1950

A study of mine scraper efficiency on materials of different specific gravities

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Recommended Citation

Rowley, Kermit Guy, "A study of mine scraper efficiency on materials of different specific gravities" (1950). *Masters Theses*. 6760.
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A STUDY OF MINE SCRAPER EFFICIENCY
ON MATERIALS OF DIFFERENT SPECIFIC GRAVITIES

BY

KERMIT GUY ROWLEY

A

THESIS

submitted to the faculty of the

SCHOOL OF MINES AND METALLURGY OF THE UNIVERSITY OF MISSOURI

in partial fulfillment of the work required for the

Degree of

MASTER OF SCIENCE, MINING ENGINEERING

1950

Approved by - J. D. Forrester
Professor of Mining Engineering

ACKNOWLEDGMENT

The writer wishes to express his sincere appreciation to Dr. J. D. Forrester, Chairman of the Department of Mining Engineering, whose aid and guidance have made this work possible. The writer also wishes to thank the other members of the Mining Department Staff for their helpful suggestions and assistance.

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INTRODUCTION

Scrapers long have been used in underground mining work, and in recent years the transfer of ore and waste rock by power drawn scrapers has become standard practice in many mining operations. Naturally the great employment of scrapers has brought about numerous changes in design as they have been adapted to, and improved for, their various uses. From these changes and improvements have evolved several common scraper types which are in use in mining throughout the world.

Although experience has brought out much information on scrapers no systematic studies of the efficiency of mine scrapers have been carried out before the experimental works done in the last few years at the Missouri School of Mines.(1, 2, 3, 4)

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(1) Forrester, J. D. and Clayton, A. B., A Study of Mine Scraper Buckets and Their Efficiency, Missouri School of Mines and Metallurgy, Technical Bulletin, Vol.17, No.2, 1946, 48 pp.

(2) Forrester, J. D., and Carmichael, R. C., The Effect of Rope Speed and Moisture on the Use of Scrapers in Mining, Missouri School of Mines and Metallurgy, Technical Bulletin, Vol.18, No.1, 1947, 31 pp.

(3) Johnsen, S. F., A Study of the Power Consumption of Mine Scrapers, A Thesis Submitted to the Faculty of the Missouri School of Mines and Metallurgy, 1949, 62 pp.

(4) Vigier, G. J., Efficiency Studies of the Effect of Moisture on the Power Consumption of Mine Scrapers, A Thesis Submitted to the Faculty of the Missouri School of Mines and Metallurgy, 1950, 62 pp.

Purpose of Problem:

The purpose of this study is to determine the effect that the specific gravity of the material scraped has on the power consumption and the efficiency of the common types of mine scrapers. As scraper weight, rope speed, and moisture content of the muck are important factors affecting the power consumption and efficiency, these variables are the ones considered for each type scraper. Two materials of different specific gravities are used in the study with an equal number of tests run on each material.

Problem Procedure:

Three types of scrapers were tested. These were: The crescent scraper, the box scraper and the straight bail hoe scraper. These scrapers were available in the mining laboratory and were used in the previous model scraper studies.

The model scrapers were constructed at a scale of 1 to 6.

A small electrically-driven hoist was used to pull the scrapers on a table 15 feet long by 4 feet wide. A Westinghouse recording wattmeter connected with the electric motor was used to record graphically the power consumed.

After a given number of passes at the muck pile on the table, the weight of the material scraped was determined. The amount of power consumed in the scraping was computed from the wattmeter graph. From the figures thus attained the results and conclusions of this study were derived.

REVIEW OF LITERATURE

History of Scraping:

Power scrapers were used first in actual mining operations for moving muck by the Bunker Hill and Sullivan Mining Company at Kellogg, Idaho in 1898. (5) A slip scraper powered by a small single drum air hoist was used. The scraper was guided and pulled back to the muck pile by hand.

Most early scraper practice employed slip scrapers and single drum hoists. Just prior to World War I the development of two drum hoists and bottomless scrapers greatly improved scraper efficiency.

Probably the greatest, early mining application of scraping practice was in the Lake Superior iron and copper mining districts. In later years, scrapers have had important use in the Tri-State lead-zinc mining district.

During the last twenty years scraper development has been characterized by increases in horsepower, rope speed, and size and weight of scraper buckets. Also, the three drum hoists for scraper control have come into universal usage.

A very good abstract of the history of scraper practice has been published by Forrester and Clayton. (6)

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(5) Van Barneveld, Charles E., Mechanical Underground Loading in Metal Mines, Missouri School of Mines and Metallurgy Technical Bulletin, No.3, Vol.7, pp.210-212, 1924.

(6) Forrester, J. D., and Clayton, A. B., <u>Op</u>. <u>cit</u>. pp.1-4.

Scraper Operation Data:

Johnsen (7) has listed the following factors which may be considered when selecting the most efficient mucking equipment for a particular mining problem:

1. Lowering of development costs.
2. Increased production from stopes.
3. Reducing hazards of mucking.
4. Availability of certain types of machinery.
5. Amount of ore or waste to be moved.
6. Type of power available.
7. Mining method employed.

The field of application of power scrapers may be outlined as follows:

- Development work
    - Inclined shafts
    - Drifts and cross cuts
- Production stopes
    - Top slicing stopes
    - Open stopes
    - Room and Pillar stopes
    - Sub level caving stopes
    - Cut and fill stopes
    - Square set stopes
    - Shrinkage stopes
    - Block caving stopes
- Waste Filling of stopes

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(7) Johnsen, S. F., *Op. cit.* p.3.

Transfer of material in sub levels

Moving of material in open pits

Reclaiming tailing piles

Placer mining

Jackson and Hedges (8) state that scrapers are best adapted to underground use where large quantities of ore must be moved comparatively short distances.

Jeppe (9) has listed the main factors affecting scraper efficiency as follows:

1. Size of scoop.
2. Speed of rope.
3. Amount of delays due to broken ropes and other inevitable repairs.
4. Stoping width, concentration of rocks, length of drag.
5. Position of scraper lines.

Pierce and Bryan (10) have given these advantages that scrapers have over other types of loading machines:

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(8) Jackson, Charles F., and Hedges, J. H., Metal Mining Practice, U. S. Bureau of Mines, Bulletin No.419, p.183, 1939.

(9) Jeppe, C. B., Gold Mining on the Witwatersrand, The Trans Vaal Chamber of Mines, Vol.1, p.889, 1946.

(10) Pierce, R. V., and Bryan, R. N., Scraping and Loading in Mines, Compressed Air Magazine, Vol.47, No.6, pp.6750-4, June 1942.

1. Operation of a mechanical scraper is very simple and does not necessitate a long educational plan.

2. Initial cost is less than that of other loading and conveying machinery.

3. It is not complex and has few exposed parts.

4. The bucket and rope of the unit usually are the only parts exposed to possible roof falls, thus, the whole scraper installation is less liable to damage than are other common loading devices.

5. It accomodates more diversified types of mining conditions.

6. Men need stay in untimbered areas but a fraction of the total working time.

Motive Power:

Scrapers usually are powered by either air hoists or electric hoists. Overpowered hoists are desirable for scraper work, as they are frequently momentarily overloaded and are subjected to very rough usage.

Johnsen (11) gives a detailed account of the motive power used in scraper operation.

Design of Scrapers:

Continued use and development of scrapers over the years has tended to develop three standard types. These are (1) the hoe scraper, (2) the box scraper, and (3) the

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(11) Johnsen, S. F., Op. cit. pp.5-17.

crescent scraper. There are modifications of each of these types made by adding side plates to the hoe scrapers, adding teeth to the cutting edges, and by counterweighting to produce desired balance conditions.

The digging angle of a scraper is an important consideration in scraper design. This is the angle that the cutting edge of the scraper blade makes with the muck pile when the rope is under maximum tension. Van Barneveld (12) states that the theoretical maximum digging effect of a scraper would occur when the plane of the cutting edge lies in the resultant of the pull and of the force of gravity. With these theoretical considerations he figures the best digging angle is 30 degrees. However, experience has shown that digging angles of 45 to 50 degrees will give better results under all conditions.

To prevent the scraper from digging in after it is loaded a forward curvature of the blade, or a baffle plate fastened to the top of the blade is often provided.

Balance is an important factor governing the digging and riding characteristics of the scraper. This balance is obtained by long and heavy bails, and by the application of counter weights. Scrapers must be rugged in construction in order to withstand the intense shock and abrasion they encounter in underground usage. Special alloys of manganese, chrome, molybdenum and nickel steels commonly are used in their construction.

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(12) Van Barneveld, Charles E., *Op. cit.* p.225.

Forrester and Clayton (13) have listed these important factors of scraper design:

1. Selection of proper type for material to be moved.
    a. Hoe type for coarse material.
    b. Box or crescent for fine material.
2. Proper digging angle and shape of blade.
    a. Average angle near 45 degrees.
    b. Top of blade curved forward to provide lifting action.
3. Proper balance so that the bail will not rise in the air but still blade has sufficient weight for digging force.
4. Rugged construction to withstand abrasive action of ore and sudden shock.

APPARATUS FOR SCRAPER TESTS

Equipment Used In Tests:

The model scrapers employed in this present study had been used previously by other students in earlier model scraper tests. The three models were constructed to a scale of 1 to 6 and are 8 inches wide, since the average mine scraper is about 4 feet wide. The scrapers used are shown in Figures 1, 2, and 3.

The scrapers were operated by a three drum hoist equipped with double faced friction brakes. The drums were

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(13) Forrester, J. D. and Clayton, A. B., *Op. cit.* p.16.

machined aluminum and were mounted freely on a three-quarter inch line shaft set in ball bearing pillar blocks. During this study a set of brakes was designed and attached to the hoist mechanism in an effort to prevent cable snarls at the hoisting drums. Most cable snarls were caused by the continued turning of the drums after the scraper motion had been stopped; this caused the cable to loop out over the drum and become entwined on the line shaft. The brakes when engaged kept a slight tension on the drums causing them to stop turning as soon as the motion of the scraper stopped. The brakes worked very well and no cable snarls developed after they were installed.

The motive power for the hoist was furnished by a 1/4-horsepower, split-phase, electric motor which used 60 cycle A.C., 115 volt current. The motor furnished 1750 R.P.M. A 2-inch pulley on the motor shaft was belted to a 12-inch pulley on a jack shaft. A three-step cone pulley on the opposite end of the jack shaft was belted to an identical three-step cone reversed on the hoist shaft. Thus the belt length for each of the three steps was the same. This combination of pulleys gave a theoretical R.P.M. of 155, 211, 233, 317, 429, 475, or 646, as desired at the hoist.

The checking of the R.P.M. available at the drum was done by S. F. Johnsen. (14) He found that the use of a

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(14) Johnsen, S. F., <u>Op</u>. <u>cit</u>., p.24.

Figure 1

Photograph of a Crescent Type Scraper
The digging angle of this scraper is 60 degrees

Figure 2

Photograph of a Box Type Scraper
The blade is set at a 30 degree angle to the line of pull

Figure 3

Photograph of a Slope Bail Hoe Type Scraper
Counterweights on bail and baffle plate
Blade angle is 45 degrees to line of pull

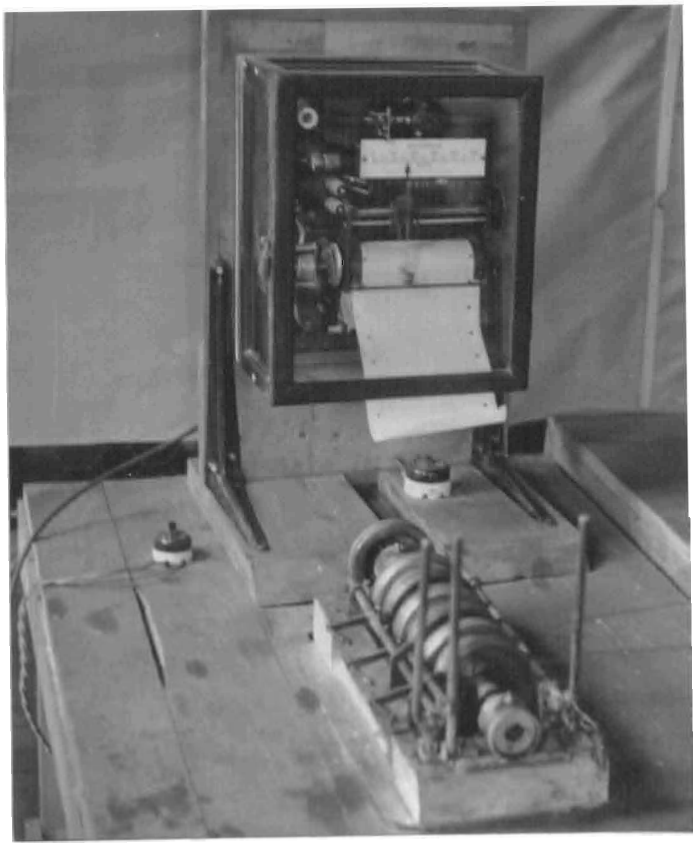

Figure 4

Photograph of hoist and recording wattmeter set up tachometer was impractical, so he filed a notch in one of the clutch plates and by holding a thin piece of wood against the plate and counting the clicks for a given time the R.P.M. could be determined. The time interval was clocked by a stop watch and several R.P.M. checks were made for each pulley combination used in the scraper tests. The hoist speeds were found to be 160, 242, and 319 R.P.M. These speeds were correlated during this study.

The radii of the hoist drums were 1.43 inches; the hoist cable used was 1/16 inch in diameter. Thus the effective radius of each drum (from the center of the drum to the center of the cable) was 1.51 inches. Using this radius the rope speeds used in the tests were calculated to be 126, 191, and 252 feet per minute. It is likely that these speeds were lowered slightly by clutch slippage but this could not be determined accurately and was not considered.

The wire cable used was 1/16 inch ordinary lay, with six strands of seven wires each and a cotton cord center. The cable was rated at 150 pounds tensil strength.

The table upon which the scraper tests were run was 15 feet long and 4 feet wide; it was surfaced with rough masonite fiborboard. The end of the table opposite the hoist could be raised or lowered from the horizontal. The table was provided with side boards and back boards to prevent the rock from spilling during operation. Two 2-inch sheave wheels, through which the scraper control ropes passed, were attached to the back board. These sheaves were installed during this study replacing sheaves of a smaller size which had been used in the earlier studies. This author believes that the larger pulleys reduced rope wear and possibly reduced power consumption. The smaller pulleys lacked sufficient bearing surface and the cable tended to slip over rather than turn the pulley wheel.

A grizzly was located two feet from the hoist end of the table. The grizzly was one foot square and equipped with brass rails set on three inch centers. An inclined chute below the grizzly directed the material down to a receiving pan placed on the floor.

A Type R Westinghouse recording wattmeter was used to record the power consumption. It was set up near the hoist as shown in Figure 4. A wiring diagram of the wattmeter and motor is shown in Figure 5.

Material Tested:

The two materials used in the scraper tests were of different specific gravities.

