METALLURGICAL EDUCATION IN THAILAND

By

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A thesis submitted to the Faculty and the Board of Trustees of the Colorado School of Mines in partial fulfillment of the requirements for the degree of Master of Science.

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ABSTRACT

This paper is concerned with metallurgical education in Thailand, including discussion of curriculum, library, laboratory, student finance, and future development.

Up to the present time, there is no provision for training a metallurgist in Thailand. The writer suggests that ore dressing and production metallurgy be offered to students who graduate with a degree of Bachelor of Mining Engineering. After two years of successful study, the degree of Master of Mining Engineering will be awarded.

The writer intends six courses in metallurgy to be the major subjects. They are as follows:

Mineral Dressing Practice
Advanced Mineral Dressing
Metallurgical Mill Design
Production Metallurgy
Metallurgical Laboratory
Physical Chemistry

For minor subjects, the writer suggests the following courses, which have been offered by the other departments:

Technical English
Engineering Mathematics
High-Voltage Engineering
Advanced A-C Machinery
Water Supply and Treatment
Sewerage and Sewage Treatment
Public Health Administration
Water and Sewage Treatment

The writer also suggests that, in order to solve the problem of shortage of books, a small library should be planned. Each of the textbooks and reference books in metallurgy and allied fields should be presented to all the graduate students so that they can use them together.

The writer wishes to see the new ore-dressing laboratory, which will be built in the coming year, well-equipped with some new machines such as a Humphreys Spiral and a hydrocyclone, the applications of which will be greatly helpful to the concentration of the major ores in the country, tin and tungsten.

The writer feels that most of the students do not have enough money to continue their study in the graduate school; therefore, he plans to ask industries to help the students acquire this higher education.

Finally, the writer expresses his wish that more students from Thailand would come to the Colorado School of Mines. The writer hopes that, after the graduation of two more such metallurgists, the standard curriculum can be introduced.

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ACKNOWLEDGEMENTS

The writer wishes to take this opportunity of expressing his gratitude to Professor Hildreth Frost, Jr for his guidance and recommendation in writing this paper. The writer also feels indebted to all professors who in the past two years have given him the knowledge which made this paper possible. These professors are too numerous to be mentioned individually but special appreciation is due Professor Gordon H. Poole, who gave much helpful advice and Professor Arthur P. Wichmann, whose teaching formed many of these thoughts.

INTRODUCTION

Thailand is a country whose area approximates the size of Texas and whose resources include many kinds of minerals. To this date, however, only tin mining seems to have the major share of attention. Capital is needed for investigation and development of other metals, including tungsten, copper, lead, zinc, and iron.

The present world situation has never seemed to be secure enough to induce foreign companies to invest in Thailand. To offer an example, a leading Dutch Company opened a mining district in the southern part of the country. Some prospecting work was done in 1948; for almost two years the company spent over $25,000 before it decided to withdraw because of political crises in the Far East. Increasing production by inducing foreign technical skill and capital is a process which would be many years in coming.

Today the hope of Thailand is in the domestic investment and in the training and use of its own engineers. Therefore, the problems to be solved are to get the capital from the people who do not know enough about the mining business and to get well-trained engineers for the job. The first problem must be solved by a public relation man. The paper will be concerned about the second problem -- training a group of young men to mine and concentrate the minerals and to produce the metals in Thailand.

At the present time, there is a mining department but no metallurgical department at Chulalongkorn University, the only University in Thailand. Because the mining industry has not been developed in this country, the metallurgist has never seemed important. However, with the new increased desire to produce metal in the country itself, the role of the metallurgist takes on a new important position; but starting a new department to train engineers as such is not easy. It takes much time and money for the government to build a staff of metallurgical instructors, and the writer is afraid that, as the mining industry is still just beginning, very few mining companies can afford to hire both a mining engineer and a metallurgical engineer.

The writer, who graduated from Chulalongkorn University with a degree of Bachelor of Mining Engineering and who worked two years in the mining industry, wishes to work out the metallurgical problem of producing metals from the ores of Thailand.

