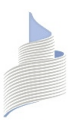
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YIP YAT HOONG

The Development of the TIN MINING INDUSTRY OF MALAYA

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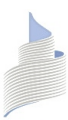
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Preface

THE two pillars of the Malayan economy have for decades been the tin mining industry and the rubber industry; yet relatively little has been written about the former. Apart from various articles by Siew Nim Chee and myself, published in the *Malayan Economic Review* and *Kajian Ekonomi Malaysia*, only two books have been published on tin. They are L. L. Fermor, *Report upon the Mining Industry of Malaya* and Wong Lin Ken, *The Malayan Tin Industry to 1914*. The former, a study undertaken by a well-known geologist for the Government of the Federated Malay States, was published in 1939. The latter, published in 1965, is an historical study and, as the title suggests, is confined to the period before the First World War.

In writing this book, I am trying to fill the gap by bringing the subject up to date.

The introduction briefly explains the present structure of the tin mining industry. Part I deals with its early development up to 1900, a period during which Chinese enterprise predominated. Part II examines the growth of the industry in the period 1900 to 1930, which saw the rapid expansion of Western enterprise. Part III examines the Malayan tin mining industry during the inter-war period, in the context of international tin control, and in Part IV the industry during the war and post-war years is surveyed. Finally, the Conclusion closely analyses the present trends and future prospects of the industry.

Most of the research for this book was undertaken between 1961 and 1963 at the London School of Economics. I would like to express my gratitude to Professor P. T. Bauer for his guidance during this period. The writing of this book was carried out in the Faculty of Economics and Administration of the University of Malaya under the guidance of Professor Ungku A. Aziz. I also wish to express my gratitude to him for his vigorous and constructive criticism.

Y.Y.H.

University of Malaya/April 1968


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I NATURE OF TIN

As an industrial metal tin may be compared to garlic in Chinese cooking—seemingly insignificant quantitatively but in fact utterly indispensable. In the modern age of canned foods tin is vitally essential in the manufacture of tinplate.

In early times the main reason for the great importance of tin was its hardening effect on copper. In many cultures copper succeeded stone for weapons and tools; but copper was relatively soft, and the discovery that it could be made harder and stronger by alloying it with tin (normally less than 10 per cent) led to the making of more effective weapons and better tools. Thus people who possessed tin-copper alloy (now known as bronze) implements which could be sharpened to a cutting edge had an enormous advantage over their fellows who only had copper. Tin thus became a strategic metal as soon as its part in making bronze was realized, and it has retained this position ever since.

In the modern world the importance of tin goes beyond the making of bronze. Tin-lead alloys are widely used as soft solders, and there is an increasing use of tin-aluminium alloys for engine bearings. Among the other tin alloys the more important are bearing metals, such as anti-friction metal, babbitt metal and white metal alloys, which contain varying amounts of tin, antimony, copper and lead. There is also a wider use of tin-copper alloys. Bronzes, gun-metals, brasses and such tin-copper alloys are now used for coinage, bearings, pump bodies, high-pressure steam plants, cymbals and bells. However the use of tin in alloys is responsible for only one-third of the world consumption of primary tin. Its most important use is in the manufacture of tinplate, the bulk of which is consumed by the can-making industry. The tinplate industry accounts for two-fifths of the world consumption of primary tin.

The demand for tin is therefore a derived demand. As an industrial metal tin is seldom used in its pure state but is usually combined, in small proportions, with other metals. For instance the proportion of tin in tinplate may be as little as 0·25 per cent. Thus in the canning industry the cost of tin in a can of meat or fish amounts to only a small fraction of the total cost. This causes the price elasticity of demand for tin to be extremely low so that fluctuations in the price of tin are seldom accompanied by significant changes in its demand. At the same time, since most of the tin produced is imported by the industrial countries of the West, slight changes in the business conditions of these countries can cause wide fluctuations in the tin price and hence in the export earnings of the tin producing countries, all of which are economically underdeveloped. In this way all the tin producing countries are tied to the industrial activity of the West. For the tin producing countries this lack of stability is significant because tin export earnings represent a considerable share of their gross national product.