One of the minerals tested was fresh unaltered dolomitic limestone with a specific gravity of about 2.8. When crushed, the shape of the particles was splintery to blocky. The other was a fresh unaltered composition of the manganese minerals, composed mainly of pyrolusite and manganite; the specific gravity of these individual minerals varied from 4.7 to 5.2 with an average for the mixture of about 4.9. The shape of the particles was generally blocky. The

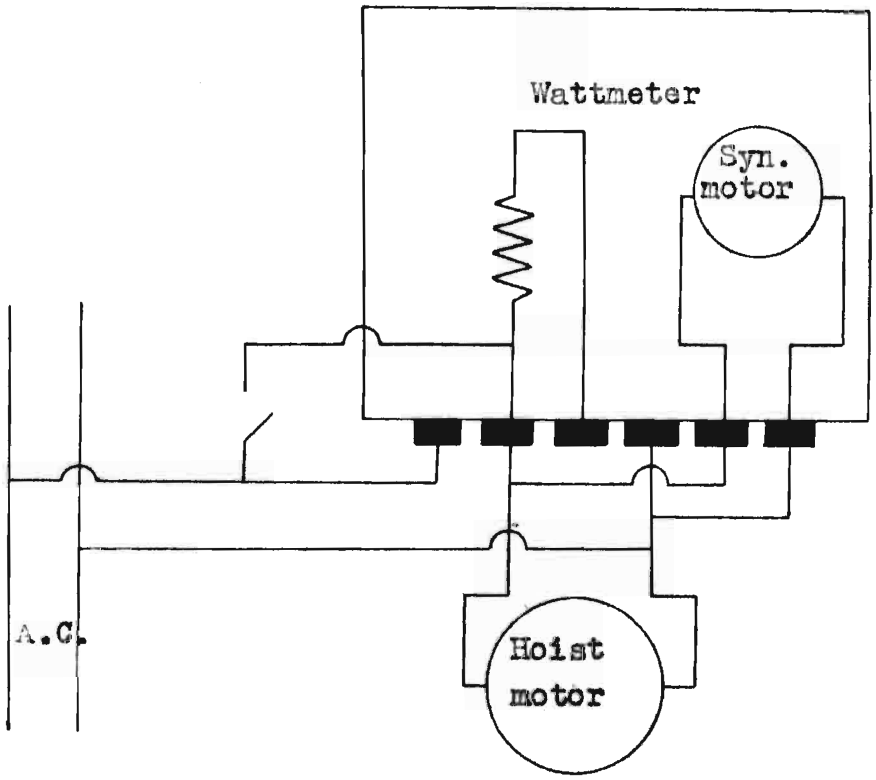

Figure 5

Wiring diagram for hoist-wattmeter setup.

specific gravity of the minerals was determined with a standard Jolly balance. Mixed sizes were used in each study and the materials were screened and classified into six size groups as follows: minus 3/16 inch, plus 3/16 minus 1/2 inch, plus 1/2minus 1 inch, plus 1 inch minus 1 1/2 inches, plus 1 1/2 minus 2 inches, plus 2 minus 6 inches. These sizes are assumed to represent mine run ore on a 1 to 6 scale.

Method of Collecting Data:

A galvanized iron pan 9 by 53 by 53 centimeters in dimension received the rock scraped as it came from the chute. The rock was then weighed on an Ohaus balance. The desired moisture content was obtained by adding sufficient water to a known amount of dry rock to bring the moisture content of the muck to the desired percentage. The moisture content was maintained throughout a given series of tests by weighing all of the material every two hours and adding enough water to bring it back to the desired percentage. This water added compensated for the moisture lost due to evaporation during the two hour period. The evaporation loss during a two hour period was very low so by weighing and bringing the rock to standard that often the material was in effect kept at the desired moisture content throughout the series of tests. The moisture content was recorded as per cent moisture by weight.

The power consumed during a given test was determined from the graphs from the wattmeter chart. For this study it was decided that the most accurate method of determining power consumption would be to measure the area enclosed by the curve recorded by the wattmeter; this area is the true representation of the power consumed. The most convenient method available for measuring this area was the planimeter so this instrument was used. Since the planimeter used measured area in square inches a conversion factor had to be determined to convert the area in square inches to a convenient electrical unit, the watt-second. The conversion factor was developed thusly:

Johnsen determined the speed of movement of the chart paper of the wattmeter to be 2.84 millimeters per second. (15)

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(15) Johnsen, S. F., Op. cit., p.29.

This converted to inches would be .112 inches per second, so on the abscissa the units were .112 inches per second. By measurement it was determined that the units along the ordinate were 95 watts per inch. If the units along the ordinate, 95 watts per inch, be divided by the units along the abscissa, .112 inches per second, the result will be 848.2 watt-seconds per inch squared. This factor multiplied by the square inches read on the planimeter gives a result in watt-seconds.

To facilitate accuracy each graph was gone over twice with the planimeter and the result divided by two and recorded as the true area.

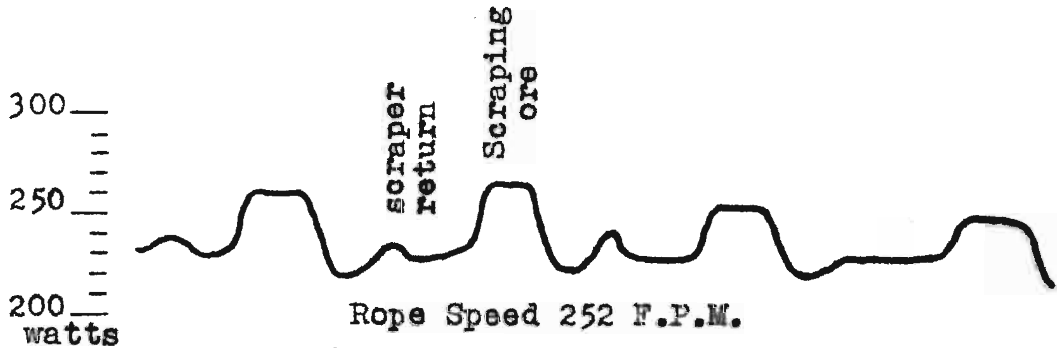
Figure 6 shows portions of some graphs traced by the wattmeter during various tests.

DESCRIPTION OF MODEL SCRAPER TESTS

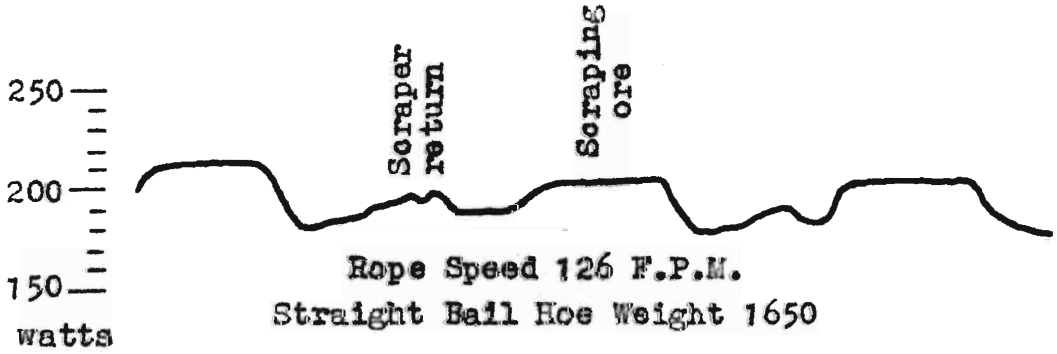
As previously stated, two materials were used during the experiments. The dolomitic limestone was crushed and mixed in the following proportions: Minus 3/16 inch, 50 per cent; plus 3/16 minus 1/2 inch, 25 per cent; plus 1/2 minus 1 inch, 10 per cent; plus 1 inch minus 1 1/2 inches, 10 per cent; plus 1 1/2 minus 2 inches, 3 per cent; plus 2 minus 6 inches, 2 per cent. The manganese was crushed and mixed in the same proportions and identical tests were run on each mineral.

The material was placed at the opposite end of the table from the hoist. Twenty passes of the scraper from the muck pile to the grizzly constituted one test. Since the catch pan used, in some instances, would not have held all the rock, each test was made in two runs, of ten passes. After each run the material scraped was weighed; the power consumed had been recorded on a graph during the operation. The results of the two runs were added and the total power consumed was computed later.

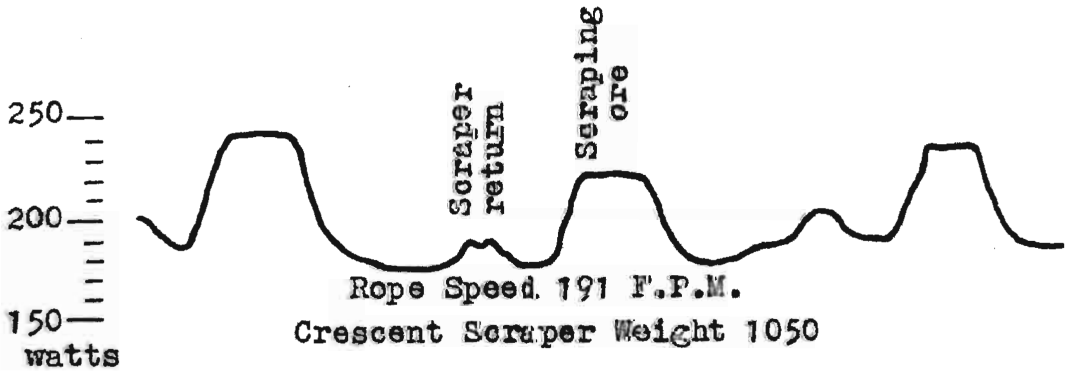
The muck pile was set in same position and given the same shape before each test, (See Figure 7) however, it was not reshaped between runs. It was noted especially in the case of the hoe scraper than much of the load was lost during the first passes due to material running from the



Rope Speed 252 F.P.M.
Box Scraper Weight 2050



Rope Speed 126 F.P.M.
Straight Bail Hoe Weight 1650



Rope Speed 191 F.P.M.
Crescent Scraper Weight 1050

Figure 6

Wattmeter graphs of model scraper tests.

sides of the scraper. However, ridges roon built up and if the scraper was kept between those ridges little rock was lost. (See Figure 8)

Another very important factor noted during these operations was the position of the larger lumps of material in the pile. In the course of scraping a natural segregation transpired and this was especially obvious in the heavier manganese ore. The fine material quickly settled to the bottom leaving the larger lumps on top. This greatly impared the digging ability of the scrapers and would impart important changes in the results if not closely watched. The material had to be remixed very often. This characteristic of the manganese ore is in large part responsible for the greater scraper efficiency at five per cent moisture content. In the dry state the fine material gathered at the bottom of the pile almost immediately and packed, forming a sort of matrix for the larger pieces. This packed fine material with interbedded holders was very difficult for the scrapers to dig. However, with the addition of 5 per cent water, due to inherent physical properties of the manganese, the fine material tended to "fluff up" becoming loose and less liable to packing. The material in this condition was at the optimum for scraping, especially with the crescent and box scrapers.

By the use of two tail ropes the scraper could be maneuvered into any spot on the table in the vicinity of the muck pile. However, in order to keep power consumption

Figure 7

Photograph of muck pile as it was shaped before each test

Figure 8

Photograph of Straight Bail Hoe Type Scraper in action
Note side ridges built up by material flowing around blade

at a minimum, the scraper was maneuvered as little as possible during operation, although an effort was made to scrape as much material as possible each trip.

Two hundred and sixteen tests were run; one hundred and eight on each material. The rope speeds used were 126, 191, and 252 feet per minute. Each of the three scrapers was tested at four different weights and zero, five and ten per cent moisture content of the muck. It was decided that ten per cent moisture was the maximum that need be examined because this was about all the water the material would absorb. Further addition of moisture would cause water to run out on the table and would have little effect on the results. Also, it might be indicated that in actual mine scraper operations muck with more than ten per cent moisture would seldom if ever be encountered.

After the completion of the experiments, an examination of the results showed that twelve of the dolomitic limestone and five of the manganese tests appeared to be erratic. These seventeen tests were rerun and the results obtained were more satisfactory and therefore these were recorded as true values.

The results obtained were plotted in two types of curves. The first type of curve is located by plotting "watt-seconds per gram scraped" along the ordinate and "per cent moisture" along the abscissa. These curves give for each scraper weight and rope speed the variation of power consumed in relation to the moisture added. The second type curve is located by plotting the "grams scraped per gram scraper weight" along the ordinate and per cent moisture along the abscissa. These curves give for each scraper weight and rope speed the variation of efficiency of the scraper in relation to the moisture added. In actual scraper operation one of the chief concerns of the operation is the amount of muck moved. Neither of these curves indicate such a relationship.

For example a scraper weighing 1,000 grams and scraping 1.5 grams rock per gram scraper weight carries 1,500 grams of rock per pass. The same type scraper weighing 2,000 grams and scraping the same 1.5 grams rock per gram scraper weight carries 3,000 grams per pass or twice as much rock as the lighter scraper. Thus, the heavy scraper could have considerably less gram weight per gram scraper efficiency and still move as much rock as the light one. Consequently, when different scraper weights are used the "grams of rock scraped per gram scraper weight" cannot be compared directly to grams of rock scraped per pass. Since the amount of load carried is an important factor to consider when judging overall efficiency of scrapers, the complete results of these tests are presented in tabular form in the appendix (See appendix A to I).

Johnsen states that "the addition of moisture to rock scraped does not increase the efficiency of scrapers."(16)

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(16) Johnsen, S. F., _Op_. _cit_., p.51.

Vigier (17) corroborates this statement in his work. However during the present study it has been found that the statement is liable to correction. Vigier and Johnsen both worked with granite, an igneous rock with much different physical properties than the materials used in this experimentation. This study has shown that an all covering statement concerning scraper efficiency in relation to the per cent moisture content is dangerous if not impossible to make. There are too many other factors involved to make a general statement taking only the moisture content into consideration. It would also seem that results obtained from one scraper type do not necessarily hold for other scraper types. Prior to this work very little study had been made of the efficiency of the straight bail hoe scraper with relation to the moisture content of the muck. Carmichael (18) ran four moisture tests with the straight bail hoe on granite of mixed sizes with constant rope speed. Johnsen (19) also ran four moisture tests with the straight bail hoe on granite of mixed sizes and with constant rope speed. Their results were conflicting as to the efficiency obtained. During this study forty eight moisture tests were made with

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(17) Vigier, G. J., *Op. cit.*, p.28.

(18) Carmichael, R. L., *Op. cit.*, pp.14 and 18.

(19) Johnsen, S. F., *Op. cit.*, p.39.

the straight bail hoe. They were run with four different scraper weights and three different rope speeds; two different materials were used.

The results of these tests indicates a sharp increase in efficiency of the straight bail hoe as the moisture content of the muck is increased from zero to five per cent and a general but decidedly lesser increase as the moisture content is increased from five to ten per cent. These increases are obvious not only on the "gram rock scraped per gram scraper weight" graphs, but also on the graphs depicting "watt second per gram rock scraped". In the first instance, the gram rock scraped per gram scraper increases as the moisture content of the muck is increased and, in the latter case, the watt-seconds per gram rock scraped decreases as the moisture content is increased. This result is common to both the dolomitic limestone and the manganese. (See Graphs 13, 14, 15, 16, 17, and 18.)