MINERAL RESOURCES

In trying to solve the problem, as has been mentioned before, it is necessary to make a survey of the mineral resources of Thailand. Thailand does not have so many minerals to be considered as America has. However, this lack of variety will provide more time to study the individual minerals. The following is a discussion of the ores to be mined in Thailand.

Tin

Tin ore is the most important mineral ore in Thailand. In 1940, the year of greatest output, 18,800 tons of metallic tin was produced. Placer deposits furnish about ninety-two per cent of all the tin produced. Sixty-two per cent of the tin produced is recovered by dredging, and twenty-two per cent comes from gravel pump mines.

Tungsten

Tungsten ore ranks second in importance to tin among the mineral commodities of Thailand. The greatest production of wolframite concentrate was 1,760 tons in 1952.

Copper

Copper minerals occur in many parts of the country. In general, there are three types of deposits: the vein type, which is derived from igneous intrusion; the bedded type, which is associated with sandstone or schist; and the contact metamorphic type, which occurs with lead and zinc as well as with the tin deposit in the south.

Lead and Zinc

The replacement lead-zinc deposit of Nong Phai in Kanchanaburi province is the only one that has been studied in detail. The ore is fine-grained galena and sphalerite, containing a few traces of pyrite. At present the company is going into large-scale mining and is building a flotation plant to improve separation of lead and zinc.

Iron

Iron deposits are the most wide spread of all minerals deposits in Thailand, but only a few workable deposits have been discovered.

Of the twenty-two deposits found in the country, only four have been studied in detail. Most of the geological studies on iron deposits were made by the Thai Cement Company, which was granted special permission to prospect for iron in 1940. A prospecting survey was run over the Gossan area and a quantity of high-grade ore was found at Khao Thap Khwai. Since the deposit is easily accessible, it is sufficient for the company to make a start.

The smelting works of the company is at Tha Laung near the city of Saraburi. The present plant consists of several small mills producing 300-350 tons of steel bars per month.

Today Thailand has to import large quantities of iron and steel products, and the demand is likely to increase steadily owing to expansion in construction industries. The production of tha Laung plant is too low to meet the requirements of the country. Realizing this fact, the Thai government established a new mineral plant late in 1952 in the Ministry of Industry in order to start another iron and steel plant with a daily production of 100 tons of steel.

Manganese

Of all the manganese deposits found in the country, only that at Koh Kram, an island in the gulf of Thailand, has been exploited to a limited extent. This deposit is of secondary replacement type, in which cmplex iron manganese oxide replaces silica along fissures, joints, and bedding plants of sandstones and conglomerates of the dynamically metamorphosed Triassic series.

Antimony

The most notable occurrences of antimony ore in Thailand are in Lampang, Surat Thani, and Phrae. In all known localities, the principal ore is stibnite, which is commonly associated with the hydrous oxide, stibiconite. The stibnite is usually found in quartz veins which occur in granite or in limestones or quartzites associated with intrusive rocks.

Ilmenite

In Thailand ilmenite is always found associated with cassiterite. Originally it occurs in granite, pegmatites, and veins where it may be associated with cassiterite, wolframite, monazite, tourmaline, zircon, and rutile. Sorted beach deposits, derived from the weathering of ilmenite-bearing rocks and containing 40 to 50 per cent ilmenite, occur in various places on the shoreline of the eastern parts of peninsular Thailand. Two such deposits are at Phetburi and Prachuap Khiri Khan.

It should be pointed out that the tailing dumps of the tin-washing sheds in southern Thailand contain 60 to 90 per cent ilmenite. There are many thousands of tons of material in such dumps. Shortly before the outbreak of World War II in the Pacific area, Japan imported about 2,500 tons of the dump from Thailand.

In view of the above survey of the minerals in Thailand, it seems necessary to train a group of young engineers to meet the requirements of the future. Some of them should be trained to concentrate and produce tin and tungsten; some of them should be trained to concentrate and produce the metals of copper, lead, zinc, and others; the rest of the group should be trained to work in the new government steel plant.

As far as new industries are concerned, it seems necessary to offer advanced courses in ore dressing and production metallurgy in the first step. Then physical metallurgy, which is beyond the background of mining engineers and which is comparatively less important for the new-born industries, should be offered.