To the industrial countries, all of which have few or no sources of supply, tin is indispensable because it is still vitally essential in most industries and there is, as yet, no satisfactory substitute. In peace time the search for a substitute is not encouraged because tin forms such a small proportion of the total cost of manufacture. During the Second World War when supplies from the Far East, representing two-thirds of the world total, were cut off, the United States did make an extensive search for a substitute, but without success. What was discovered during the war, however, was the process of electrolytic tin plating which has reduced the amount of tin used in tinplate by as much as five-sixths. But this is essentially a method of saving the use of tin rather than a substitute, as in the case of synthetic rubber for natural rubber. Today tin continues to be indispensable to modern industry.

Properties

Physically, the metal tin is white in colour and possesses a slightly bluish tinge. It is whiter than silver or zinc and bluer than chromium. It has a brilliant lustre and when polished it has a high light reflectivity.

Mechanically, tin is weak. Normally it is relatively soft and can be easily cut with a knife, although its hardness varies directly with the temperature it is subjected to. It is most malleable and ductible in the vicinity of 100 degrees Centigrade when it can easily be rolled or beaten into thin sheets, but at 200 degrees Centigrade it becomes so brittle that it is easily shattered by a blow from a hammer. In its ability to be rolled into thin sheets tin has found an important use in industry as a foil when it is usually rolled to thicknesses of 0·0035 to 0·006 of an inch.

Although when pure or slightly alloyed tin can be used in producing

collapsible tubes and foil, its main use is as a protective coating for stronger materials and as an alloying element with a wide variety of other metals. One of man's earliest metallurgical observations was that tin would harden copper. Its modifying influence on both copper and lead constitutes one of its most useful properties. Without this property it would be impossible to produce such important industrial materials as bronze and solder. As a protective coating for stronger materials the most successful is in plating steel. Tin-bearing solutions used in plating are more conductive than many other plating baths, such as those used in nickel plating, so that the covering of tin over iron or steel is much more continuous than is nickel. Such continuity of tin plating leaves fewer pinholes available for the entrance of corrosive agents.

Chemically, the most outstanding property of tin is its ability to resist attack by air and by many of the organic acids, including those found in foods of various kinds. It is because of this property that tin has been used mainly as a container of foods in the form of tinplate. The actual number of cases in which tin has been found to be poisonous to human beings is extremely small. Thus with the use of tinplate as food containers the risk of food poisoning is reduced to the minimum.

Types, Forms and Grades

There are several known tin-bearing minerals in the earth's crust. Of these, cassiterite or tin-stone is the only ore mineral of widespread importance. The others which are all complex sulfides are of little importance. Stannite is perhaps the best known of these sulfides. The Bolivian ores contain a mixture of various sulfides in addition to cassiterite. The presence of these other minerals is the main cause of the variation in the tin content of Bolivian concentrates and of the difficulties in their smelting and refining because of the necessity of having to remove the other base metals. In contrast, Malayan ores which are largely alluvial are mainly cassiterite, although they contain certain impurities such as ilmenite, monazite and zircon.

As with all mineral deposits, the grade of tin-ore varies considerably from one deposit to the next within a given region and between different regions as well. The metal content of the ore that can be worked commercially depends on the type and cost of the extraction process used and on the difficulty of concentration and refining. In general, the grade of tin-ore that can be mined by the various mining methods varies. Lode mining of tin requires the highest grade of ore to be commercially viable, while dredges can operate in the low-grade ores found in placer-type deposits.

The ore deposits of Malaya, Indonesia and other parts of South-East Asia, which are usually amenable to dredging, gravel pumping and other surface methods, have been economic sources of tin, even though in recent years the tin content has been only a fraction of 1 per cent. On the other

hand, Bolivian producers, who produce tin almost exclusively from underground lode operations, must depend on higher tin content in order to compensate for the higher cost of mining and treatment of their complex ores.