Tests with the crescent and box scrapers further overt the hazard of extending results obtained from a study of one material to include similar studies on all materials.

The crescent and box scraper tests on the dolomitic limestone would seem to confirm Johnsen's (20) and Vigier's (21) conclusions. However, the tests on the manganese definitely indicate greater efficiency at five per cent moisture

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(20) Johnsen, S. F., *Op. cit.*, p.51.

(21) Vigier, G. J., *Op. cit.*, p.51.

content. These results will be treated with more thoroughly in the following discussion in which each scraper is considered individually.

Crescent Type Scraper Tests:

Considering first the action of the crescent scraper on the dolomitic limestone the solid lines on Graphs 1, 2, and 3 indicate that power consumption increases as the moisture content of the muck increases. Considering that the muck became "wet" with the addition of only five per cent moisture and tended to pack, thereby becoming more difficult to dig, the increasing power consumption seems logical. This increase is greater for the lighter weight scrapers than it is for the heavier ones.

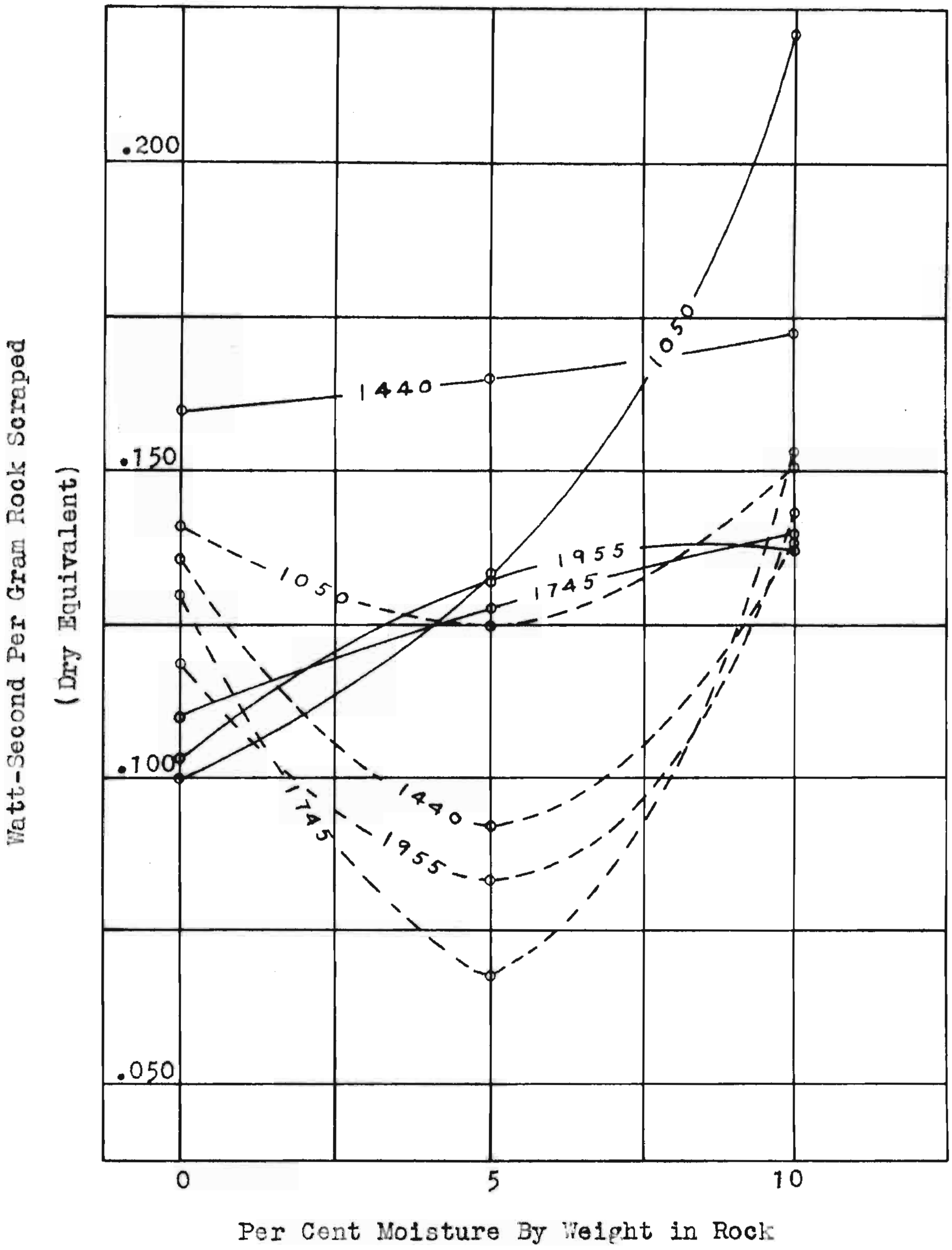
The solid lines in Graphs 4, 5, and 6 show that the load carried by the scrapers decreases as the moisture content of the muck increases. This drop in efficiency is more pronounced in the lighter scrapers than it is in the heavier ones. As the graphs and the tables in the appendices indicate, the quantity of material scraped at a definite speed is at a maximum at a given weight, and from the standpoint of grams of material scraped per pass the heavy scrapers give the most favorable results.

The results obtained from the crescent action on the manganese ore, however, show an entirely different picture. The dashed lines in Graphs 1, 2, and 3 indicate that the power consumption decreases from zero to five per cent moisture and then increases sharply from five to ten per cent moisture. As was mentioned earlier, the reason for this decrease at five per cent moisture seems to be that the muck at this moisture content tends to "fluff up" and not become stratified and packed as it does at both the zero and ten per cent moisture contents. It was not ascertained whether this "fluffing" action was due to certain physical properties peculiar to the manganese ore, to surface tension phenomena through which the moisture was adsorbed, trapping air bubbles at the surface of the particle instead of being absorbed, or to other unknown factors. The fact remains that the material did fluff and less power was consumed at five per cent moisture than at zero per cent.

The dashed lines in Graphs 4, 5, and 6 indicate that the grams scraped per gram scraper weight also increased from zero to five per cent moisture. The same fluffing action mentioned above accounts for this.

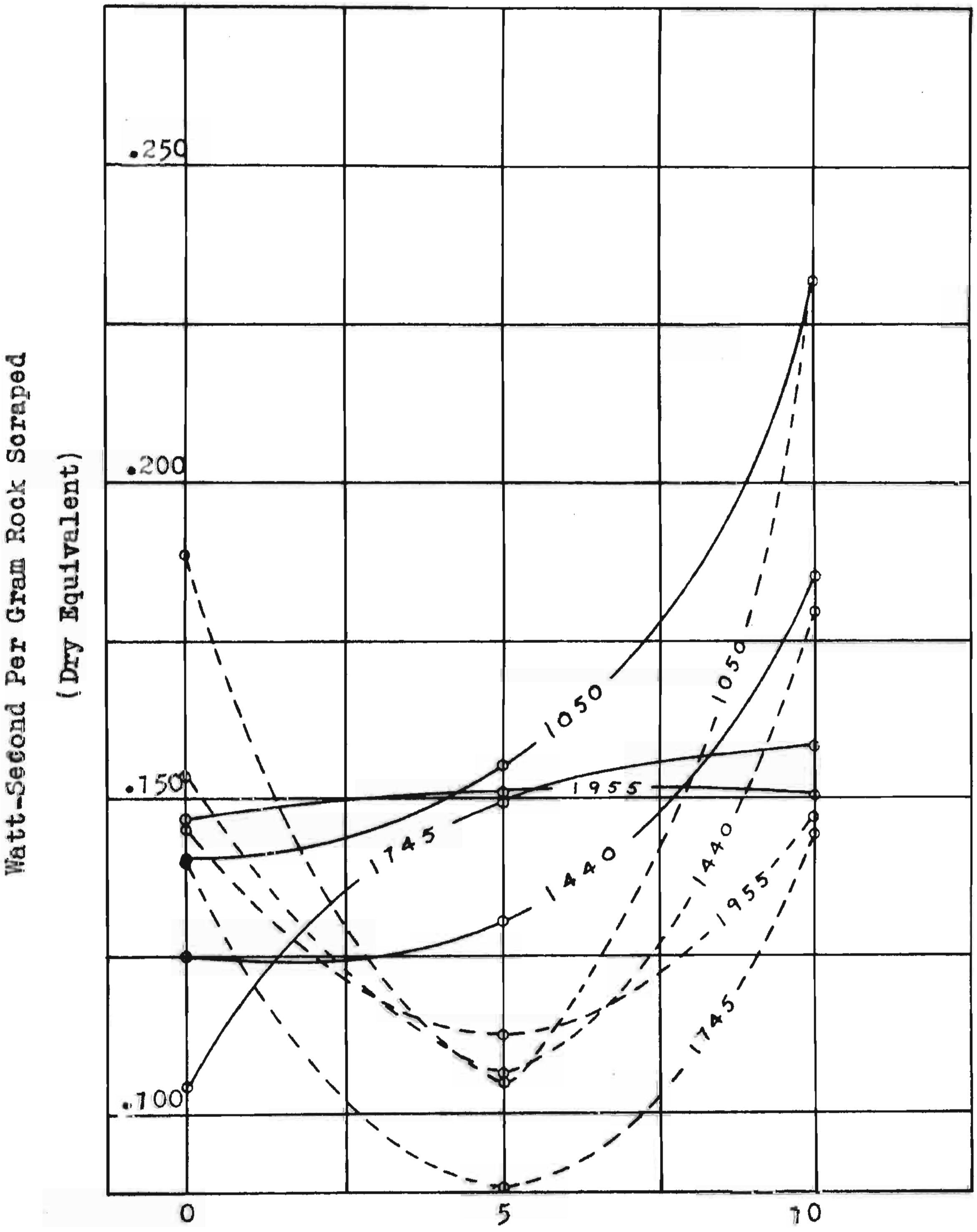
It will be noted on both the graphs for power consumption and for grams scraped that the efficiency is greatly reduced as the moisture content goes from five to ten per cent. This can be explained by the fact that at ten per cent moisture the muck becomes very muddy and tends to be sticky. This greatly impares digging action of the scraper and therefore increases power consumption and decreases grams scraped.

The difference in specific gravity between the limestone and the manganese seems to have little or no effect on the results obtained. A study of the graphs and of the tables



Graph 1. Relationship between moisture contnet of rock and power consumption.

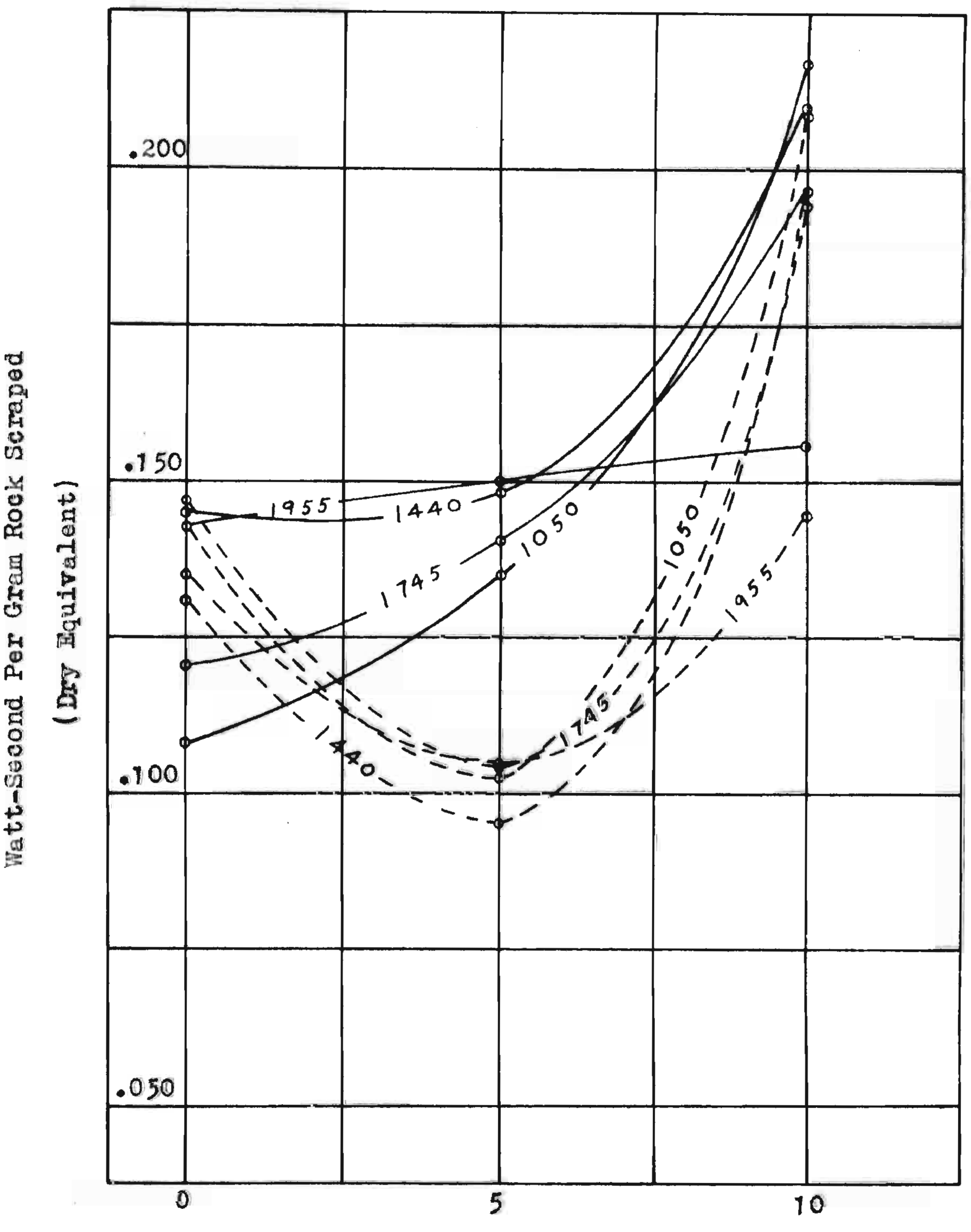
Crescent Type
126 fpm



Per Cent Moisture by Weight in Rock

Graph 2. Relationship between moisture content of rock and power consumption.