PRESENT CURRICULUM

The College of Engineering of Chulalongkorn University offers a program in basic engineering designed to prepare the young man for a place in the industrial and commercial development of Thailand. The student is at the same time given educational training in the field of learning which fits him to be a member of the society in which he lives. Both technical and non-technical courses are included in the four-year course of study.

Requirements for the Degree of Bachelor of Engineering

The degree of Bachelor of Engineering in Mining is granted to persons who complete the following courses. (All courses continue for a period of 36 weeks. Class periods are of 55 minutes duration, except laboratory periods which vary from one to three hours as indicated.)

First Year Basic Course

	Hours per week Lecture	Tutorial	Laboratory
Mathematics I	5	2	0
Physics I	3	2	0
Physics Laboratory I	1	0	2
Chemistry	3	2	0
Chemistry Laboratory	1	0	2
English I	1	2	0
Engineering Drawing I	0	0	3
Workshop I	1	0	2
Hygiene and First Aid	1	0	0
Total	16	8	9

Second Year Basic Course

	Lecture	Tutorial	Laboratory
Mathematics II	4	1	0
Physics II	3	1	0
Physics Laboratory II	0	0	3
English II	1	2	0
Engineering Drawing II	0	0	3
Workshop II	1	0	2
Surveying I	1	0	3
Applied Mechanics	3	1	0
Materials of Construction	1	0	0
Accounting	2	0	0
Total	16	5	11

Third Year

	Lecture	Tutorial	Laboratory
Surveying II	2	0	3
Mechanical Engineering Lab. I	0	0	3
Strength of Materials	3	1	0
Fluid Mechanics	2	0	0
Engineering Thermodynamics	3	0	0
Fundamentals of Electrical Engineering	2	0	2
Elements of Geology (1st half of year)	3	0	3
Structural and Field Geology (2nd half of year)	3	0	3
Mineralogy(1st half of year)	2	0	2
Petrology (2nd half of year)	2	0	2
Principles of Mining	2	0	0
Total	19	1	13

Two weeks of surveying practice at the end of the second year, and four weeks of geological survey at the end of the third term are in addition to the courses listed.

Fourth year	Hours per week Lecture	Tutorial	Laboratory
Mechanical Engineering Lab. II	1	0	3
Mining Method	2	0	0
Mining Surveying(1st term)	2	0	0
Mine Economics(2nd & 3rd)	2	0	0
Mining Machinery	2	0	2
Mine Design	2	0	3
Ore Dressing	2	0	3
Assaying	1	0	3
General Metallurgy	2	0	0
Heat Engines	2	0	0
Mining Gelogy	3	0	0
Total	19	0	14

Two weeks of mine surveying practice at the end of the first term; three weeks of practical mining experience at the end of the second term; and two-weeks of mining trip at the end of the third term, are in addition to the courses listed.

Requirements for the Degree of Master of Engineering

Starting with the year of 1955, the faculty of engineering offers the degree of Master of Engineering to selected and qualified persons. The graduate degree is now offered in the following fields:

Civil Engineering

Electrical Engineering, and

Sanitary Engineering

The Master of Engineering degree is a two-year course. A minimum of 30 units of graduate subjects including seminar and thesis must be fulfilled by each graduate student. (One unit is equivalent to one lecture hour per week throughout the year. One laboratory hour per week throughout the year is equivalent to one-half unit.)

PROPOSED CURRICULUM FOR DEGREE OF MASTER OF ENGINEERING

In view of the new graduate school courses mentioned previously, it seemed possible to offer the degree of Master of Mining Engineering. Instead of more mining courses, the advanced courses in ore dressing and production metallurgy will be given. Two years of study provide enough time, in the writer's opinion, for the training program to build the engineers to meet the needs of the nation of Thailand.

The suggested instruction and curriculum for the Master of Mining Engineering are shown as follows:

Admission

Applicant for graduate work in mining engineering must comply with following requirements:

(1) He must hold a degree of Bachelor of Engineering in Mining Engineering from Chulalongkorn University or its equivalent.

(2) He must prepare an official transcript of previous university or college work to the office of the dean. His credits will be evaluated and his graduate standing determined by the graduate committee.

