for the mining year in which the lease is terminated. The words "mining year" as used in this paragraph shall be construed as commencing on July 1 and ending on June 30 and does not mean a calendar year.

(6) LESSOR(S) hereby agree(s) that the said LESSEE may assign this lease or sub-lease the mining claims under such terms as he sees fit; provided that the provisions of Paragraph (2) hereof shall be carried out by the said assignee or sub-lessee and provided further that if manganese ore is removed from the said mining claims that said

assignee or sub-lessee shall assume the obligation to pay and shall pay the seven (7¢) cents per ton royalty provided for in Paragraph (3) hereof.

(7) This agreement shall be binding upon the heirs, executors, administrators, successors and assigns of all parties hereto.

IN WITNESS WHEREOF the parties hereto have executed this agreement on this 5TH day of June, 1952.

Cecil B. Chenoweth, Agent, LESSEE

S. A. Wier

LESSORS

ACKNOWLEDGMENT

STATE OF ~~ARKANSAS~~ TEXAS
COUNTY OF DALLAS

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, S. A. Wier, to me well known to be the person(s) whose name(s) appear as Lessor(s) in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 29th day of August, 1952.

Maureen Massingill
Notary Public
(MAUREEN MASSINGILL)

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessee in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 5 day of June, 1952.

Clarice E. Lecke
Notary Public

My comm. expires July 28, 1955.

Form 2299X-10922

COON CREEK GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This contract and lease made by and between Cecil B. Chenoweth, Agent, hereinafter called LESSOR, and Inland Mining Corporation, a corporation duly chartered under the laws of the State of Delaware, hereinafter called LESSEE,

W I T N E S S E T H:

WHEREAS, said LESSOR owns, controls, claims or holds under lease those certain mining claims situated in Polk County, Arkansas, described in the attached Exhibit "A", said exhibit being made a part hereof, and all of which claims are hereinafter known as "mining property"; and said LESSEE desires to obtain leasehold rights in said property;

NOW THEREFORE, in consideration of the sum of One ($1.00) Dollar, in hand paid by LESSEE to LESSOR, the receipt of which is hereby acknowledged, and the hereinafter recited reservations of interest in the property, and other good and sufficient consideration, including the mutual covenants and agreements herein contained, the LESSOR has leased, let and demised, and by these presents does lease, let and demise unto the said LESSEE the exclusive right to mine and operate solely for manganese and other metallic ores (together with all other materials necessarily removed in such mining), all of the mining property and claims described in said Exhibit "A", subject to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest and further subject to the reservations, conditions, terms, restrictions and agreements hereinafter set forth, to-wit:

(1) Subject to the other provisions hereof, the term of this lease shall be for five (5) years from the date hereof, and as long thereafter as manganese is produced or mined from said land by the LESSEE, its successors or assigns.

(2) LESSOR reserves unto himself absolutely all minerals other than metallic minerals lying on, in and under said mining property.

(3) LESSOR reserves unto himself and his respective heirs and assigns, as royalty, one-fourth (1/4) of all manganese and of all other metals, intending that such reservation shall cover and extend to all commercial materials produced, saved and made marketable from said mining property. Such royalty reservation in LESSOR is and shall be separate and apart and in addition to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest, and LESSEE assumes the obligations to pay and shall timely pay such original royalty or delay rentals of seven (7¢) cents per ton of raw manganese ore.

(4) LESSEE shall begin with reasonable promptness and continue thereafter with due diligence the exploration of said property in an orderly manner. LESSEE shall furnish reports to LESSOR, upon request, in appropriate written form, setting forth the information revealed by such exploration. LESSEE shall begin as early as practicable in accordance with its needs the mining of said property with the purpose and object of producing manganese therefrom, and shall continuously thereafter mine and remove from the property all ores commercially profitable for such purpose, and shall commercially process, clean, condition and concentrate all marketable products and by-products derived from such mining operations, all such commercially recovered materials, products and by-products produced and saved from said mining and processing being known herein as "products."

(5) LESSEE shall be obligated to process, clean, condition and concentrate all marketable products and by-products derived from mining operations on the mining properties and shall deliver over to LESSOR, his nominees and assigns, one-fourth (1/4) of all of the commercially recovered materials, products and by-products produced and saved from said mining and processing operations, as reserved royalty, free of all costs and expenses, and such deliveries shall be made in kind if LESSOR

so elects; if such election be not made, from time to time, with at least thirty (30) days notice in writing thereof, then LESSEE shall pay to LESSOR a sum in cash equal to the then established market value of such products. Delivery to LESSOR, his nominees or assigns of the said reserved royalty shall be made on or before the 20th day of each calendar month immediately following that month in which the same shall have been reduced to proper and acceptable commercial form, and shipped from the conditioning plant of LESSEE.

(6) LESSEE shall keep full and accurate records and books of account, showing the quantity of all ores mined and of all products derived therefrom, together with the market value of the latter, the amounts thereof shipped, the amounts thereof sold, and the sales volume thereof in money; and all such records and books shall be open to inspection by LESSOR and his agents at all reasonable business hours. Not later than the 20th day of each calendar month, LESSEE shall make reports in writing to LESSOR stating the quantity of ore mined, the quantity of ore processed, and the quantity, character and market value of all products derived therefrom and shipped during the calendar month immediately preceding the making of such report.

(7) LESSEE shall work and mine the leased property in the most effective, workmanlike and proper manner, according to the most approved and suitable methods and practices of modern mining and especially of modern strip mining, and in such manner as to ultimately recover the greatest amount of merchantable products reasonably recoverable from said property during the term of this lease; and during such term LESSEE shall allow to LESSOR full access to said property and to all mining operations thereon and also to all mills, plants and conditioning establishments processing ore from the leased property and operated by LESSEE or for its benefit wherever situated.