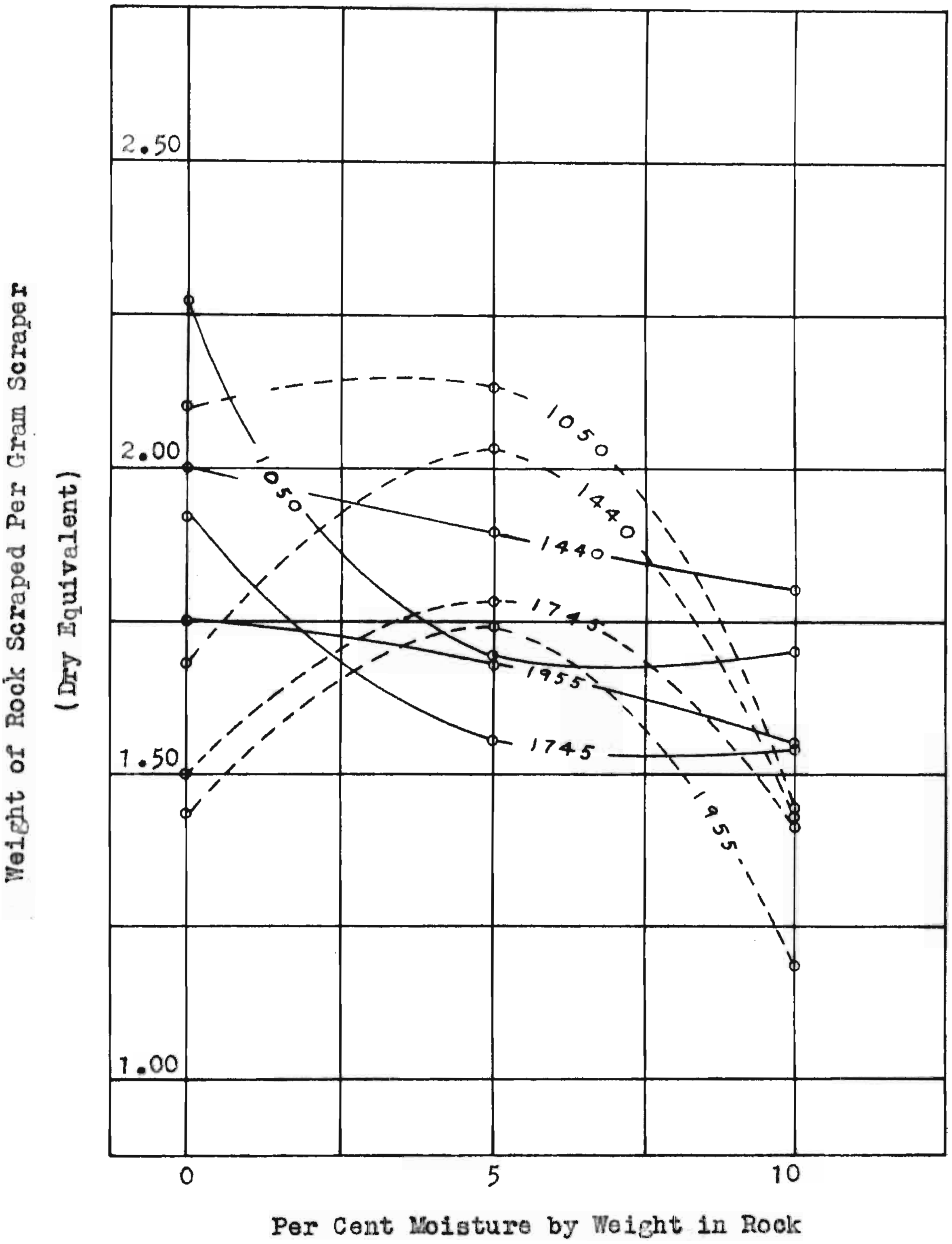
Crescent Type
191 fpm



Per Cent Moisture by Weight in Rock

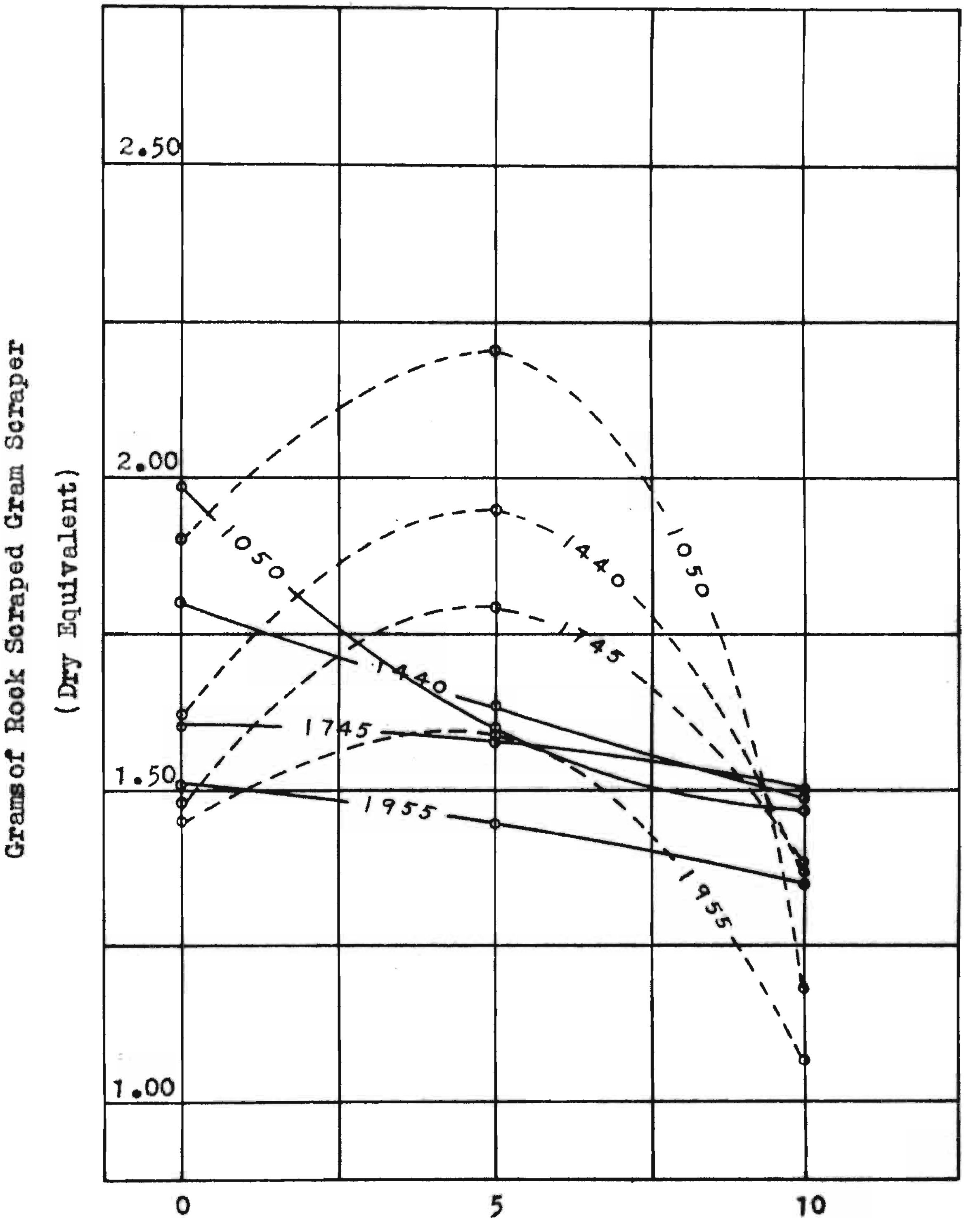
Graph 3. Relationship between moisture content and power consumption.

Crescent Type
252 fpm



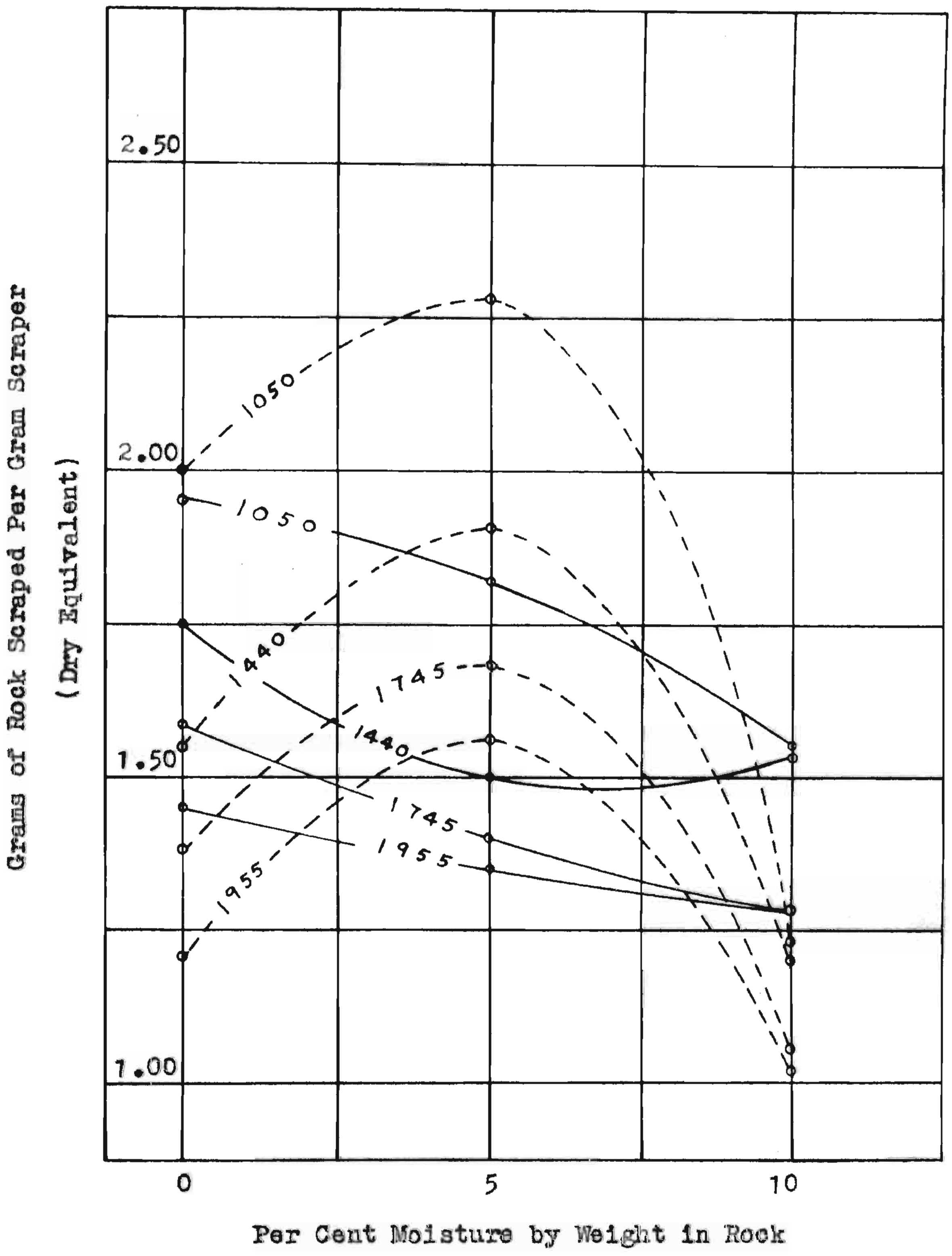
Graph 4. Relationship between moisture content and weight of rock scraped.

Crescent Type
126 fpm



Graph 5. Relationship between moisture content and weight of rock scraped.

Crescent Type
191 fpm



Graph 6. Relationship between moisture content and weight of rock scraped.

Crescent Type
252 fpm

in the appendices indicates little variation that could be considered due to the differences in specific gravity. The power consumption seems to be a little less for the limestone when the scrapers were run at 191 feet per minute but in general it seems to be physical properties rather than the specific gravity which cause the difference in results between the two materials.

Box Scraper Tests:

The box scraper is affected by variations in moisture content in much the same manner as the crescent scraper. The general results obtained with the crescent scraper were correlated by the results of the box scraper tests.

For the limestone the solid lines in Graphs 7, 8, and 9 indicate that the power consumption increases as the moisture content of the muck increases. The solid lines in Graphs 10, 11, and 12 show that the grams of rock scraped per gram scraper weight decreases as the moisture content increases.

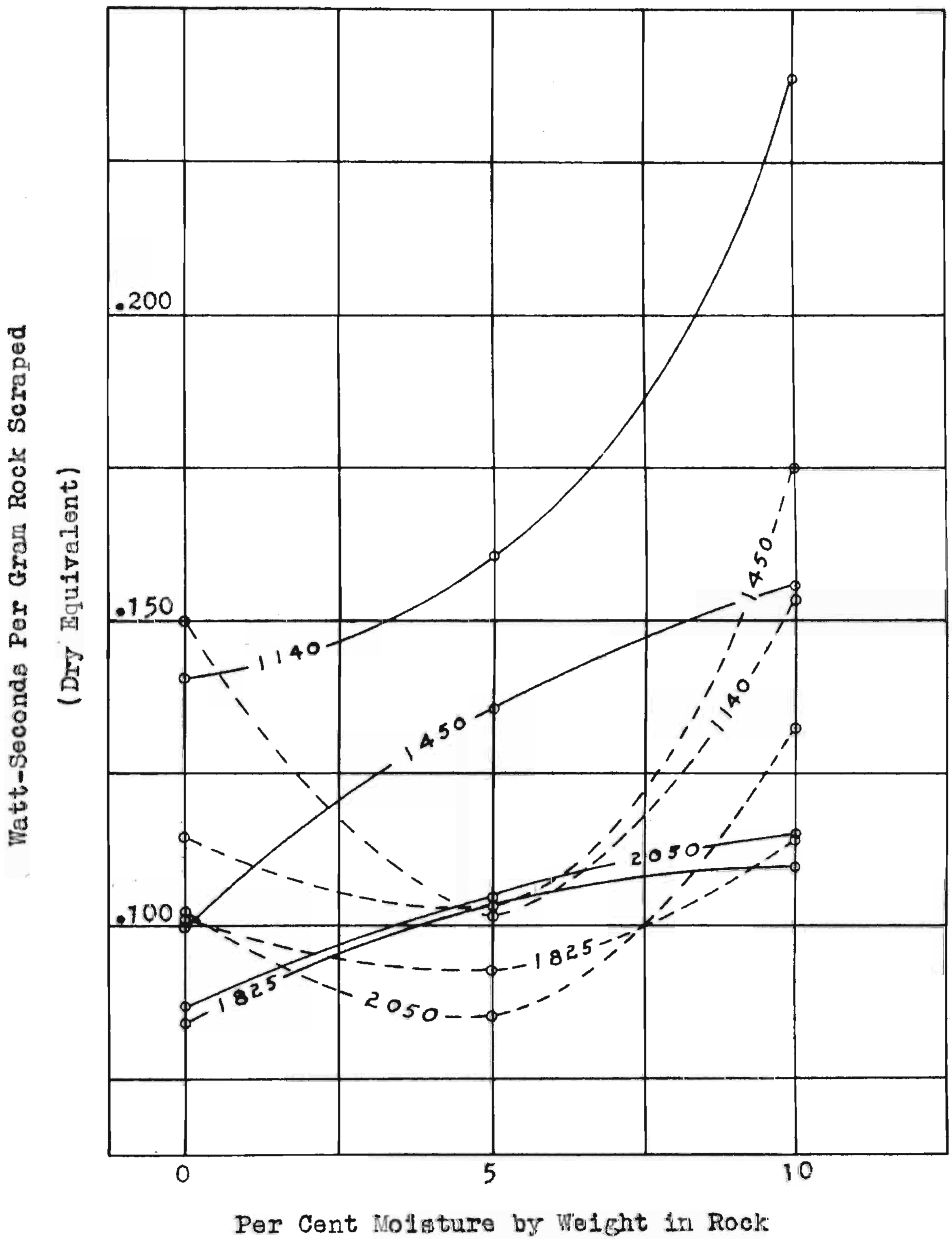
For the manganese the dashed lines in Graphs 7, 8, and 9 indicate that the power consumption decreases sharply as the moisture content is changed from zero to five per cent and then increases even more sharply as the moisture content is increased to ten per cent.