(3) He must comply with all the rules and regulations concerning graduate work as set forth by the dean and the faculty of the graduate committee.

School Hours

The graduate courses will be offered from 8 A.M. to 5 P.M. Monday through Saturday during the university calendar year.

Major and Minor Subjects

Each graduate student must take or have taken at least two-thirds of the required units in the major subjects offered by the mining department. The minor subjects are the allied fields which are selected from departments of civil engineering, electrical engineering, and sanitary engineering. Major subjects are listed on pages 16-18, minor subjects on pages 18-20.

Program of Study

Each student must make out his own progress of study to be handed in for the approval of the head of the department before the academic year begins. Graduate studies may not be dropped without a grade "F" later than four weeks after the class begins.

Attendance

For each subject an attendance throughout the year of at least 75 per cent of all scheduled hours is required; otherwise the student will not be allowed to take the final examination.

Resident Requirements

The minimum time required to qualify for the degree of Master of Engineering is two full academic years.

Maximum Period of Study

A student enrolled in graduate study must complete all the work toward an advanced degree in a period of five consecutive years from his first year enrollment; otherwise no degree will be awarded.

Graduate Student in Full-Time Position

Members of the teaching staff and other persons holding a full-time position may register for not more than one-half of normal full-time load in any one term or academic year. One-half full-time load is set at approximately 7½ units per year.

Passing Grade

Grades received in graduate courses of less than 80 per cent shall be deemed unsatisfactory, and another course must be taken to replace the course in which the low grade was made. The same course may not be replaced unless it is required by faculty advisers.

Graduate Thesis

Each student is required to submit a thesis in partial fulfillment of the requirements for the degree of Master of Engineering. In general, the thesis will be written under the supervision of one member of the department as approved by head of the department.

Examination

Examinations will be held at the discretion of the examiners throughout the year. The final examination will be given during the regular examination period at the university. The candidate may be called before the examining board appointed by the graduate committee for presentation of and examination on the subject matter for the thesis and allied subjects.

INSTRUCTION OF SUGGESTED COURSES

The writer plans the following courses for the graduate students of mining engineering. The courses are classified into major and minor courses as shown below:

Major Courses

The graduate student must take at least 20 units in the major courses offered by the department of mining.

Mineral Dressing Practice: This course would involve the discussion of flowsheets of various mills as well as discussion of typical mineral dressing treatment of complex ores, byproducts, and tailings. Different combinations of unit operations necessary for the various types of minerals occurring in Thailand would be presented.

Speical emphasis is to be given to the basic theory of the unit operations involved, i.e., comminution screening, classification, jigging, flotation, tabling thickening, filtering, and any other which may be necessary.

Advanced Mineral Dressing: This course is a further study of methods used in mineral dressing. Recent developments and problems dealing with separation of valuable minerals in the country will be studied in detail.

Speical emphasis is to be given to the basic theory of material handling throughout the milling process, i.e., conveying, sampling, pumping, launder flow, and material balance. Also included would be theory, statistics, and practice involving replacement of worn parts, lubrication, reagent consumption, and general mill use of such items as balls, ball-mill liners, etc.

This course involves three hours per week; three units are given.

Metallurgical Mill Design: This course includes fundamental consideration involved in the design of a concentration mill, including the selection of the plant site, building, and equipment. The design of a plant based on the date obtained from the previous courses will be given:

This course involves one lecture hour and four laboratory hours three units are given.

Production Metallurgy: This course would involve an analytical study of the operating problem in the production of ferrous and non-ferrous metals.

The blast furnace, the open-hearth furnace, and Bessemer converter would be discusses in the first half of the year. Operating problems of lead, copper, tin, wolfram, and associated byproduct metals would be discussed during the second half.

Special emphasis would be on the basis chemical and physical aspects of the process involved.

The course involves three lecture hours and three laboratory hours per week; four and one-half units are given.

<u>Metallurgical Laboratory</u>: More laboratory work should be planned to give the student more practice in the use of the equipment dealing with ore dressing. Basic instruction in advanced equipment and technique in the same field would be studied.