Examples of the grade of ore as mined in several parts of the world can be found in the following Table:[1]

SOURCES OF THE ORE		1939–40	1948	1950–1
Malaya	(lb. tin per cu. yd.)	0·45	0·44	0·36
Indonesia	(lb. tin per cu. yd.)	0·84	0·86	n.a.
Nigeria	(lb. tin per cu. yd.)	1·62	0·73	0·50
Bolivia	(% of tin in ore):			
	Patino, Catavi mine	2·31	1·60	1·20
	Hochschild Group	2·88	1·91	1·72
	Aramayo Chorolque mine	4·55	3·30	1·40

It is interesting to note how modern techniques have apparently made it possible to mine lower-grade ores more profitably than was done in earlier days. This is particularly true in the case of Malaya. Before 1900 no tin miner in Malaya would consider it worthwhile to work a ground with less than one pound of tin per cubic yard; today, most of the dredges are working grounds with about one-quarter pound of tin per cubic yard.

It is not possible to smelt tin-ores directly as they come from the mine because of their small tin content; they must be concentrated and the bulk of the waste removed prior to smelting. In addition to the necessity of preparing the ore for smelting, the elimination of waste materials by concentration reduces the cost of transporting the ores. In Malaya and most parts of South-East Asia the concentration is usually done as part of the mining, using very simple gravity types of separation like the *palong* as used by gravel-pump miners in Malaya.[2] In Malaya as much as 99 per cent of the non-tin-bearing rock is thus removed so that the resulting concentrate is almost pure cassiterite.[3]

There is a close similarity among the tin content of the concentrates produced from many widely-separated regions in the world as a result of the similarity of mineral occurrence, for example, placer deposits of

[1] United States Department of Commerce (National Production Authority), *Materials Survey—Tin*, Washington, June 1953, chapter 3, p. 2.

[2] In recent years, however, jigs have been used as an adjunct to *palongs* in many gravel-pump and hydraulic mines in many places in Malaya.

[3] The concentration operation as described here is very much simplified, and may be regarded as preliminary concentration. The final concentration of impure tin concentrate entails further treatment involving sizing, jigging and table concentration, followed by drying and both electro-magnetic and electro-static or high tension separation. Some washing by hand is done in the final cleaning.

cassiterite with essentially the same impurities. Again, the exception is Bolivia. While the other mining regions are generally working somewhat similar deposits of cassiterite, Bolivian producers are dealing with lode deposits of a complex nature. Even though the tin content of the average Bolivian ores is largely in cassiterite, it almost always contains other metallic sulfide minerals which are usually incompletely separated from the cassiterite in the concentration process. As the proportions of these sulfide minerals differ from deposit to deposit, and because the efficiency of concentration is quite different from one plant to another, the tin content of the concentrates from Bolivian mines varies widely compared to those in other countries. This is illustrated in the following Table:[1]

SOURCES OF CONCENTRATES	NORMAL RANGE OF TIN CONTENT PERCENTAGES
Malaya, Thailand, Indonesia, Belgian Congo, Nigeria	72–75
China, Kochiu	70–72
Burma	72–73
Indo-China	55–65
Bolivia[2]	18–66

This increases the difficulty of smelting compared with the much purer concentrates in Malaya and other parts of South-East Asia. This is one of the reasons why Bolivia is the highest-cost tin producer in the world while Malaya is one of the lowest-cost.

The process of smelting and refining turns tin concentrates into tin metal. In the world tin trade, the metal is graded by brand names. Tin dealers have become accustomed to buying or selling tin on the basis of brand names because of their general confidence that the brand in question will have a tin content and impurities within an acceptable range. The brand names employed are usually based on the company producing the tin, the name of the smelter from which it came or the region in which the ores were produced. In general, the brands of tin originating from high-grade Malayan and South-East Asian ores are looked upon as being the highest in tin content and lowest in impurities. The Straits Trading and the Eastern Smelting brands of tin from Malaya, for instance, are regarded as Class A tin (i.e., the highest grade with a tin content of 99·8 per cent or above) in the New York Metal Exchange. In the trading of tin on the London Metal Exchange, on the other hand, the so-called London 'Standard' tin is normally employed in price quotations. London 'Standard'

[1] United States Department of Commerce (National Production Authority), *Material Survey—Tin*, p. 4.