The dashed lines in Graphs 10, 11, and 12 demonstrate that the grams of rock scraped per gram scraper weight increases from zero to five per cent moisture and decreases sharply as the moisture is increased to ten per cent. The fluffing action of the ore facilitates the increase in scraping efficiency from zero to five per cent moisture.

There is some difference in scraper efficiency between the two materials as scraped by the box scraper, however. Whereas Graphs 7, 8, and 9 indicate that the power consumption at zero moisture content covers about the same ranges for both the limestone and manganese, Graphs 10, 11, and 12 clearly show that the grams rock scraped per gram scraper weight is less (for any given scraper weight at any given rope speed) for the manganese than it is for the limestone. This further substantiates the theory that all embracing statements concerning these model scraper tests are liable to error no matter how closely results seem to check. It is obvious that these studies are very valuable in developing certain definite trends common to all scrapers and scraping problems. However, to use the results of one or a series of scraper tests to definitely predict the reaction of scrapers on another untested material seems open to criticism.

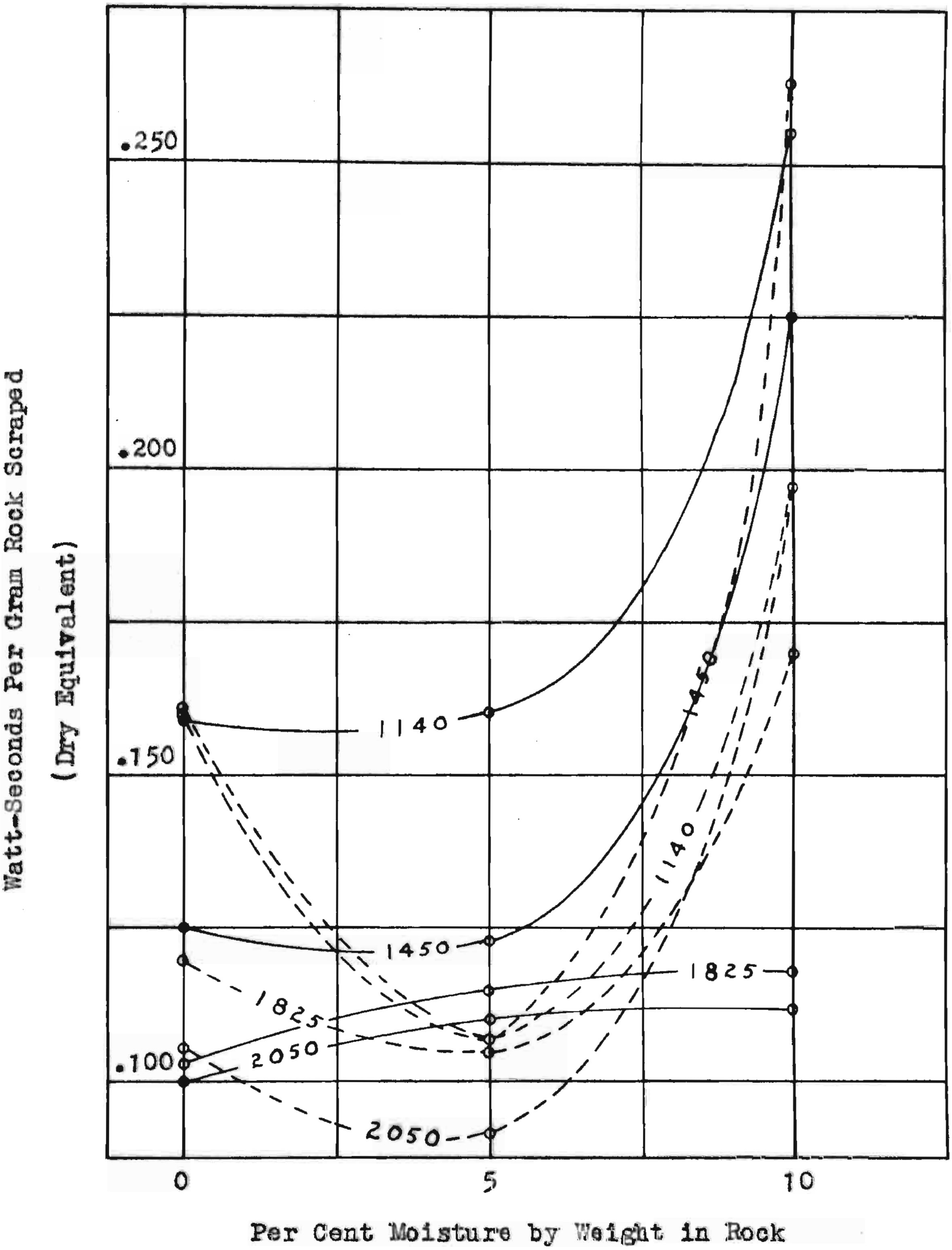
Straight Bail Hoe Scraper Tests:

The results of experimentation with this straight bail hoe scraper shows that it is affected by variations in moisture in a different manner than are the crescent and box scrapers. For both materials tested, the efficiency of the scraper increased as the moisture content of the muck increased.



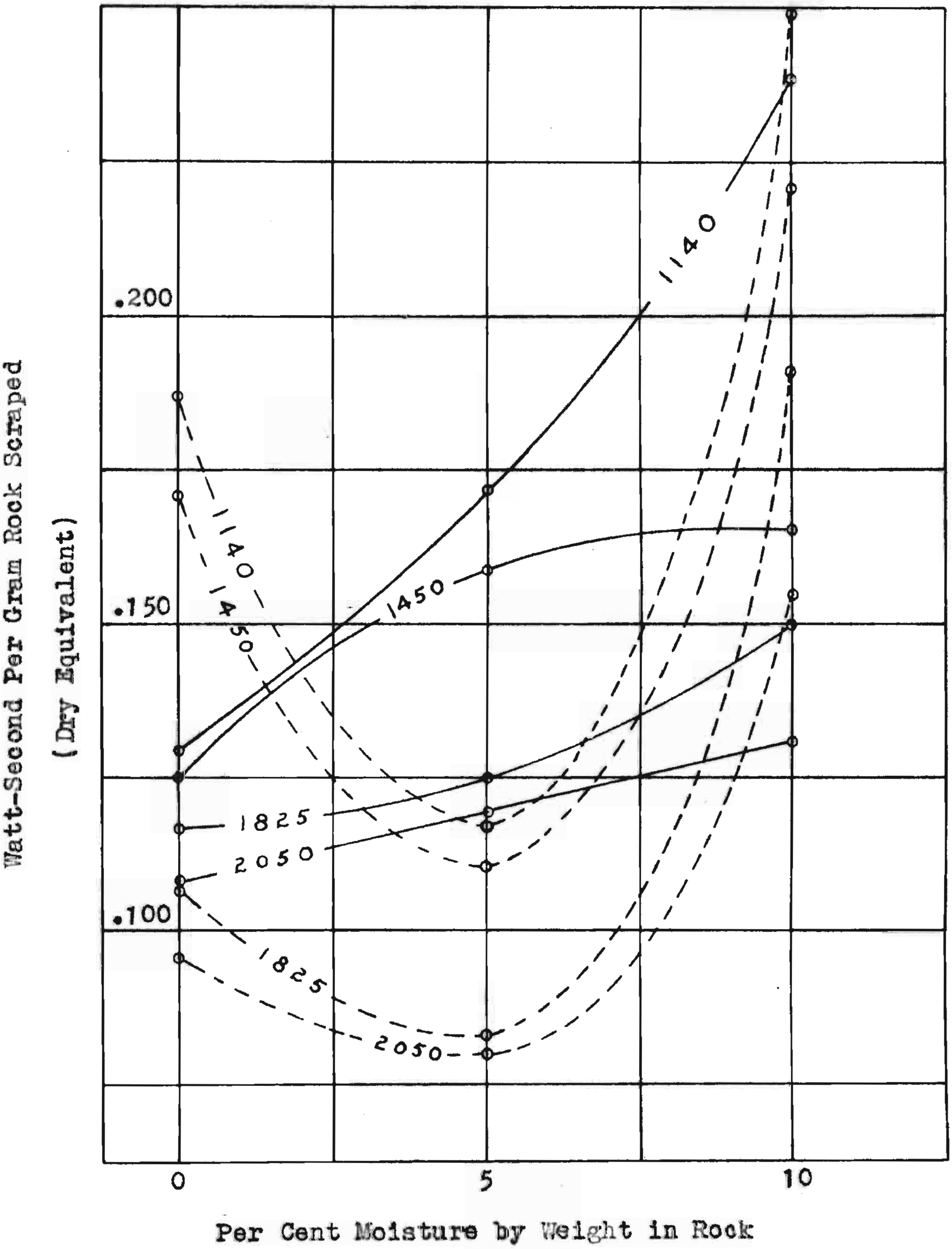
Graph 7. Relationship between moisture content of rock and power consumption.

Box Type
126 fpm



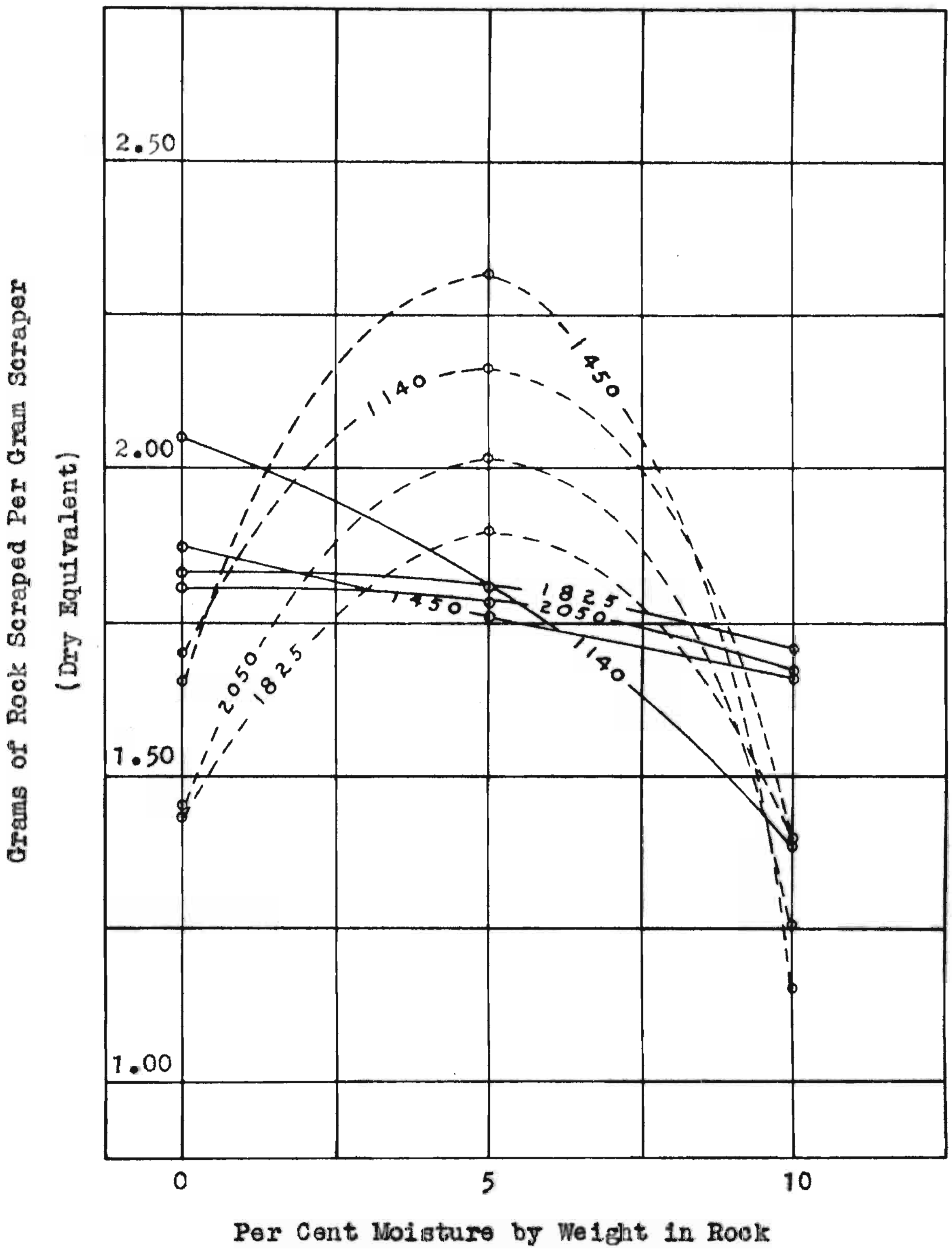
Graph 8. Relationship between moisture content and power consumption.