This course involves three to six lecture hours; one and one-half to three units are given.

<u>Physical Chemistry</u>: This course, a comprehensive study of theory, application, and problems, is designed to enlarge the student's point of view with the respect to mining industries. The laboratory work also places emphasis on the scientific instruments that are in common use in research and industrial laboratories.

This course involves three hours of lecture three hours of laboratory per week; four and one-half units are given. It is required of candidates for advanced study in mining engineering.

Graduate Thesis: Laboratory, library, or field work for the Master's thesis will be conducted under the supervision of the graduate committee.

Credits will be arranged.

Minor Courses

The following courses offered by the other departments are opened to graduate students in mining engineering.

Technical English: The course is offered to give students more written and oral exercises, the major assignments to be correlated as closely as possible with the professional work.

This course involves one lecture hour per week; no credit will be given, but it is required of the candidate for an advanced degree in mining engineering.

Engineering Mathematics: This course is a study of ordinary differential equations, graphical and numerical solutions of differential equations, Orthogonal function, Fourier series, Bessels functions, Legendre polynomials and their application to boundry value problems.

This course involves two lecture hours per week; two units are given.

High-Voltage Engineering: In this course attention is given to analysis of dielectric field, conformal representation, capacitance, and potential gradients; dielectric under high-voltage stresses; corona; transients, travelling waves, reflection, and lightning phenomena and protection; surge generatiors and surge generatiors and surge testing of dielectrics.

This course involves three lectures hours; three units are given.

Advances A-C Machinery: Study is made in the course of unbalanced conditions on the operation of synchronous and induction machines; eddy currents in laminations; harmonic analysis of magnetic flux density in air gap of synchronous and induction machines and the effect on general e.m.f., torque, and vibration; transition conditions of synchronous and induction machines.

This course involve three lecture hours per week; three units are given.

Water Supply and Treatment: This is a study of sources of supply, problems of distribution, intensive study of water treatment from design and operating standpoint.

This course involves three lecture hours per week for one semester; one and one-half units are given.

Sewerage and Sewage Treatment; The course is offered to familiarize the student with sewerage problems, stream sanitation, methods of sewage treatment.

This course involves three lecture hours per week for one semester; one and one-half units are given.

Public Health Administration: This course is a general outline of functions and responsibility of the public health department; organization of the department; public health laws.

This course involves two lecture hours per week; two units are given.

Water and Sewage Treatment: The course is a study of plant operation, control tests, and records.

This course involves one lecture hour and three laboratory hours per week for one semester; one and one-fourth units are given.

NEW COURSES

The writer plans the following new courses to be taught in the graduate school.

Mineral Dressing Practice

Typical treatments and flowsheets of the operating mills concerned with the ores that are similar to deposits found in Thailand will be studied in detail. Following are some of the mills having available flowsheets:

Tin

a. Portuguese American Tin Co., Southern Europe
b. Butler Mine, New South Wales
c. Victoria Ore Dressing Plants, Bolivia

Tungsten

a. Wah Chang's Plant, Long Island
b. Good Friday Tungsten, Colorado
c. Marion Tungsten Mill, Colorado

Copper

a. Magma Copper Co., Arizona

Lead

a. Giant Mascot Mines Ltd., British Columbia

Lead-Zinc

a. Kooten Base Metals Ltd., British Columbia
b. Silver Standard Mines Ltd., British Columbia

Zinc

a. Mastodon Zinc Mines Ltd., BritishhColumbia

Manganese

a. Cuban-American Manganese Corp., Cuba
b. Anaconda Copper Co., Manganese Plant, Montana

Advanced Mineral Dressing

a. Further studies in mineral dressing will continue in the theory and/or application of the following:

Size Reduction and Screening

a. Balanced jaw crusher
b. Roll crusher
c. Rod mill and ball mill
d. Grizzly screen and vibrating screen
e. Measuring the crushing resistance of ores

Gravity Concentration

a. Heavy media separation
b. Humphreys spiral
c. Hydrocyclone

Flotation

a. Selection of the flotation machines
b. Classification of flotation reagents
c. Kinetics of the flotation process
d. Adsoprtion and surface energy
e. Colloids and slimes in flotation

Magnetic Separation

a. Low intensity machines
b. High intensity machines

Others

a. Conveyors
b. Pumps
c. Classifiers
d. Driers
e. Etc.