(8) LESSEE shall be privileged to build, erect, operate, remove, transport and employ any buildings, structures, bridges, dams, roads, machinery and equipment at any locations on the leased property as may be considered desirable, necessary or expedient thereby; and LESSEE may take from such property all materials and waters necessary in mining and processing ores removed therefrom.

(9) As part of the consideration for this lease and for the benefit of the LESSOR, LESSEE shall timely, fully and properly do all assessment work necessary and requisite by law and custom to adequately maintain in full force and effect all mining claims included in the leased property, and shall make and timely file full and complete statements and evidences of the assessment work done.

(10) At the option and election of LESSOR, this lease may be cancelled in the event that LESSEE is placed in receivership, or a petition in bankruptcy is filed against LESSEE, whether voluntary or involuntary, or if LESSEE makes a composition with creditors.

(11) This lease shall not be assigned by LESSEE unless permission for such assignment be given by LESSOR in writing; and LESSEE shall make no sub-lease or sub-leases concerning the mining property unless and until approval therefor has been given by LESSOR in writing.

(12) This lease shall inure to the benefit of and be binding upon the parties hereto and upon their respective heirs, assigns and successors.

WITNESS THE HANDS OF THE PARTIES on the 5th day of June, 1952.

Cecil B. Chenoweth

Cecil B. Chenoweth, Agent LESSOR

INLAND MINING CORPORATION

By Cecil B. Chenoweth

Vice Pres & Gen. Mgr. LESSEE

ATTEST:

S. A. Wier

S. A. Wier, Secretary

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF ~~POLK~~

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, ~~Cecil B. Chenoweth~~, to me well known to be the person whose name appears as Lessor in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this ~~5th.~~ day of ~~June~~, 195~~2~~.

Clarice E. Decker
Notary Public

My com. expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF ~~POLK~~

On this ~~5th.~~ day of ~~June~~, 195~~2~~, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named ~~Cecil B. Chenoweth~~, being the ~~1st. Vice President~~ of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the ~~1st. Vice President~~ of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this ~~5th.~~ day of ~~June~~, 195~~2~~.

Clarice E. Decker
Notary Public

My com. expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 195___, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named _____, being the _____ of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the _____ of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this _____ day of _____, 195____.

_____
Notary Public

COON CREEK GROUP

SUBORDINATION AGREEMENT AND CONSENT TO LIEN

KNOW ALL MEN BY THESE PRESENTS that:

WHEREAS, the "Undersigned" (as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller) have an interest in certain mining property in the State of Arkansas, County of Polk, hereinafter called "Property", said property being unpatented lode mining claims located on lands in the public domain; and the interest of the undersigned in said property includes the right to receive rentals and/or royalties on products mined and/or extracted therefrom; and the said property is the subject of a proposed Exploration Project Contract, hereinafter called "Contract", between the United States of America, hereinafter called the "Government", and Inland Mining Corporation, hereinafter called the "Operator"; and

WHEREAS, under certain provisions of said Contract which are set forth on the reverse side hereof, the Government will acquire certain rights and equities which do or may conflict with or be adverse to the interest of the undersigned in said property;

NOW THEREFORE, the undersigned, in consideration of said Contract and as an inducement to the Government and Operator to enter into same, undertakes and agrees as follows:

1. The Government's equity in and right to remove facilities, buildings, fixtures, and equipment, as provided in the Contract, shall prevail over and be prior and superior to any conflicting or adverse rights of the undersigned.

2. The Government's percentage royalty on net smelter returns or other net proceeds realized from ore, concentrates, or metal produced within ten (10) years from the date of the Contract, and the Government's lien for the payment of said percentage royalty shall attach to the mineral deposit and the production therefrom, in the amount of the Government's contribution, not in excess of $75,000.00, all upon the terms and conditions set forth in said Contract.

3. The undersigned shall commit no act nor assert any claim that may contravene or conflict with the lien, claim, or rights of the Government under the provisions of the said Contract. This agreement shall be binding upon the heirs, executors, administrators, successors, and assigns of the undersigned.

DATED this 1st. day of July, 1952; and
EXECUTED by the "Undersigned" as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller, thus:

W. S. Parsons	Cecil D. Chenoweth, Agent
S. A. Wier	INLAND MINING CORPORATION By Cecil D. Chenoweth Vice President

No. 2299X-A-10919

RELEVANT CONTRACT PROVISIONS

Title to and disposition of property. All facilities, buildings, fixtures, equipment, or other items costing more than $50 each, paid for or purchased with funds contributed jointly by the Operator and the Government, shall belong to the Operator and the Government jointly, in proportion to their respective contributions, and upon the termination of the contract, if they have any salvage value, shall be disposed of for their joint account unless the Government, in writing, waives its interest in any such items. The Government may require the dismantling, severance from land, and removal of any such items in order to realize its interest in the salvage value thereof, and the cost of any such removal and of the disposal of the items shall be for the joint account of the parties in proportion to their respective interests.

Repayment by Operator. If, upon the completion of the exploration project or termination of the contract, the Government considers that a discovery or development has resulted from the work from which commercial production of ore may be made, the Government, within 6 months thereafter, shall so certify to the Operator, particularly describing and delimiting its estimate of the discovery or the development. Thereafter, if and as ore is produced as a result of such discovery or development, the Operator and his successor in interest shall be and become obligated to pay to the Government a percentage royalty on the net smelter returns or other net proceeds realized from such ore, concentrates, or metal produced within ten (10) years from the date of this contract, until the total amount contributed by the Government, without interest, is fully repaid or said 10 years have elapsed, whichever occurs first, as follows:

> Of net smelter returns or other net proceeds not in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent.
>
> Of net smelter returns or other net proceeds in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent, plus one-half ($\frac{1}{2}$) percent for each additional full fifty cents ($0.50) in excess of eight dollars ($8.00) per ton of ore, but not in excess of a maximum of five (5) percent.