Box Type
191 fpm



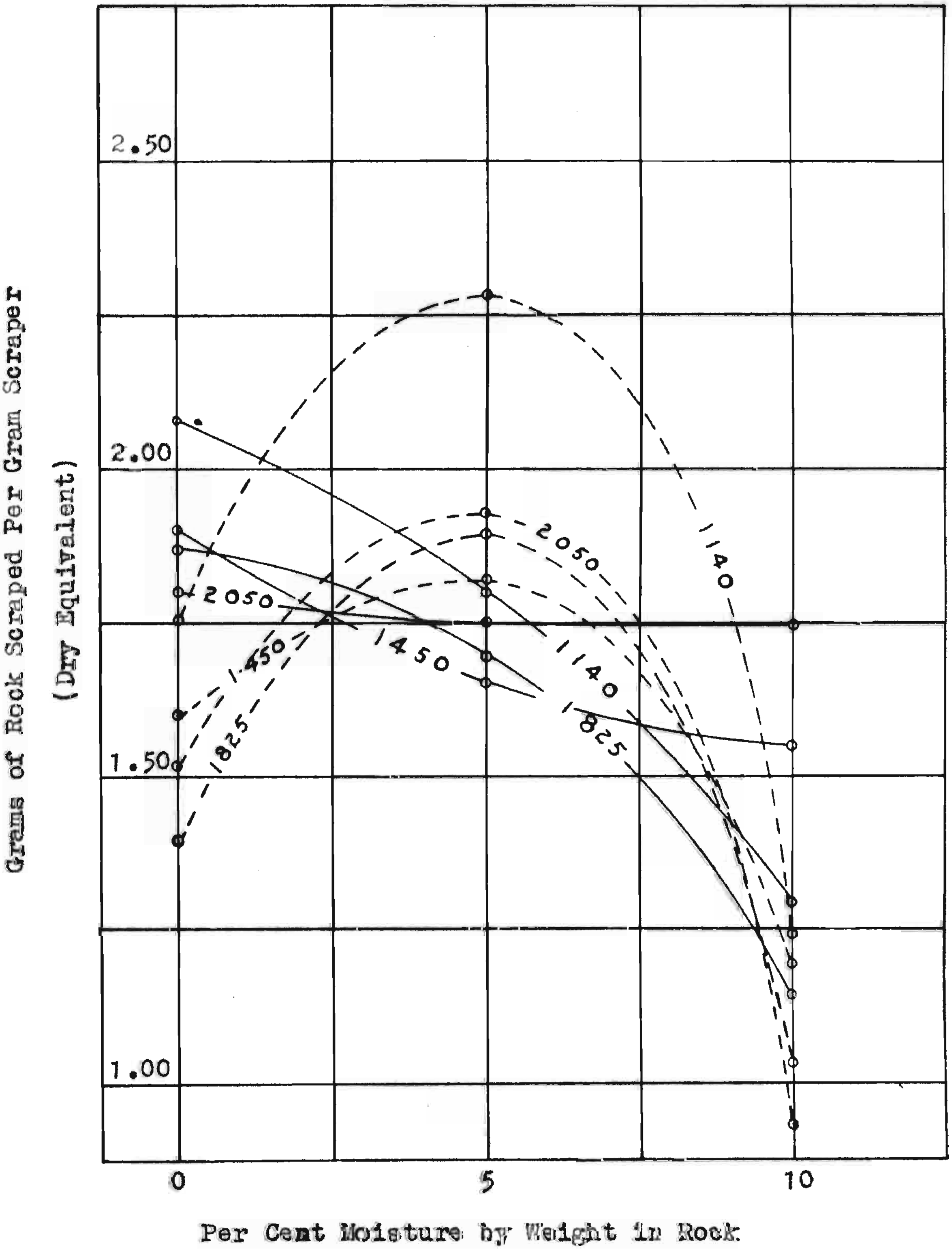
Graph 9. Relationship between moisture content and power consumption.

Box Type
252 fpm



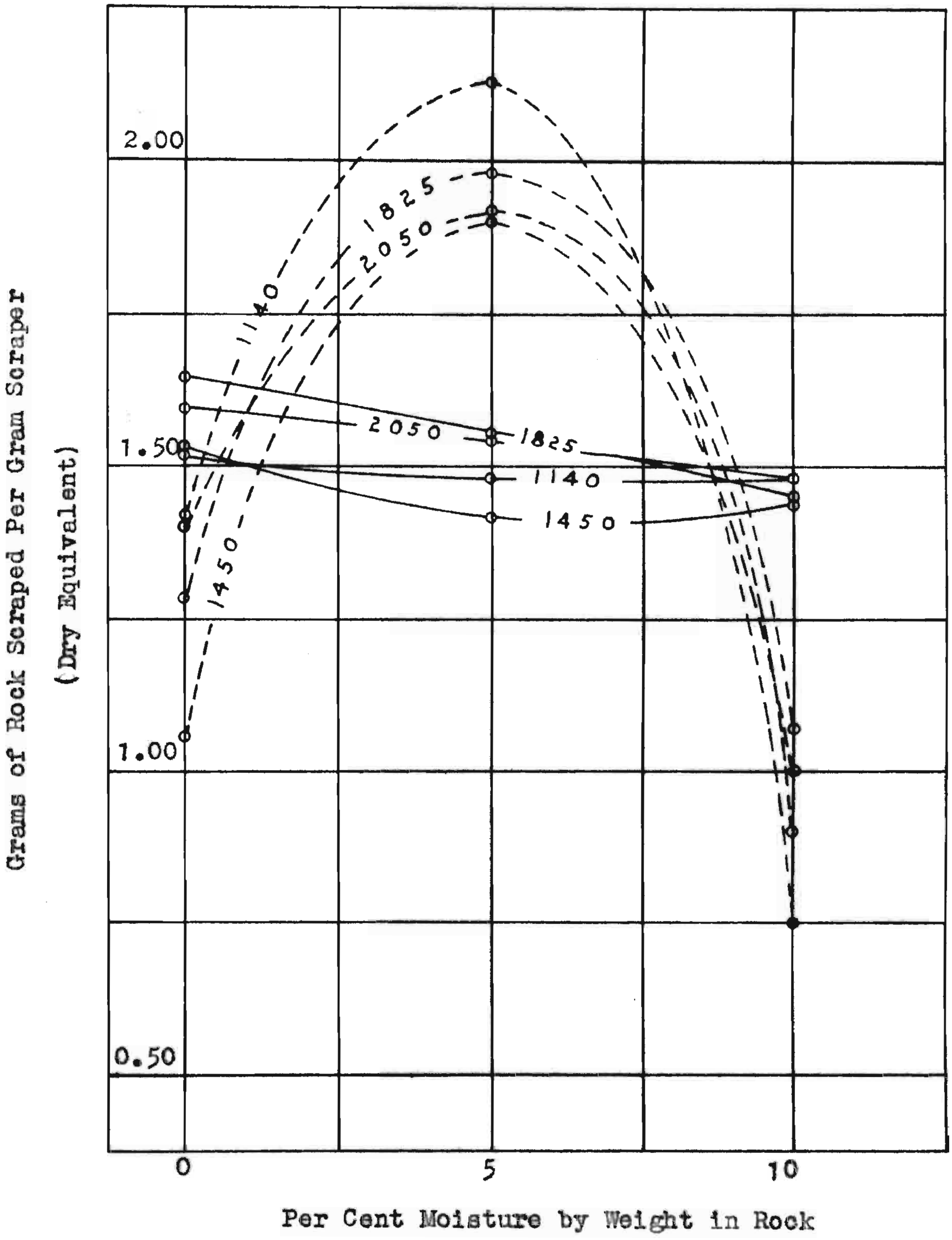
Graph 10. Relationship between moisture content and weight of rock scraped.

Box Type
126 fpm



Graph 11. Relationship between moisture content and weight of rock scraped.

Box Type
191 fpm.



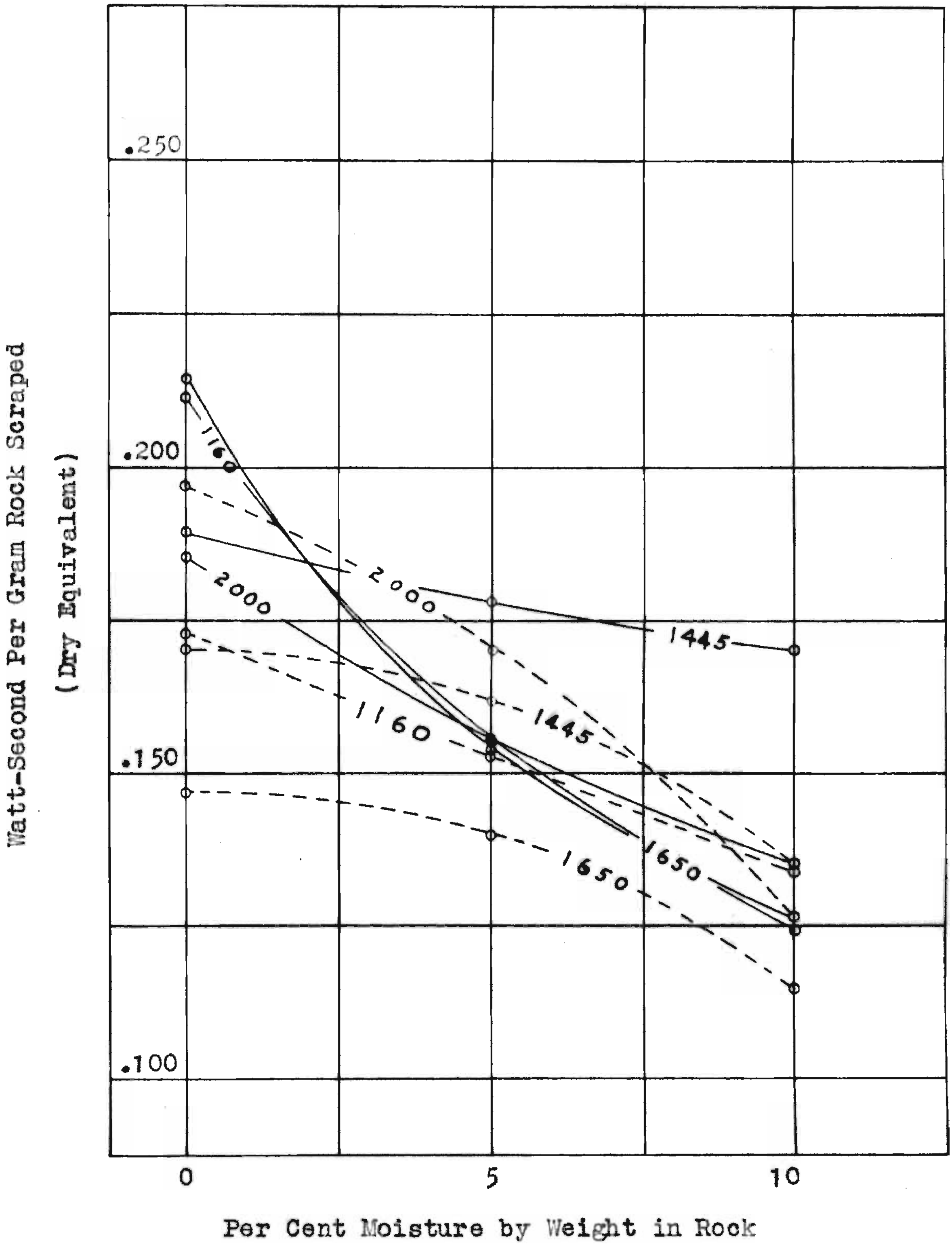
Graph 12. Relationship between moisture content and weight of rock scraped.

Box Type
252 fpm

Graphs 13, 14, and 15 show that the power consumption decreases as the moisture content of the muck increases.

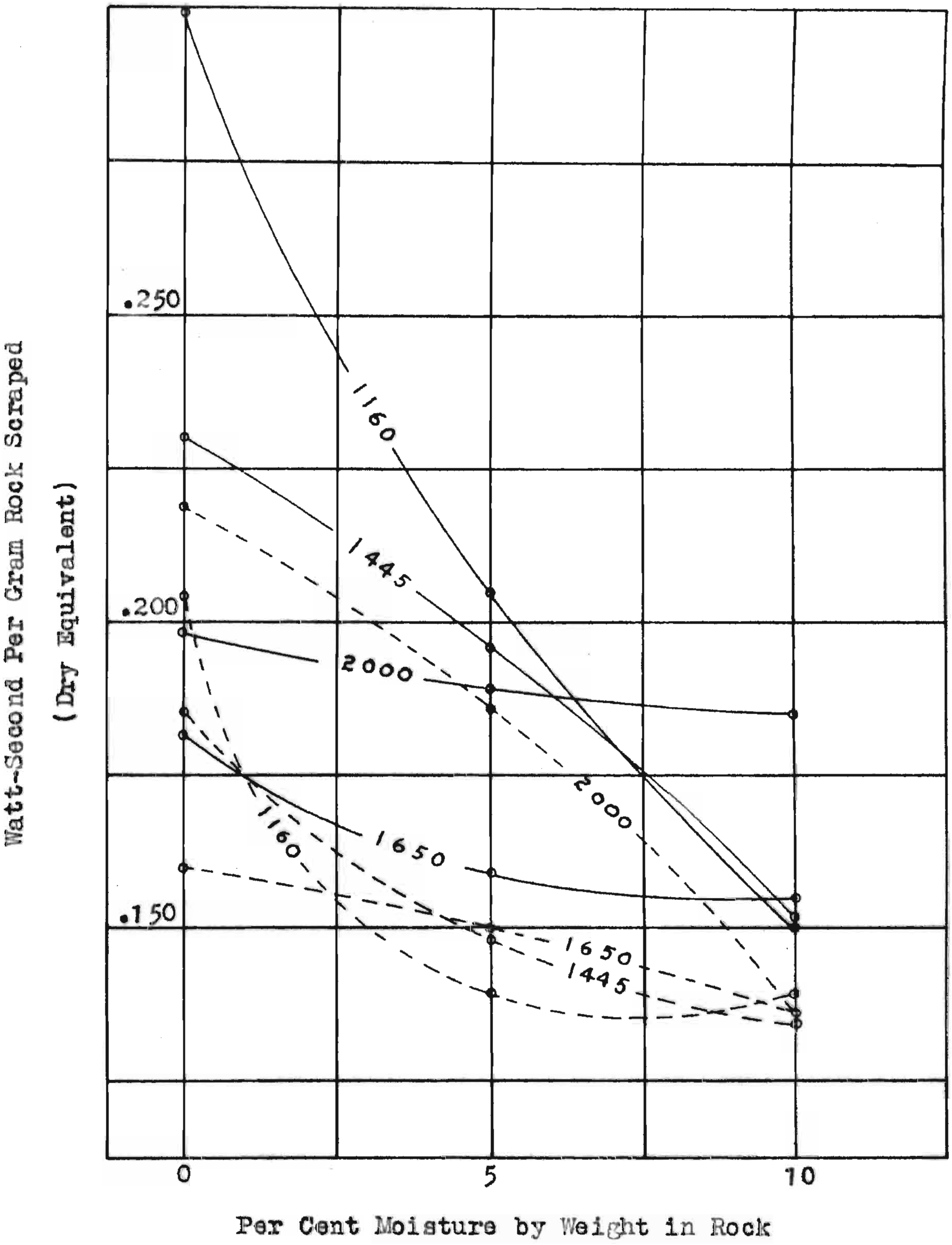
Graphs 16, 17, and 18 indicate that the grams scraped increase as the moisture content of the muck increases. Considering the design of the hoe scraper a reason can be given for this.

The hoe, as can be seen in Figure 3 has no sides, thus the material dug by the hoe and pushed in front of it is free to run out around the blade during transportation from the muck pile to the grizzly. As was stated earlier, this action tends to build up side ridges during the first few passes of the scraper. The very building of these ridges indicates that little of the material dug during the first few passes actually reaches the grizzly. This is especially true with dry ore which tends to run freely once it is broken away from the muck pile. As the moisture content is increased the material becomes more adherent and thus less likely to run out the sides of the scraper. It was noted during the experiment that side ridges were not nearly so important during the moisture tests as they were when the ore was dry. The first passes with the scraper carried almost as much muck as the latter passes. It was also noted that during the moisture tests much material was actually pushed ahead of the scraper out under the bail; this occurred even on the first passes. With the dry material this pushing effect was not accomplished until considerable side ridges had been built.