[2] A large proportion of the Bolivian tin concentrates fall within the upper bracket of this range of 18–66 per cent of tin content.

is defined as any metal having a tin content of between 99·00 and 99·75 per cent. The numerous brands of tin which have a tin content higher than this receive a premium above the 'Standard' quotation.

Uses

Tin as a metal is seldom used in industry in its pure state except in the manufacture of collapsible tubes, foil, pipes and tubes. As an industrial metal it is usually alloyed, combined or associated with other metals. The uses of tin may be divided into three broad groups: in tinplate, in alloys and in other uses.

USE OF TIN IN TINPLATE

Above 40 per cent of the primary tin consumed in the world is used in the manufacture of tinplate. In the United States the proportion is higher, being nearly 60 per cent (see Table below). Tinplate is steel sheet coated very thinly with tin.

CONSUMPTION OF PRIMARY TIN BY FINISHED PRODUCTS, UNITED STATES, 1958–62 (AVERAGE)

USES	CONSUMPTION	
	IN TONS	PER CENT
Tinplate	29,500	59·0
Solder	8,200	16·4
Bronze and brass	3,500	7·0
Babbitt	2,000	4·0
White metal	1,400	2·8
Type metal	100	0·2
Terne metal	100	0·2
Miscellaneous alloys	300	0·6
Tinning	2,000	4·0
Pipe and tubing	100	0·2
Bar tin	1,100	2·2
Collapsible tubes and foil	900	1·8
Chemicals	700	1·4
Miscellaneous	100	0·2
TOTAL	50,000	100·0

Source. International Tin Council, *Statistical Supplement*, 1963, p. 40.

World production of tinplate has increased, almost without interruption, from less than 1 million tons a year at the beginning of the present century to nearly 9 million tons in 1960 (excluding the U.S.S.R., Mainland China

and Eastern Europe). Until the last decade of the nineteenth century practically all the world's tinplate was manufactured in the United Kingdom. However the growth of the industry in the United States was so rapid that by 1912 its output of tinplate had outstripped that of the United Kingdom. In other parts of the world the industry was slow to develop and until 1950 less than 15 per cent of the world's tinplate was produced outside the United States and the United Kingdom. Since then the most striking trend in tinplate production has been the high rate of development in such countries as Japan, Belgium, France and Italy, together with the emergence of new producers such as the Netherlands, Australia and South Africa. By 1958 the proportion of world production outside the United States and the United Kingdom had risen to 25 per cent and by 1961 to 30 per cent.

Before the Second World War the coat of tin on tinplate used to be deposited by the hot-dipping process in which the steel sheet was made to pass through molten tin metal. Today this is mainly done by the electrolytic process in which the steel sheet receives an electro-deposition of tin while passing through a solution of stannous salts. To the tin industry the economic significance of the change-over from hot-dipping to electrolytic coating lies in the saving of tin. Whereas in the former process the proportion of tin in tinplate was about 1·5 per cent, in the new process it is reduced to as little as 0·25 per cent. Thus in 1959, 3 per cent less tin was used in the United States than in 1945 to produce 75 per cent more tinplate.[1]

Although many new uses have been found for tinplate in recent years, the bulk of the world output is still used by the can-making industry. It seems likely, in view of the still low per capita consumption of canned foods in many parts of the world, that food preservation will remain the main use of tinplate in the future.

USE OF TIN IN ALLOYS

The tin alloys industry as a group is second only to tinplate as a consumer of tin metal. The most important are tin-lead alloys which are widely employed as soft solders, the addition of lead lowering the melting point of the solder while increasing its strength. Among the other tin alloys are bearing metals[2] and the tin-copper alloys and also type metal which contains tin with lead and antimony. A new development is the increasing use of tin-aluminium alloys for engine bearings.

Apart from a few countries like the United States, the United Kingdom, Canada and Spain, which collect statistics on the use of tin in solder and other alloys, only production figures of these alloys are available in other countries. The amount of tin used in these alloys is difficult to estimate for two reasons. In the first place, the tin content of the various alloys is far

[1] International Tin Council, *Statistical Year Book*, 1962, p. 28.
[2] See p. 1.