This obligation to repay from net returns or proceeds shall be and remain a claim and lien upon the mineral deposit which is the subject of the exploration project and upon any production resulting from such discovery or development, in favor of the Government, until fully paid, or until said 10-year period has elapsed; and this claim and lien and the Government's right to repayment shall survive any termination of the contract, whether by completion of the exploration project or otherwise. This article is not to be construed as imposing any obligation on the Operator or his successor in interest to produce ore from any such discovery or development.

EXHIBIT "A"

Mining claim #1 of the Coon Creek Group located by S. A. Wier and recorded in the Official Mining Records of the Recorder of Polk County, Arkansas in Book "I", Page 18.

Form 2299X-10921

COON CREEK GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This agreement made and entered into this 5 day of June, 195 2, by and between Cecil B. Chenoweth, Agent (hereinafter called LESSEE) and

S.A. Wier

(hereinafter called LESSOR(S)),

W I T N E S S E T H:

(1) That for and in consideration of the sum of One ($1.00) Dollar, receipt of which is hereby acknowledged, the mutual agreements hereinafter recited, and in further consideration of the royalties herein to be paid by the LESSEE, the LESSOR(S) Hereby let(s) and demise(s) unto the LESSEE the right to mine for manganese or other metallic ores (together with all other materials necessarily removed in said mining) the unpatented lode mining claims situated in the County of Polk, State of Arkansas, together with all appurtenances thereunto belonging, described on the instrument attached hereto designated as Exhibit "A" and made a part hereof and incorporated herein. To have and to hold unto the said LESSEE, his heirs and assigns for a term of five (5) years from the date hereof and as long thereafter as manganese ore is produced or mined from said claims by LESSEE, his heirs or assigns.

(2) LESSEE hereby agrees that during the term of this lease, he will do assessment work on the above described claim in compliance with statutory requirements for the benefit of the LESSOR(S) of at least One Hundred ($100.00) Dollars annually on or before June 30 of each year. The first assessment work under this lease shall be done on or before June 30, 195 3. LESSEE further agrees to execute and file with the Circuit Clerk of the County in which the claim lies affidavits of assessment work done on the said mining claim for the benefit of the LESSOR(S). LESSEE may enter upon the said mining claims for exploratory and mining purposes and may take whatever steps he deems necessary in accordance with good mining practice to explore or mine said claim.

(3) In addition to doing the above mentioned assessment work, LESSEE agrees to pay to LESSOR(S) the sum of seven (7¢) cents per ton as royalty on all raw manganese ore removed from the said claims within sixty (60) days after said ore is removed; provided that it is hereby understood and agreed that as long as the aforementioned assessment work is done by the LESSEE that this lease shall remain in full force and effect and that LESSEE is under no obligation to mine the claim or to remove and sell the ore thereon.

(4) LESSEE agrees to furnish upon written request of LESSOR(S) records and accounts of the mining or exploratory activity on the said claims to the LESSOR(S).

(5) This lease may be terminated by the LESSEE at any time during the term thereof by giving notice of such termination to the LESSOR(S) at least sixty (60) days prior to the final date for doing the required assessment work for the mining year in which the lease is terminated. The words "mining year" as used in this paragraph shall be construed as commencing on July 1 and ending on June 30 and does not mean a calendar year.

(6) LESSOR(S) hereby agree(s) that the said LESSEE may assign this lease or sub-lease the mining claims under such terms as he sees fit; provided that the provisions of Paragraph (2) hereof shall be carried out by the said assignee or sub-lessee and provided further that if manganese ore is removed from the said mining claims that said

assignee or sub-lessee shall assume the obligation to pay and shall pay the seven (7¢) cents per ton royalty provided for in Paragraph (3) hereof.

(7) This agreement shall be binding upon the heirs, executors, administrators, successors and assigns of all parties hereto.

IN WITNESS WHEREOF the parties hereto have executed this agreement on this 5th. day of June, 1952.

Cecil B. Chenoweth
Cecil B. Chenoweth, Agent, LESSEE

S. A. Wier
S. A. Wier

LESSORS

ACKNOWLEDGMENT

STATE OF ~~ARKANSAS~~ TEXAS
COUNTY OF DALLAS

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, S. A. Wier, to me well known to be the person(s) whose name(s) appears as Lessor(s) in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 29th day of August, 1952.

Maureen Massingill
Notary Public
(MAUREEN MASSINGILL)

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessee in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 5th. day of June, 1952.

Clarice E. Decker
Notary Public

My comm. expires July 28, 1955.

Form 2299X-10922

COON CREEK GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This contract and lease made by and between Cecil B. Chenoweth, Agent, hereinafter called LESSOR, and Inland Mining Corporation, a corporation duly chartered under the laws of the State of Delaware, hereinafter called LESSEE,

W I T N E S S E T H:

WHEREAS, said LESSOR owns, controls, claims or holds under lease those certain mining claims situated in Polk County, Arkansas, described in the attached Exhibit "A", said exhibit being made a part hereof, and all of which claims are hereinafter known as "mining property"; and said LESSEE desires to obtain leasehold rights in said property;

NOW THEREFORE, in consideration of the sum of One ($1.00) Dollar, in hand paid by LESSEE to LESSOR, the receipt of which is hereby acknowledged, and the hereinafter recited reservations of interest in the property, and other good and sufficient consideration, including the mutual covenants and agreements herein contained, the LESSOR has leased, let and demised, and by these presents does lease, let and demise unto the said LESSEE the exclusive right to mine and operate solely for manganese and other metallic ores (together with all other materials necessarily removed in such mining), all of the mining property and claims described in said Exhibit "A", subject to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest and further subject to the reservations, conditions, terms, restrictions and agreements hereinafter set forth, to-wit:

(1) Subject to the other provisions hereof, the term of this lease shall be for five (5) years from the date hereof, and as long thereafter as manganese is produced or mined from said land by the LESSEE, its successors or assigns.