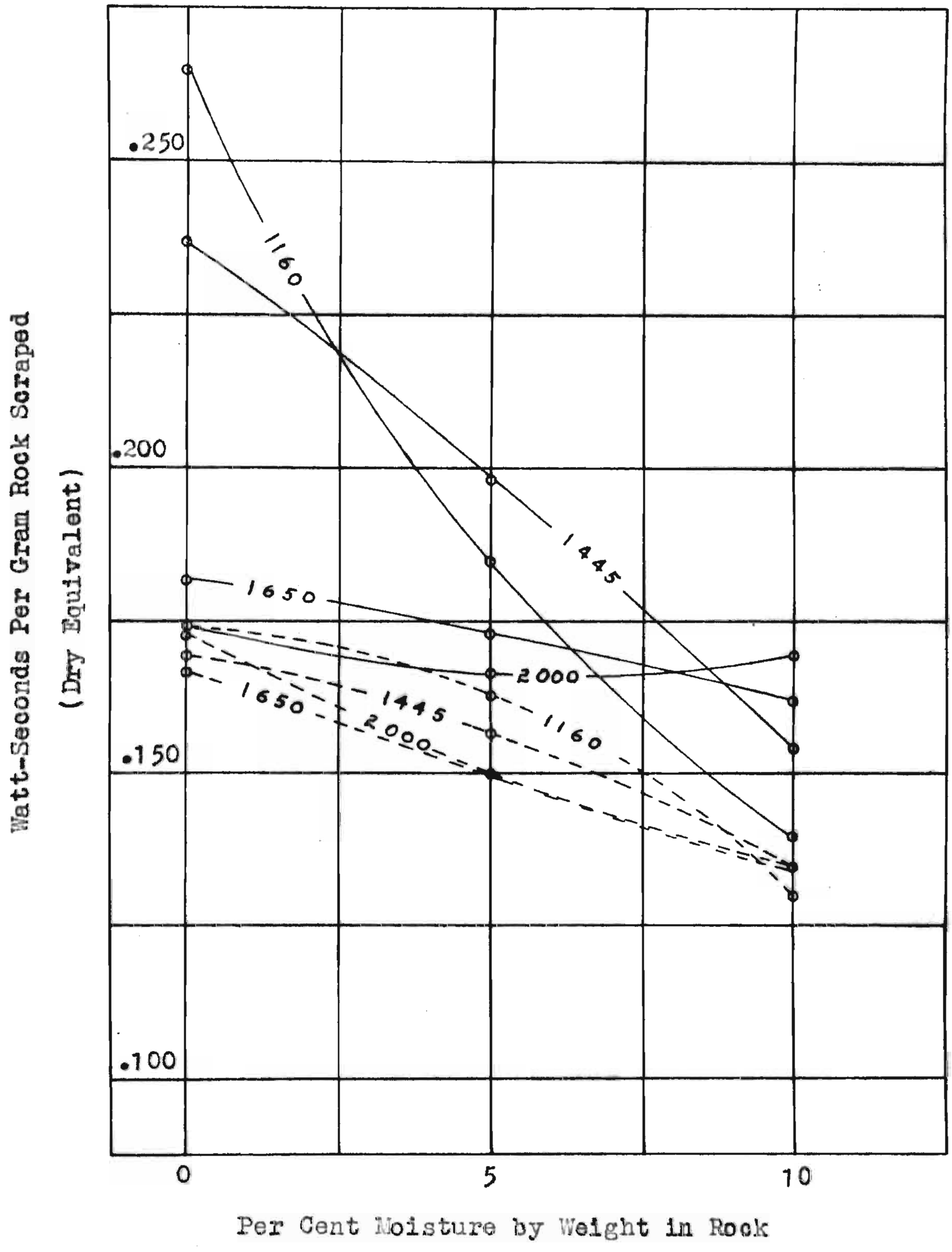
Graph 13. Relationship between moisture content and power consumption.

Straight Bail Hoe Type
126 fpm



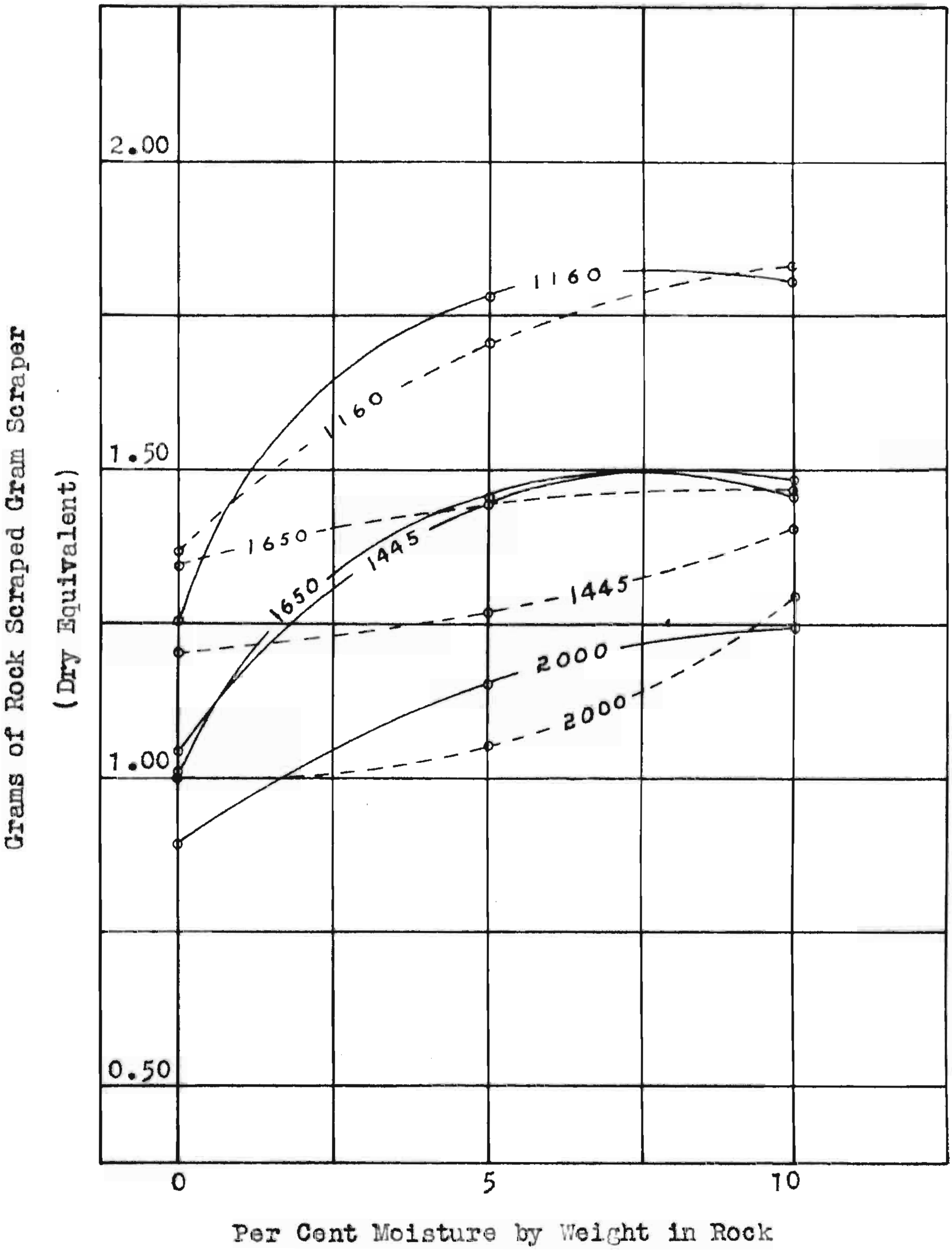
Graph 14. Relationship between moisture content and power consumption.

Straight Bail Hoe Type
191 fpm



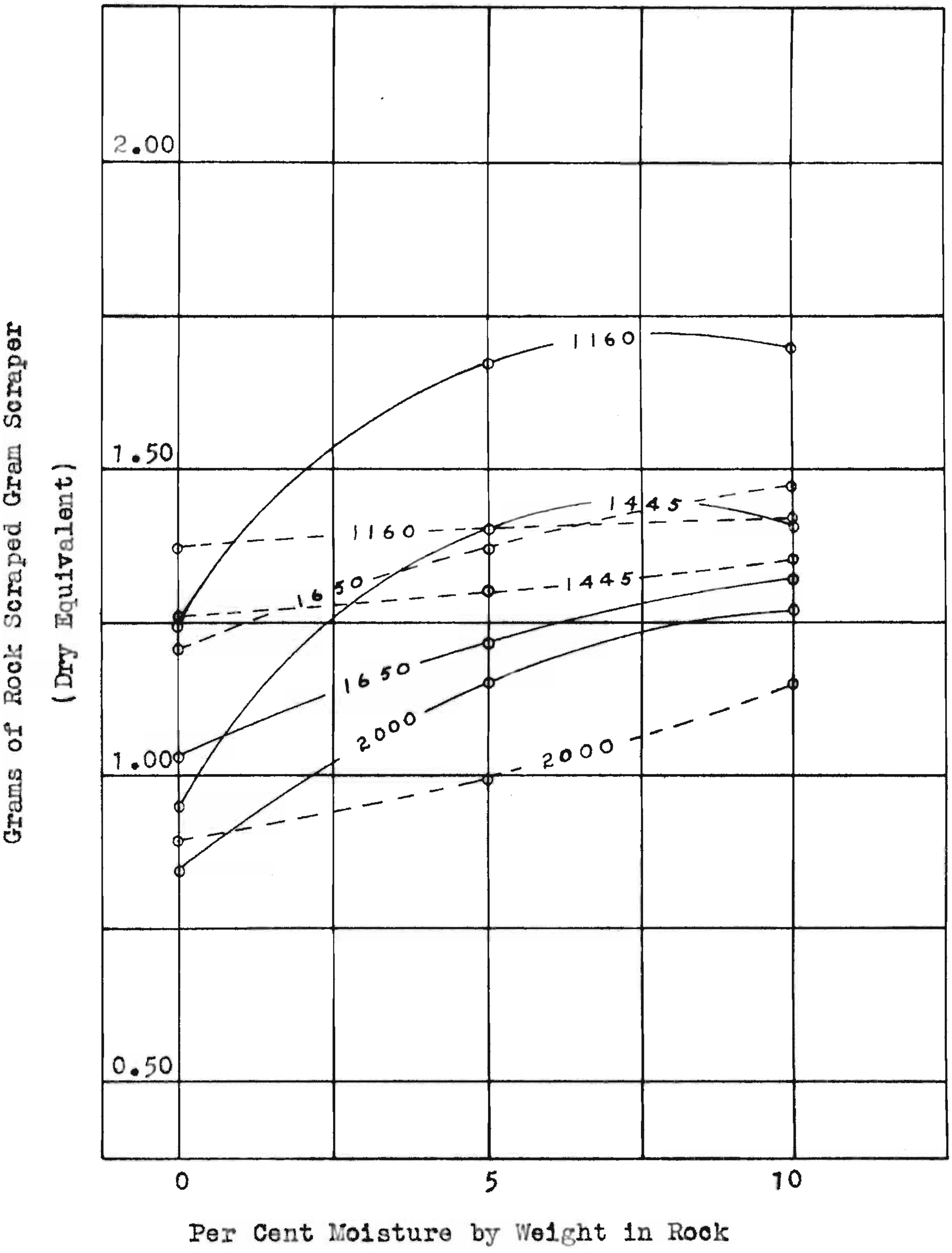
Graph 15. Relationship between moisture content and power consumption.

Straight Bail Hoe Type
252 fpm



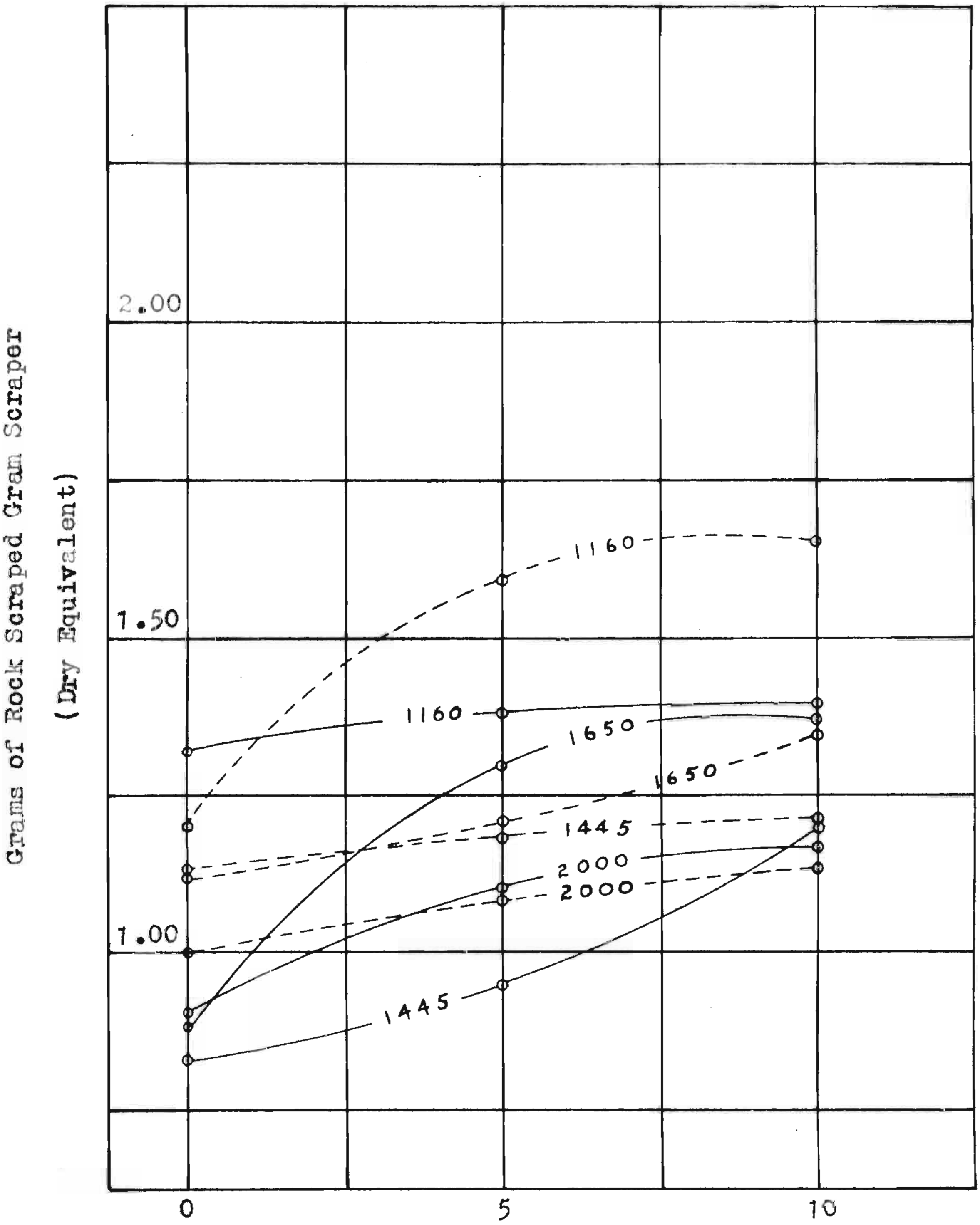
Graph 16. Relationship between moisture content and weight of rock scraped.