Metallurgical Mill Design

Following factors will be included in the consideration:

Mill Justification

a. Accurate sampling of the ore body
b. Quantities of ore
c. Record of the results that might be obtained
d. Smelting schedules or other terms of sale

Flowsheet

a. Qualitative flowsheet
b. Quantitative flowsheet
c. Calculation for water balance
d. Selection of equipment

Plant Layout and Assembly

a. Equipment location
b. Department arrangement
c. Materials handing, expansion, storage, machine shop

Location of the Plant

a. Raw materials
b. Market and transportation
c. Topography
d. Flood protection
e. Soil structure
f. Tailing disposal
g. Labor
h. Power Supply

Building and Power Transmission

a. Type of Building
b. Materials of construction
c. Illumination
d. Ventilation
e. Power motivation and transmission

Cost Estimating

a. Building
b. Equipment
c. Installation
d. Power
e. Maintenance and repairs

Production Metallurgy

This course will be divided into two parts, ferrous and non-ferrous metallurgy, to be taught in two consecutive semesters.

Ferrous Metallurgy

a. Properties of iron and its alloys
b. Chemistry reaction in the furnace
c. Combustion
d. Manufacture of coke and producer gas
e. Heat balances
f. Calculation of charges for smelting
g. Raw materials
h. Iron blast furnace
i. Refractory
j. Slag
k. Pig Iron
l. Bessemer process
m. Basic open-hearth process
n. Electric furnace
o. Ingot and ingot molds

Non-Ferrous Metallurgy

Tin

a. Properties of tin and its alloys
b. Special treatment of ores
c. Metallurgical methods
d. Smelting furnaces
e. Typical smelting practice
    Penang Plant, Malaya
    Penpoll, England
    Longhorn Smelter, Amerida
    German practice
    Canadian practice
f. Refining of tin

Tungsten

a. Properties of tungsten and its alloys
b. Decomposition of tungsten ore
c. Purification of tungsten oxide
d. Production of tungsten powder
e. Manufacture of ferrotungsten

Copper

a. Properties of copper and its alloys
b. Roasting
c. Smelting
d. Refractory and construction
e. Matte
f. Fuel
g. Leaching
h. Reclaimation from scrap
i. Refining

Zinc

a. Properties of zinc and its alloys
b. Roasting
c. Sintering
d. Horizontal retorting
e. Vertical retorting
f. Preparation of mix
g. Refining

Antimony

a. Properties of antimony and its alloys
b. Liquation of rich ores
c. Roasting sulfide ores
d. Reduction of antimony oxide to metal
e. Direct production of metal from sulfide
f. Refining

Metallurgical Laboratory

Individual work dealing with the student's own field will be assigned in order to familiarize the student with his future project.

Physical Chemistry

In general, the course is planned to introduce the following subjects:

a. Chemical industrial calculation
b. Chemistry of solid state
c. Properties of solution
d. Colloidal chemistry
e. Thermochemistry
f. Nuclear physics
g. Electrolysis and polarization
h. Chemical equilibria
i. Ionic equilibria
j. Phase rule
k. Atomic structure and radioactivity
l. Corrosion
m. Adsorption
n. Structure of metals
o. Spectrography
p. X-ray analysis

CONCLUSIONS

When the writer began to think about metallurgical education in his country, he felt that the first two factors to be faced were finance and time. As the writer has mentioned before, there is no department of metallurgy in Thailand at present. In starting a new department, we need many qualified instructors. These instructors whould be educated abroad. However, even if we had the money on hand to do so, we would still have to wait at least five years to get these teachers.

The aim of the writer, therefore, is to solve the problems temporarily. In order to have the young men to meet the now-present requirement in the industries, the writer suggests offering metallurgical education to the mining engineer who graduates with the degree of Bachelor of Mining Engineering. The major courses will be in the field of ore dressing and production metallurgy. Some other graduate courses offered in departments of civil engineering, electrical engineering, and sanitary engineering may be selected by the students to be the minor courses. After two years of successful study, the students will be awarded the degree of Master of Mining Engineering.