(2) LESSOR reserves unto himself absolutely all minerals other than metallic minerals lying on, in and under said mining property.

(3) LESSOR reserves unto himself and his respective heirs and assigns, as royalty, one-fourth (1/4) of all manganese and of all other metals, intending that such reservation shall cover and extend to all commercial materials produced, saved and made marketable from said mining property. Such royalty reservation in LESSOR is and shall be separate and apart and in addition to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest, and LESSEE assumes the obligations to pay and shall timely pay such original royalty or delay rentals of seven (7¢) cents per ton of raw manganese ore.

(4) LESSEE shall begin with reasonable promptness and continue thereafter with due diligence the exploration of said property in an orderly manner. LESSEE shall furnish reports to LESSOR, upon request, in appropriate written form, setting forth the information revealed by such exploration. LESSEE shall begin as early as practicable in accordance with its needs the mining of said property with the purpose and object of producing manganese therefrom, and shall continuously thereafter mine and remove from the property all ores commercially profitable for such purpose, and shall commercially process, clean, condition and concentrate all marketable products and by-products derived from such mining operations, all such commercially recovered materials, products and by-products produced and saved from said mining and processing being known herein as "products."

(5) LESSEE shall be obligated to process, clean, condition and concentrate all marketable products and by-products derived from mining operations on the mining properties and shall deliver over to LESSOR, his nominees and assigns, one-fourth (1/4) of all of the commercially recovered materials, products and by-products produced and saved from said mining and processing operations, as reserved royalty, free of all costs and expenses, and such deliveries shall be made in kind if LESSOR

so elects; if such election be not made, from time to time, with at least thirty (30) days notice in writing thereof, then LESSEE shall pay to LESSOR a sum in cash equal to the then established market value of such products. Delivery to LESSOR, his nominees or assigns of the said reserved royalty shall be made on or before the 20th day of each calendar month immediately following that month in which the same shall have been reduced to proper and acceptable commercial form, and shipped from the conditioning plant of LESSEE.

(6) LESSEE shall keep full and accurate records and books of account, showing the quantity of all ores mined and of all products derived therefrom, together with the market value of the latter, the amounts thereof shipped, the amounts thereof sold, and the sales volume thereof in money; and all such records and books shall be open to inspection by LESSOR and his agents at all reasonable business hours. Not later than the 20th day of each calendar month, LESSEE shall make reports in writing to LESSOR stating the quantity of ore mined, the quantity of ore processed, and the quantity, character and market value of all products derived therefrom and shipped during the calendar month immediately preceding the making of such report.

(7) LESSEE shall work and mine the leased property in the most effective, workmanlike and proper manner, according to the most approved and suitable methods and practices of modern mining and especially of modern strip mining, and in such manner as to ultimately recover the greatest amount of merchantable products reasonably recoverable from said property during the term of this lease; and during such term LESSEE shall allow to LESSOR full access to said property and to all mining operations thereon and also to all mills, plants and conditioning establishments processing ore from the leased property and operated by LESSEE or for its benefit wherever situated.

(8) LESSEE shall be privileged to build, erect, operate, remove, transport and employ any buildings, structures, bridges, dams, roads, machinery and equipment at any locations on the leased property as may be considered desirable, necessary or expedient thereby; and LESSEE may take from such property all materials and waters necessary in mining and processing ores removed therefrom.

(9) As part of the consideration for this lease and for the benefit of the LESSOR, LESSEE shall timely, fully and properly do all assessment work necessary and requisite by law and custom to adequately maintain in full force and effect all mining claims included in the leased property, and shall make and timely file full and complete statements and evidences of the assessment work done.

(10) At the option and election of LESSOR, this lease may be cancelled in the event that LESSEE is placed in receivership, or a petition in bankruptcy is filed against LESSEE, whether voluntary or involuntary, or if LESSEE makes a composition with creditors.

(11) This lease shall not be assigned by LESSEE unless permission for such assignment be given by LESSOR in writing; and LESSEE shall make no sub-lease or sub-leases concerning the mining property unless and until approval therefor has been given by LESSOR in writing.

(12) This lease shall inure to the benefit of and be binding upon the parties hereto and upon their respective heirs, assigns and successors.

WITNESS THE HANDS OF THE PARTIES on the 5th day of June, 1952.

Cecil B. Chenoweth

Cecil B. Chenoweth, Agent LESSOR

INLAND MINING CORPORATION

By Cecil B. Chenoweth

Vice Pres & Gen. Mgr. LESSEE

ATTEST:

S. A. Wier

S. A. Wier Secretary

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessor in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 5th. day of June, 1952.

Clarice E. Decker
Notary Public

My com. expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this 5th. day of June, 1952, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named Cecil B. Chenoweth, being the 1st. Vice President of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the 1st. Vice President of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this 5th. day of June, 1952.

Clarice E. Decker
Notary Public

My com. expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 195___, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named _____, being the _____ of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the _____ of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this _____ day of _____, 195____.

_____
Notary Public

COON CREEK GROUP

SUBORDINATION AGREEMENT AND CONSENT TO LIEN

KNOW ALL MEN BY THESE PRESENTS that:

WHEREAS, the "Undersigned" (as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller) have an interest in certain mining property in the State of Arkansas, County of Polk, hereinafter called "Property", said property being unpatented lode mining claims located on lands in the public domain; and the interest of the undersigned in said property includes the right to receive rentals and/or royalties on products mined and/or extracted therefrom; and the said property is the subject of a proposed Exploration Project Contract, hereinafter called "Contract", between the United States of America, hereinafter called the "Government", and Inland Mining Corporation, hereinafter called the "Operator"; and

WHEREAS, under certain provisions of said Contract which are set forth on the reverse side hereof, the Government will acquire certain rights and equities which do or may conflict with or be adverse to the interest of the undersigned in said property;

NOW THEREFORE, the undersigned, in consideration of said Contract and as an inducement to the Government and Operator to enter into same, undertakes and agrees as follows:

1. The Government's equity in and right to remove facilities, buildings, fixtures, and equipment, as provided in the Contract, shall prevail over and be prior and superior to any conflicting or adverse rights of the undersigned.