Straight Bull Hoe Type
126 fpm



Graph 17. Relationship between moisture content and weight of rock scraped.

Straight Bail Hoe Type
191 fpm



Graph 18. Relationship between moisture content and weight of rock scraped.

Straight Bail Hoe Type
252 fpm

The lack of sides on the hoe facilitates digging action so that the hoe tends to penetrate into either a wet or a dry muck pile instead of bouncing over the top as was characteristic of the crescent and box type scrapers on compacted material.

There might be some question as to the results obtained on the manganese ore at five per cent moisture content. It has been pointed out that the manganese tends to "fluff up" instead of becoming sticky at this moisture content. In light of this foregoing discussion on the hoe scraper one might expect its efficiency to drop at five per cent moisture due to the material being lost at the sides. The only explanation for the converse happening is that the "fluffed" material was so easy to scrape that the side ridges were built quickly and in the remaining passes much material was pushed ahead of the scraper. This ease of scraping was enough to make up for the fact that the material did not stick together.

The difference in specific gravity between the two materials seemed to have no effect on the efficiency of the hoe scraper. The power consumption and grams scraped cover about the same ranges for each material in the dry state.

CONCLUSIONS DRAWN FROM STUDY OF MODEL SCRAPERS

1. Conclusions drawn from the model scraper study of one material cannot necessarily be generalized to obtain for all materials. Physical properties inherent to each material prevent this generalization.

2. The box scraper shows a definite drop in efficiency from the limestone (specific gravity 2.8) to the manganese (specific gravity 4.9).

3. The crescent and hoe scrapers show little or no change in effeciency when used to move limestone and manganese ore.

4. The efficiency of the hoe scraper increases as the moisture content of the muck is increased from zero to ten per cent.

5. The efficiency of the crescent and box scrapers for scraping manganese ore is increased as the moisture content is raised from zero to five per cent. The efficiency of the scrapers fall sharply as the moisture content is increased from five to ten per cent.

SUMMARY OF SCRAPER TESTS

Three model scrapers were tested to determine the effect that specific gravity has on the efficiency of the scrapers, and to decide whether conslusions drawn from the study of one material could be generalized to obtain for any kind of material. Materials of two different specific gravities were examined and the variables considered were rope speed, scraper weight and moisture content of the muck.

The model scrapers experimented with were the crescent scraper, the box scraper, and the straight bail hoe scraper. They were 8 inches wide constructed on a scale of 1 to 6.

The materials used were crushed dolomitic limestone (Sp. G. 2.8) and manganese ore (Sp. G. 4.9).

It was found that these materials reacted differently to the different scrapers. With the limestone, the efficiency of the crescent and box scrapers decreased as the moisture content of the muck increased. These findings were similar to those found in earlier experimentation. However, with the manganese, the efficiency of the crescent and box scrapers increased as the moisture content of the muck was increased from five to ten per cent. This increase seemed due to inherent physical properties of the manganese rather than its higher specific gravity.

The box scraper was the only scraper tested which showed a definite change in efficiency due to the difference in specific gravity. The efficiency of the box scraper decreased in scraping the heavier ore.

It was found that moisture increases the efficiency of the hoe scraper on both the limestone and manganese. The power consumption decreases and the grams scraped increase as the moisture content is increased from zero to ten per cent.

The results of this study indicate that a generalization of conclusions drawn from experiments on one material to include other untested materials is liable to error.

In the opinion of this writer the great value of these model tests lies in the information they may import to indicate certain trends of scrapers on which hypotheses may be established to be later proved or disproved in actual practice.

APPENDIX A

Rope Speed Tests at 126 FPM

Crescent Type

Weight Scraper	Per cent Moisture	Watt-sec.per gram rock	Gms.rock per gram scraper	Wt.dry matter per pass.gms.
		LIMESTONE		
1050	0	0.100	2.27	2388
1050	5	0.133	1.69	1775
1050	10	0.221	1.70	1780
1440	0	0.159	2.00	2883
1440	5	0.165	1.89	2723
1440	10	0.172	1.80	2594
1745	0	0.109	1.92	3356
1745	5	0.127	1.56	2726
1745	10	0.139	1.54	2686
1955	0	0.103	1.75	3418
1955	5	0.132	1.68	3278
1955	10	0.137	1.55	3018
		MANGANESE		
1050	0	0.141	2.10	2206
1050	5	0.124	2.13	2244
1050	10	0.151	1.43	1503
1440	0	0.135	1.68	2430
1440	5	0.089	2.03	2925
1440	10	0.138	1.42	2046
1745	0	0.129	1.50	2608
1745	5	0.068	1.78	3101
1745	10	0.153	1.44	2504
1955	0	0.118	1.43	2802
1955	5	0.083	1.74	3404
1955	10	0.143	1.18	2319

APPENDIX B

Rope Speed Tests at 191 FPM

Crescent Type

Weight Scraper	Per cent Moisture	Watt-sec.per Gram Rock	Gms.Rock per Gram Scraper	Wt.Dry Matter Per Pass.Gms.
		LIMESTONE		
1050	0	0.141	1.98	2077
1050	5	0.156	1.60	1677
1050	10	0.232	1.47	1546
1440	0	0.125	1.80	2646
1440	5	0.131	1.63	2353
1440	10	0.185	1.49	2150
1745	0	0.104	1.60	2788
1745	5	0.149	1.58	2739
1745	10	0.158	1.51	2635
1955	0	0.147	1.51	2953
1955	5	0.151	1.44	2808
1955	10	0.150	1.35	2624
		MANGANESE		
1050	0	0.188	1.90	1995
1050	5	0.105	2.21	2324
1050	10	0.232	1.18	1237
1440	0	0.153	1.62	2328
1440	5	0.106	1.95	2810
1440	10	0.179	1.37	1988
1745	0	0.139	1.48	2591
1745	5	0.087	1.79	3133
1745	10	0.144	1.38	2417
1955	0	0.145	1.45	2837
1955	5	0.112	1.58	3098
1955	10	0.147	1.07	2097

APPENDIX C

Rope Speed Tests at 252 FPM

Crescent Type

Weight Scraper	Per cent Moisture	Watt-sec.per Gram Rock	Gms.Rock per Gram Scraper	Wt.Dry Matter Per Pass.Gms.
LIMESTONE				
1050	0	0.108	1.95	2049
1050	5	0.135	1.82	1909
1050	10	0.217	1.55	1628
1440	0	0.145	1.75	2509
1440	5	0.148	1.50	2166
1440	10	0.210	1.54	2245
1745	0	0.121	1.58	2767
1745	5	0.141	1.40	2450
1745	10	0.197	1.28	2253
1955	0	0.143	1.45	2843
1955	5	0.150	1.36	2649
1955	10	0.156	1.28	2496
MANGANESE				
1050	0	0.147	2.00	2097
1050	5	0.104	2.28	2395
1050	10	0.195	1.23	1289
1440	0	0.131	1.54	2218
1440	5	0.096	1.91	2757
1440	10	0.197	1.20	1723
1745	0	0.143	1.38	2399
1745	5	0.103	1.68	2934
1745	10	0.209	1.06	1845
1955	0	0.135	1.21	2360
1955	5	0.105	1.56	3046
1955	10	0.145	1.02	1992

APPENDIX D

Rope Speed Tests at 126 fpm

Box Type

LIMESTONE

Weight Scraper	Per Cent Moisture	Watt-sec.per Gram Rock	Gms.Rock per Gram Scraper	Wt.Dry Matter Per Pass.Gms.
1140	0	0.141	2.05	2337
1140	5	0.161	1.81	2067
1140	10	0.238	1.38	1568
1450	0	0.100	1.87	2709
1450	5	0.136	1.76	2552
1450	10	0.156	1.66	2407
1825	0	0.084	1.83	3340
1825	5	0.103	1.81	3325
1825	10	0.115	1.71	3120
2050	0	0.087	1.81	3724
2050	5	0.104	1.78	3650
2050	10	0.109	1.67	3432

MANGANESE

Weight Scraper	Per Cent Moisture	Watt-sec.per Gram Rock	Gms.Rock per Gram Scraper	Wt.Dry Matter Per Pass.Gms.
1140	0	0.149	1.70	1942
1140	5	0.102	2.17	2470
1140	10	0.153	1.39	1586
1450	0	0.114	1.66	2408
1450	5	0.103	2.32	3358
1450	10	0.174	1.15	1678
1825	0	0.101	1.45	2649
1825	5	0.093	1.90	3492
1825	10	0.114	1.39	2549
2050	0	0.102	1.43	2931
2050	5	0.085	2.02	4150
2050	10	0.132	1.26	2582

APPENDIX E

Rope Speed Tests at 191 fpm

Box Type

Weight Scraper	Per cent Moisture	Watt-sec.per Gram Rock	Gms.Rock per Gram Scraper	Wt.Dry Matter Per Pass.Gms.
		LIMESTONE		
1140	0	0.159	2.08	2367
1140	5	0.161	1.80	2055
1140	10	0.255	1.29	1410
1450	0	0.126	1.90	2757
1450	5	0.123	1.66	2399
1450	10	0.224	1.55	2258
1825	0	0.103	1.87	3414
1825	5	0.115	1.69	3087
1825	10	0.116	1.14	3081
2050	0	0.101	1.80	3689
2050	5	0.111	1.76	3594
2050	10	0.112	1.75	3582
		MANGANESE		
1140	0	0.160	1.76	1991
1140	5	0.107	2.28	2600
1140	10	0.197	1.24	1417
1450	0	0.161	1.52	2109
1450	5	0.107	1.93	2797
1450	10	0.263	0.93	1356
1825	0	0.120	1.40	2559
1825	5	0.105	1.89	3430
1825	10	0.170	1.03	1887
2050	0	0.106	1.60	3289
2050	5	0.092	1.82	3727
2050	10	0.197	1.19	2443

APPENDIX F

Rope Speed Tests at 252 fpm

Box Type

Weight Scraper	Per cent Moisture	Watt-sec.per Gram Rock	Gms.Rock per Gram Scraper	Wt.Dry Matter Per Pass.Gms.
		LIMESTONE		
1140	0	0.129	1.52	1736
1140	5	0.172	1.48	1693
1140	10	0.238	1.48	1686
1450	0	0.125	1.53	2214
1450	5	0.158	1.42	2060
1450	10	0.165	1.44	2082
1825	0	0.117	1.64	2986
1825	5	0.125	1.56	2853
1825	10	0.149	1.45	2645
2050	0	0.108	1.59	3267
2050	5	0.119	1.54	3164
2050	10	0.131	1.48	3030
		MANGANESE		
1140	0	0.187	1.42	1617
1140	5	0.117	2.13	2430
1140	10	0.250	0.75	858
1450	0	0.171	1.06	1535
1450	5	0.111	1.90	2757
1450	10	0.221	1.01	1463
1825	0	0.107	1.28	2340
1825	5	0.083	1.98	3610
1825	10	0.154	1.07	1960
2050	0	0.096	1.40	2865
2050	5	0.080	1.92	3948
2050	10	0.191	0.90	1853

APPENDIX G

Rope Speed Tests at 126 fpm

Straight Bail Hoe Type

Weight Scraper	Per cent Moisture	Watt-sec.per Gram Rock	Gms.Rock Per Gram Scraper	Wt.Dry Matter Per Pass.Gms.
		LIMESTONE		
1160	0	0.214	1.26	1458
1160	5	0.154	1.78	2066
1160	10	0.127	1.81	2103
1445	0	0.189	1.09	1558
1445	5	0.178	1.44	2080
1445	10	0.170	1.48	2134
1650	0	0.212	1.01	1662
1650	5	0.156	1.46	2395
1650	10	0.124	1.46	2416
2000	0	0.186	0.89	1782
2000	5	0.155	1.15	2308
2000	10	0.135	1.24	2477
		MANGANESE		
1160	0	0.173	1.37	1589
1160	5	0.153	1.71	1981
1160	10	0.134	1.83	2119
1445	0	0.171	1.21	1751
1445	5	0.162	1.27	1833
1445	10	0.134	1.41	2033
1650	0	0.147	1.34	2214
1650	5	0.140	1.44	2377
1650	10	0.114	1.47	2425
2000	0	0.197	1.00	1996
2000	5	0.170	1.06	2118
2000	10	0.127	1.30	2600

APPENDIX H

Rope Speed Tests at 191 fpm

Straight Bail Hoe Type

Weight Scraper	Per cent Moisture	Watt-sec.per Gram Rock	Gms.Rock Per Gram Scraper	Wt.Dry Matter Per Pass.Gms.
		LIMESTONE		
1160	0	0.302	1.24	1442
1160	5	0.205	1.67	1932
1160	10	0.150	1.69	1964
1445	0	0.230	0.95	1362
1445	5	0.196	1.41	2039
1445	10	0.152	1.40	2030
1650	0	0.182	1.03	1695
1650	5	0.158	1.22	2018
1650	10	0.155	1.32	2174
2000	0	0.198	0.84	1681
2000	5	0.188	1.15	2294
2000	10	0.185	1.27	2540
		MANGANESE		
1160	0	0.204	1.37	1591
1160	5	0.139	1.40	1623
1160	10	0.139	1.42	1642
1445	0	0.185	1.26	1815
1445	5	0.148	1.30	1879
1445	10	0.134	1.35	1961
1650	0	0.160	1.21	2008
1650	5	0.150	1.37	2255
1650	10	0.137	1.44	2379
2000	0	0.218	0.89	1786
2000	5	0.187	0.99	1980
2000	10	0.137	1.14	2277

APPENDIX I

Rope Speed Tests at 252 fpm

Straight Bail Hoe Type

Weight Scraper	Per cent Moisture	Watt-sec.per Gram Rock	Gms.Rock Per Gram Scraper	Wt.Dry Matter Per Pass.Gms.
		LIMESTONE		
1160	0	0.265	1.20	1394
1160	5	0.185	1.59	1854
1160	10	0.140	1.65	1914
1445	0	0.237	0.83	1211
1445	5	0.198	0.95	1378
1445	10	0.154	1.20	1742
1650	0	0.182	0.88	1446
1650	5	0.173	1.29	2128
1650	10	0.162	1.37	2257
2000	0	0.174	0.91	1922
2000	5	0.167	1.11	2232
2000	10	0.169	1.17	2336
		MANGANESE		
1160	0	0.174	1.32	1534
1160	5	0.163	1.38	1600
1160	10	0.130	1.39	1618
1445	0	0.169	1.12	1610
1445	5	0.157	1.18	1700
1445	10	0.135	1.21	1753
1650	0	0.167	1.13	1861
1650	5	0.150	1.21	2001
1650	10	0.135	1.34	2215
2000	0	0.173	1.00	1995
2000	5	0.150	1.08	2161
2000	10	0.135	1.13	2250

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