Up to now, we have two lecturers who graduated from Colorado School of Mines, one from the department of Mining and the other from the Department of Geology. We also have one more lecturer, who graduated in mining engineering from Royal School of Mines, England. The writer, therefore, believes that these teachers will be able to educate our young men for the new requirement. For further study in production metallurgy, the writer hopes that it will be possible to invite some metallurgists from the other orgainzations of the government, especially the ones which are in need of our students, to teach the students to meet the problem of metal production.

The next problem seems to be that of student support. In the knowledge of the writer, the average parents earn about $150 a month. Therefore, we cannot expect the students to buy books as American students do. To solve our problem, the writer suggests a small library containing textbooks and reference books on metallurgy and related fields of knowledge.

The students will be permitted to use the library any time during school hours. If it is possible, the writer would like to have the new library located in the new ore-dressing laboratory building that will be planned in the coming year. The library room, even if it is a small one, should have enough space for the meeting of about ten persons. Besides, the library, the room may be used for seminars in the field of metallurgy. The library should be supported by the college.

According to the standard of living in Thailand at the time of this writing, the weiter believes that most of the students do not have enough money to continue their study in the graduate school. The writer thinks that industries or organizations expecting to get these qualified engineers should give the students a hand.

It appears to the writer that some industries expect our young engineers who just get out of the college to know everything. From the questionnaires which the writer got back for this paper, the only complaint is that the students have not had enough practice. No specific mention was made, however, of kind of practice. The students, during four years of their study, spend about 33 hours a week for the training. It seems impossible to load more work upon them, especially in laboratory.

At the recent "Engineers' Day" at the Colorado School of Mines, Mr. Robert Henderson, president manager of Climax Molybdenum Company, said in his lecture on "The Organization of the Climax Company" that the young engineers who just graduate from the college should start their jobs from the bottom. The writer learns that Mr. Henderson meant that the company should provide a chance for the young men to be trained to fit the job. The company provides and offers the time of experienced engineers to educate the new men to work into higher positions. Mr. Henderson, who started his job as a helper on a mucking crew, confirmed what the writer learned from Professor Hildreth Frost, Jr., professor in metallurgical department, that it is American business policy to train engineers, graduated from college with the general background, to fit the job of their own industries. In Thailand, it is impossible for new industries to train their engineers but these industries should help students to study two more years in the graduate school.

In order to familiarize the student with industrial practices during the school day, specialists from the individual firms will be invited to talk to the class.

For example, Mr. A, who is a skilled manager of one of the well-known industries and who is the sponsor of one student in the class, may be invited to talk about management. The lecture will be helpful to the other students. Time can be arranged during two years of graduate study for the lecture as such. The thesis of the individual student, if it is possible, should deal with the work of the firm which the student expects to work for. The sponsor of the student is supposed to be concerned with the thesis.

The last thing to be considered seemed to be the laboratory. The writer wishes to see the new ore-dressing building well-equipped. Besides the instruments we have at present, some other new equipment for the gravity concentration, such as Humphreys spiral, hydrocyclone, and heavy-media separators should be introduced. The writer hopes that this equipment will be helpful in the concentration of the major ores in the country, tin and tungsten. The building should not be too close to the main engineering building, and enough space should be provided beside the new building for the production metallurgy and physical metallurgy laboratories.

Finally, the writer hopes that, after the graduation of two new metallurgists from the Colorado School of Mines, it will be possible to start a department of metallurgy in Thailand. The undergraduate program of study leading to the Degree of Bachelor of Metallurgical Engineering will be designed to give the students a strong back-ground in engineering principles and professional subjects. More courses in the field of metallurgy, including organic chemistry, physical metallurgy, pyrometallurgy, hydrometallurgy, mineral economics, and industrial relations, will be offered in order to make it possible for the graduating students to enter almost any area of metallurgical engineering. For graduate study, advanced courses will be arranged to meet the requirements of the individual industry. In general, the curriculum at that time will be more or less similar to that of the Colorado School of Mines.

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