2. The Government's percentage royalty on net smelter returns or other net proceeds realized from ore, concentrates, or metal produced within ten (10) years from the date of the Contract, and the Government's lien for the payment of said percentage royalty shall attach to the mineral deposit and the production therefrom, in the amount of the Government's contribution, not in excess of $75,000.00, all upon the terms and conditions set forth in said Contract.

3. The undersigned shall commit no act nor assert any claim that may contravene or conflict with the lien, claim, or rights of the Government under the provisions of the said Contract. This agreement shall be binding upon the heirs, executors, administrators, successors, and assigns of the undersigned.

DATED this 1st. day of July, 1952; and
EXECUTED by the "Undersigned" as claimant, owner, co-owner, assignor, assignee, lessor, lessee or seller, thus:

W. S. Parsons

Cecil B. Chenoweth, Agent

S. A. Wier

INLAND MINING CORPORATION
By Cecil B. Chenoweth
Vice President

No. 2299X-A-10919

OCT 8 1953

RELEVANT CONTRACT PROVISIONS

Title to and disposition of property. All facilities, buildings, fixtures, equipment, or other items costing more than $50 each, paid for or purchased with funds contributed jointly by the Operator and the Government, shall belong to the Operator and the Government jointly, in proportion to their respective contributions, and upon the termination of the contract, if they have any salvage value, shall be disposed of for their joint account unless the Government, in writing, waives its interest in any such items. The Government may require the dismantling, severance from land, and removal of any such items in order to realize its interest in the salvage value thereof, and the cost of any such removal and of the disposal of the items shall be for the joint account of the parties in proportion to their respective interests.

Repayment by Operator. If, upon the completion of the exploration project or termination of the contract, the Government considers that a discovery or development has resulted from the work from which commercial production of ore may be made, the Government, within 6 months thereafter, shall so certify to the Operator, particularly describing and delimiting its estimate of the discovery or the development. Thereafter, if and as ore is produced as a result of such discovery or development, the Operator and his successor in interest shall be and become obligated to pay to the Government a percentage royalty on the net smelter returns or other net proceeds realized from such ore, concentrates, or metal produced within ten (10) years from the date of this contract, until the total amount contributed by the Government, without interest, is fully repaid or said 10 years have elapsed, whichever occurs first, as follows:

> Of net smelter returns or other net proceeds not in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent.
>
> Of net smelter returns or other net proceeds in excess of eight dollars ($8.00) per ton of ore: One and one-half ($1\frac{1}{2}$) percent, plus one-half ($\frac{1}{2}$) percent for each additional full fifty cents ($0.50) in excess of eight dollars ($8.00) per ton of ore, but not in excess of a maximum of five (5) percent.

This obligation to repay from net returns or proceeds shall be and remain a claim and lien upon the mineral deposit which is the subject of the exploration project and upon any production resulting from such discovery or development, in favor of the Government, until fully paid, or until said 10-year period has elapsed; and this claim and lien and the Government's right to repayment shall survive any termination of the contract, whether by completion of the exploration project or otherwise. This article is not to be construed as imposing any obligation on the Operator or his successor in interest to produce ore from any such discovery or development.

EXHIBIT "A"

Mining claim #1 of the Coon Creek Group located by S. A. Wier and recorded in the Official Mining Records of the Recorder of Polk County, Arkansas in Book "I", Page 18.

Form 2299X-10921

COON CREEK GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This agreement made and entered into this 5 day of June, 195 2, by and between Cecil B. Chenoweth, Agent (hereinafter called LESSEE) and

S.A. Wier

(hereinafter called LESSOR(S)),

W I T N E S S E T H:

(1) That for and in consideration of the sum of One ($1.00) Dollar, receipt of which is hereby acknowledged, the mutual agreements hereinafter recited, and in further consideration of the royalties herein to be paid by the LESSEE, the LESSOR(S) Hereby let(s) and demise(s) unto the LESSEE the right to mine for manganese or other metallic ores (together with all other materials necessarily removed in said mining) the unpatented lode mining claims situated in the County of Polk, State of Arkansas, together with all appurtenances thereunto belonging, described on the instrument attached hereto designated as Exhibit "A" and made a part hereof and incorporated herein. To have and to hold unto the said LESSEE, his heirs and assigns for a term of five (5) years from the date hereof and as long thereafter as manganese ore is produced or mined from said claims by LESSEE, his heirs or assigns.

(2) LESSEE hereby agrees that during the term of this lease, he will do assessment work on the above described claim in compliance with statutory requirements for the benefit of the LESSOR(S) of at least One Hundred ($100.00) Dollars annually on or before June 30 of each year. The first assessment work under this lease shall be done on or before June 30, 195 3. LESSEE further agrees to execute and file with the Circuit Clerk of the County in which the claim lies affidavits of assessment work done on the said mining claim for the benefit of the LESSOR(S). LESSEE may enter upon the said mining claims for exploratory and mining purposes and may take whatever steps he deems necessary in accordance with good mining practice to explore or mine said claim.

(3) In addition to doing the above mentioned assessment work, LESSEE agrees to pay to LESSOR(S) the sum of seven (7¢) cents per ton as royalty on all raw manganese ore removed from the said claims within sixty (60) days after said ore is removed; provided that it is hereby understood and agreed that as long as the aforementioned assessment work is done by the LESSEE that this lease shall remain in full force and effect and that LESSEE is under no obligation to mine the claim or to remove and sell the ore thereon.

(4) LESSEE agrees to furnish upon written request of LESSOR(S) records and accounts of the mining or exploratory activity on the said claims to the LESSOR(S).

(5) This lease may be terminated by the LESSEE at any time during the term thereof by giving notice of such termination to the LESSOR(S) at least sixty (60) days prior to the final date for doing the required assessment work for the mining year in which the lease is terminated. The words "mining year" as used in this paragraph shall be construed as commencing on July 1 and ending on June 30 and does not mean a calendar year.

(6) LESSOR(S) hereby agree(s) that the said LESSEE may assign this lease or sub-lease the mining claims under such terms as he sees fit; provided that the provisions of Paragraph (2) hereof shall be carried out by the said assignee or sub-lessee and provided further that if manganese ore is removed from the said mining claims that said

assignee or sub-lessee shall assume the obligation to pay and shall pay the seven (7¢) cents per ton royalty provided for in Paragraph (3) hereof.

(7) This agreement shall be binding upon the heirs, executors, administrators, successors and assigns of all parties hereto.

IN WITNESS WHEREOF the parties hereto have executed this agreement on this 5th. day of June, 1952.

Cecil B. Chenoweth
Cecil B. Chenoweth, Agent, LESSEE

S. A. Wier S. A. Wier

LESSORS

ACKNOWLEDGMENT

STATE OF ~~ARKANSAS~~ TEXAS
COUNTY OF DALLAS

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, S. A. Wier, to me well known to be the person(s) whose name(s) appears as Lessor(s) in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 29th day of August, 1952.

Maureen Massingill
Notary Public
(MAUREEN MASSINGILL)

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessee in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 5th. day of June, 1952.

Clarice E. Decker
Notary Public

My comm. expires July 28, 1955.

Form 2299X-10922

COON CREEK GROUP

MINING LEASE

KNOW ALL MEN BY THESE PRESENTS:

This contract and lease made by and between Cecil B. Chenoweth, Agent, hereinafter called LESSOR, and Inland Mining Corporation, a corporation duly chartered under the laws of the State of Delaware, hereinafter called LESSEE,

W I T N E S S E T H:

WHEREAS, said LESSOR owns, controls, claims or holds under lease those certain mining claims situated in Polk County, Arkansas, described in the attached Exhibit "A", said exhibit being made a part hereof, and all of which claims are hereinafter known as "mining property"; and said LESSEE desires to obtain leasehold rights in said property;

NOW THEREFORE, in consideration of the sum of One ($1.00) Dollar, in hand paid by LESSEE to LESSOR, the receipt of which is hereby acknowledged, and the hereinafter recited reservations of interest in the property, and other good and sufficient consideration, including the mutual covenants and agreements herein contained, the LESSOR has leased, let and demised, and by these presents does lease, let and demise unto the said LESSEE the exclusive right to mine and operate solely for manganese and other metallic ores (together with all other materials necessarily removed in such mining), all of the mining property and claims described in said Exhibit "A", subject to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest and further subject to the reservations, conditions, terms, restrictions and agreements hereinafter set forth, to-wit:

(1) Subject to the other provisions hereof, the term of this lease shall be for five (5) years from the date hereof, and as long thereafter as manganese is produced or mined from said land by the LESSEE, its successors or assigns.

(2) LESSOR reserves unto himself absolutely all minerals other than metallic minerals lying on, in and under said mining property.

(3) LESSOR reserves unto himself and his respective heirs and assigns, as royalty, one-fourth (1/4) of all manganese and of all other metals, intending that such reservation shall cover and extend to all commercial materials produced, saved and made marketable from said mining property. Such royalty reservation in LESSOR is and shall be separate and apart and in addition to the original royalty or delay rentals required to be paid to LESSOR's predecessors in interest, and LESSEE assumes the obligations to pay and shall timely pay such original royalty or delay rentals of seven (7¢) cents per ton of raw manganese ore.

(4) LESSEE shall begin with reasonable promptness and continue thereafter with due diligence the exploration of said property in an orderly manner. LESSEE shall furnish reports to LESSOR, upon request, in appropriate written form, setting forth the information revealed by such exploration. LESSEE shall begin as early as practicable in accordance with its needs the mining of said property with the purpose and object of producing manganese therefrom, and shall continuously thereafter mine and remove from the property all ores commercially profitable for such purpose, and shall commercially process, clean, condition and concentrate all marketable products and by-products derived from such mining operations, all such commercially recovered materials, products and by-products produced and saved from said mining and processing being known herein as "products."

(5) LESSEE shall be obligated to process, clean, condition and concentrate all marketable products and by-products derived from mining operations on the mining properties and shall deliver over to LESSOR, his nominees and assigns, one-fourth (1/4) of all of the commercially recovered materials, products and by-products produced and saved from said mining and processing operations, as reserved royalty, free of all costs and expenses, and such deliveries shall be made in kind if LESSOR

so elects; if such election be not made, from time to time, with at least thirty (30) days notice in writing thereof, then LESSEE shall pay to LESSOR a sum in cash equal to the then established market value of such products. Delivery to LESSOR, his nominees or assigns of the said reserved royalty shall be made on or before the 20th day of each calendar month immediately following that month in which the same shall have been reduced to proper and acceptable commercial form, and shipped from the conditioning plant of LESSEE.

(6) LESSEE shall keep full and accurate records and books of account, showing the quantity of all ores mined and of all products derived therefrom, together with the market value of the latter, the amounts thereof shipped, the amounts thereof sold, and the sales volume thereof in money; and all such records and books shall be open to inspection by LESSOR and his agents at all reasonable business hours. Not later than the 20th day of each calendar month, LESSEE shall make reports in writing to LESSOR stating the quantity of ore mined, the quantity of ore processed, and the quantity, character and market value of all products derived therefrom and shipped during the calendar month immediately preceding the making of such report.

(7) LESSEE shall work and mine the leased property in the most effective, workmanlike and proper manner, according to the most approved and suitable methods and practices of modern mining and especially of modern strip mining, and in such manner as to ultimately recover the greatest amount of merchantable products reasonably recoverable from said property during the term of this lease; and during such term LESSEE shall allow to LESSOR full access to said property and to all mining operations thereon and also to all mills, plants and conditioning establishments processing ore from the leased property and operated by LESSEE or for its benefit wherever situated.

(8) LESSEE shall be privileged to build, erect, operate, remove, transport and employ any buildings, structures, bridges, dams, roads, machinery and equipment at any locations on the leased property as may be considered desirable, necessary or expedient thereby; and LESSEE may take from such property all materials and waters necessary in mining and processing ores removed therefrom.

(9) As part of the consideration for this lease and for the benefit of the LESSOR, LESSEE shall timely, fully and properly do all assessment work necessary and requisite by law and custom to adequately maintain in full force and effect all mining claims included in the leased property, and shall make and timely file full and complete statements and evidences of the assessment work done.

(10) At the option and election of LESSOR, this lease may be cancelled in the event that LESSEE is placed in receivership, or a petition in bankruptcy is filed against LESSEE, whether voluntary or involuntary, or if LESSEE makes a composition with creditors.

(11) This lease shall not be assigned by LESSEE unless permission for such assignment be given by LESSOR in writing; and LESSEE shall make no sub-lease or sub-leases concerning the mining property unless and until approval therefor has been given by LESSOR in writing.

(12) This lease shall inure to the benefit of and be binding upon the parties hereto and upon their respective heirs, assigns and successors.

WITNESS THE HANDS OF THE PARTIES on the 5th day of June, 1952.

Cecil B. Chenoweth
Cecil B. Chenoweth, Agent LESSOR

INLAND MINING CORPORATION

By Cecil B. Chenoweth
Vice Pres., & Gen. Mgr. LESSEE

ATTEST:

S.A. Wier
S.A. Wier, Secretary

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this day personally appeared before the undersigned, a Notary Public in and for the County and State aforesaid, duly qualified and acting, Cecil B. Chenoweth, to me well known to be the person whose name appears as Lessor in the foregoing instrument, and stated that he had executed the same for the consideration, uses and purposes therein mentioned and set forth.

IN WITNESS WHEREOF I have hereunto set my hand and seal as such on this 5th. day of June, 1952.

Clarice E. Decker
Notary Public

My comm. expires July 28, 1955.

ACKNOWLEDGMENT

STATE OF ARKANSAS
COUNTY OF POLK

On this 5th day of June, 1952, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named Cecil B. Chenoweth, being the 1st. Vice President of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the 1st. Vice President of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this 5th. day of June, 1952.

Clarice E. Decker
Notary Public

My comm. expires July 28, 1955.

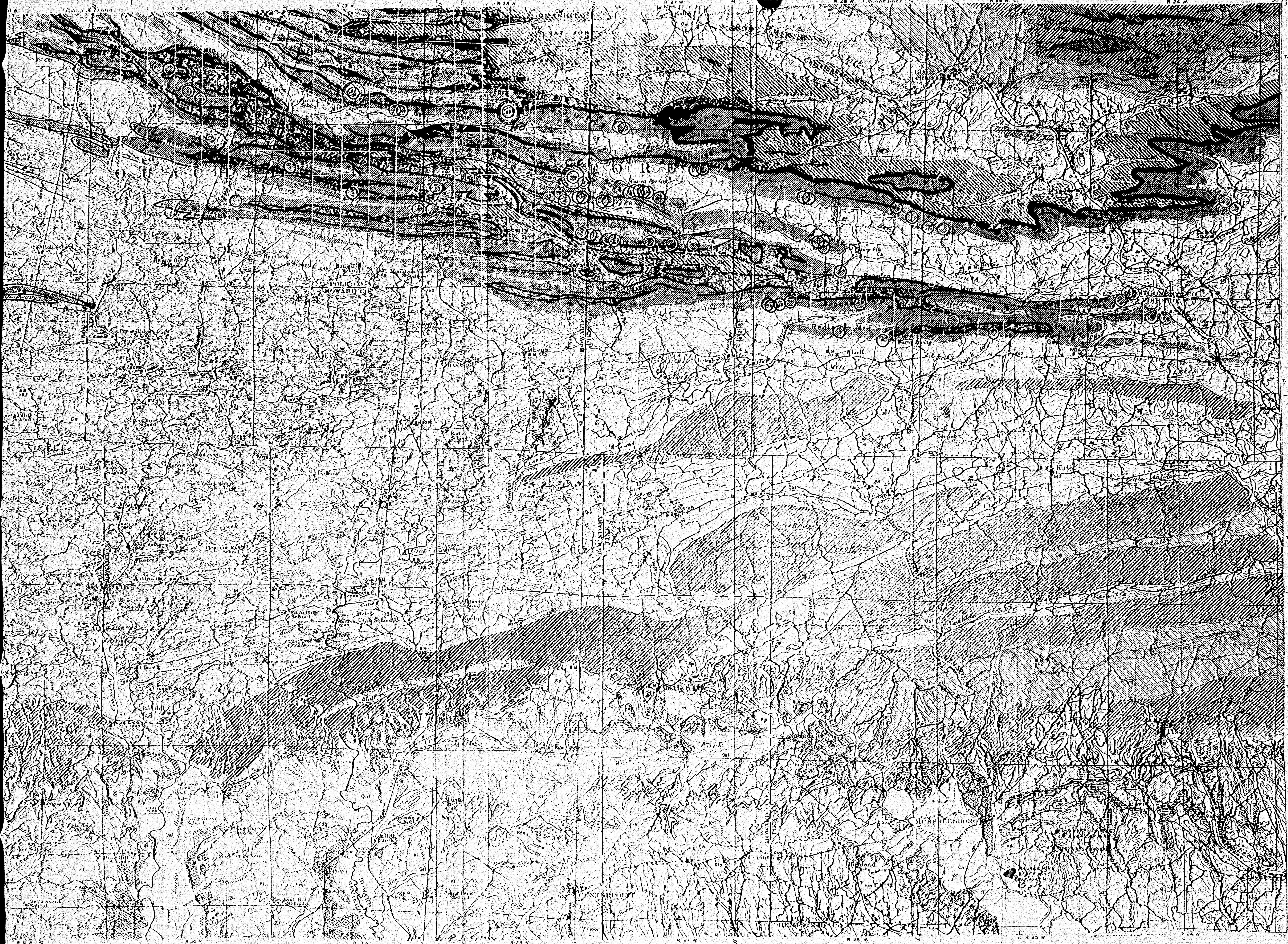
ACKNOWLEDGMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 195___, before me, a Notary Public in and for the County and State aforesaid, appeared in person the within named _____, being the _____ of Inland Mining Corporation, a corporation, to execute the above instrument, to me personally known, who stated that he is the _____ of said Inland Mining Corporation, and was duly authorized in his capacity to execute the foregoing instrument for and in the name and behalf of said corporation, and further stated and acknowledged that he had so signed, executed and delivered said foregoing instrument for the consideration, uses and purposes therein mentioned and set forth.

IN TESTIMONY WHEREOF I have hereunto set my hand and seal this _____ day of _____, 195____.

_____
Notary Public



EXPLANATION

SEDIMENTARY ROCKS

QUATERNARY

Qal — **Alluvium** (*Gravel and silt in valley bottoms; partly represented in Ouachita Mountain region*)

Terrace deposits (*Gravel and loam on stream terraces; areas in Ouachita Mountain region are small and are not represented on map*)

TERTIARY (?)

Tertiary (?) gravel (*Fine and coarse gravel on Athens Plateau. It rests upon the Stanley shale*)

CRETACEOUS

Upper Cretaceous (Gulf series)

Kbs — **Brownstown marl** (*Blue and gray calcareous clay*)

Kto — **Tokio formation** (*Gravel, sand, and clay*)

Kw — **Woodbine formation** (*Gravel, clay, and water-laid volcanic tuff*)

UNCONFORMITY

Lower Cretaceous (Comanche series)

Kt — **Trinity formation, with De Queen limestone member, Kdq, Ultima Thule gravel lentil, Ku, Dierks limestone lentil, Kds, and Pike gravel member, Kp** (*Gravel, gray sand, variegated clay, and fossiliferous limestone*)

UNCONFORMITY

CARBONIFEROUS

Pennsylvanian

Ca — **Atoka formation** (*Gray sandstone and black shale*)

Mississippian

Cj — **Jackfork sandstone** (*Massive gray sandstone*)

Cs — **Stanley shale, with Hatton tuff lentil** (*Olive-green and black fissile shale, greenish-gray sandstone, and tuff. Beds of tuff, Ct, above Hatton tuff, Ch, are only partly represented on map*)

UNCONFORMITY

DEVONIAN

Dn — **Arkansas novaculite** (*Upper part mostly thin-bedded dark novaculite and dark shale; lower part massive white novaculite*)

SILURIAN

Missouri Mountain slate (*Red and green clay slate*)

UNCONFORMITY (?)

Blaylock sandstone (*Gray sandstone and buff to dark shale*)

UNCONFORMITY (?)

ORDOVICIAN

Polk Creek shale (*Black carbonaceous shale; in part siliceous*)

Obf — **Bigfork chert** (*Thin-bedded gray to black chert much shattered; some black shale*)

Ow — **Womble shale** (*Black and green banded shale with lenses of bluish limestone near top. Base not traceable west of Womble*)

Oby — **Blakely sandstone** (*Gray sandstone and black and green shale; sandstone beds thin out at Womble; the shale west of Womble is not traceable and is mapped with the Womble and Mazarn shales*)

Om — **Mazarn shale** (*Black and green banded shale with thin lenses of limestone*)

ORDOVICIAN (?)

Oc — **Crystal Mountain sandstone** (*Coarse-grained massive gray and brown sandstone*)

UNCONFORMITY

CAMBRIAN

Cc — **Collier shale** (*Bluish-black soft crumpled shale and dark fine-grained limestone*)

IGNEOUS ROCKS

CRETACEOUS

Peridotite (*Exposed near Murfreesboro; includes three types—1, intrusive peridotite; 2, volcanic breccia; 3, tuff and fine-grained breccia*)

Synclinal axis

Strike and dip (*a, normal; b, overturned; c, horizontal; d, vertical*)

Faults

ECONOMIC DATA

x pm — Pyrite and marcasite prospect

x tr — Tripoli prospect

x sl — Slate quarry and prospect

q — Quartz crystal mine

x m — Manganese mine and prospect

x as — Asphalt mine and prospect

x d — Diamond mine and prospect

x lz — Lead and zinc mine and prospect

x c — Copper prospect

x g — Gypsum prospect

x b — Railroad ballast quarry and pit

x s — Antimony mine and prospect

GEOLOGIC MAP OF DE QUEEN AND CADDO GAP QUADRANGLES, ARKANSAS AND OKLAHOMA

Scale 1/125000

1 0 1 2 3 4 5 Miles

1 0 1 2 3 4 5 Kilometers

Contour interval 50 feet

Datum is mean sea level

1929

Geology by A. H. Purdue and H. D. Miser, assisted by R. D. Mesler
Surveyed in 1907, 1908, 1910–1912, 1916, 1923, and 1925