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Expert Group Meeting on the Utilization of
Non-ferrous Scrap Metal in Developing Countries

Vienna, Austria, 25 - 29 November 1969

# PROBLEMS OF QUALITY IN PROCESSING SECONDARY NON-FERROUS SCRAP METAL [1]

by

N.G. Chakrabarti
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Calcutta, India

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# PROBLEMS OF QUALITY
# IN PROCESSING SECONDARY NON-FERROUS SCRAP METAL

## Addendum 1:

## Pattern of Future Development of the Secondary Non-ferrous Metals Industries in Developing Countries 1/

by

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id. 69-4792

## [illegible] of the [illegible] non-ferrous metals industries in developing countries

[illegible] the foregoing [illegible] efforts have been made to explain the [illegible]chnology of non-ferrous metal manufacture, its quality control and [illegible] aluminium and copper as the basis. The [illegible] commonly used metals, in present day civilisation are (1) Aluminium (2) Copper (3) Zinc (4) Lead and (5) Tin. These metals enter in any [illegible]ping country either as a virgin metal to meet the local demands in [illegible] shapes and forms or infiltrate through various products of almost [illegible] necessity. A large proportion of non-ferrous metals are accumulated [illegible] scrapping of automobiles, railway components and other spares of [illegible] plants and machinery installed in a developing country. Although [illegible] statistics are not available yet it can be visualised that [illegible] quantity of non-ferrous metals remain unutilised or go to waste [illegible] (1) Tin in tin cans and containers of various types and shapes used [illegible] packing of food and other valuable materials, (2) Aluminium in the form of [illegible] utensils, (3) Aluminium alloys in the form of rejected automobile [illegible] (4) Copper in the form of clippings from electric cables and wires, (5) Copper base alloys such as railway wagon or coach bearing and other [illegible] industrial plant spares (6) Lead from lead products used for [illegible] and sanitation purposes and also separating plates from rejected [illegible]. There is hardly any organised efforts for the collection, [illegible] and effective utilisation of these secondary metals partly due to lack of [illegible] of the metals and their present day market value or price structures.

In this connection it will be interesting to note the upward trend of [illegible]ices from the attached price-graphs of London Metal market quotation from [illegible]50 to 1969 for some of the commonly used non-ferrous metals such as -

(1) Aluminium, (2) Copper, (3) Lead, (4) Zinc, (5) Tin. In the case of copper and Tin the price increase has been nearly [illegible]%. This spiral ring of prices are bound to increase further in the very near future due to high rate of population and their efforts to maintain a definite standard of life in all the developing countries.

It is imperative therefore, that every effort should be made to make use of this hidden treasure in each of the developing countries. While the production of virgin metal has not been or cannot be intensified over-night, yet due to the rapid process of civilization and need for modern amenities of life the consumption of non-ferrous metals are going up in leaps and bounds and as a matrual corollary the prices are shooting up every day.

While to increase mine production needs heavy capital expenditure and time to fabricate heavy plant and machinery, it is comparatively much easier to recover secondary metals in any developing country with much less capital cost. In India there are large number of enterpreneurs who by investing only about Rs. 5000/- are producing about one ton of Copper and copper base alloys per month, employing about 5 direct men. The monthly revenue varies from 15,000 to Rs. 20,000/- .

An aluminium utensil manufacturing unit with a capital of Rs. 5,00,000/- produce about 30 tons of finished products per month employing about 50 men. The revenue per month comes to about Rs. 3,00,000/-. The essential and fundamental requirement is (a) to impart the required knowledge to the people who may be already in the trade in some form or other in the collection and re-selling of the metalic products and (b) by installing typical melting, refining and product manufacturing units by providing the

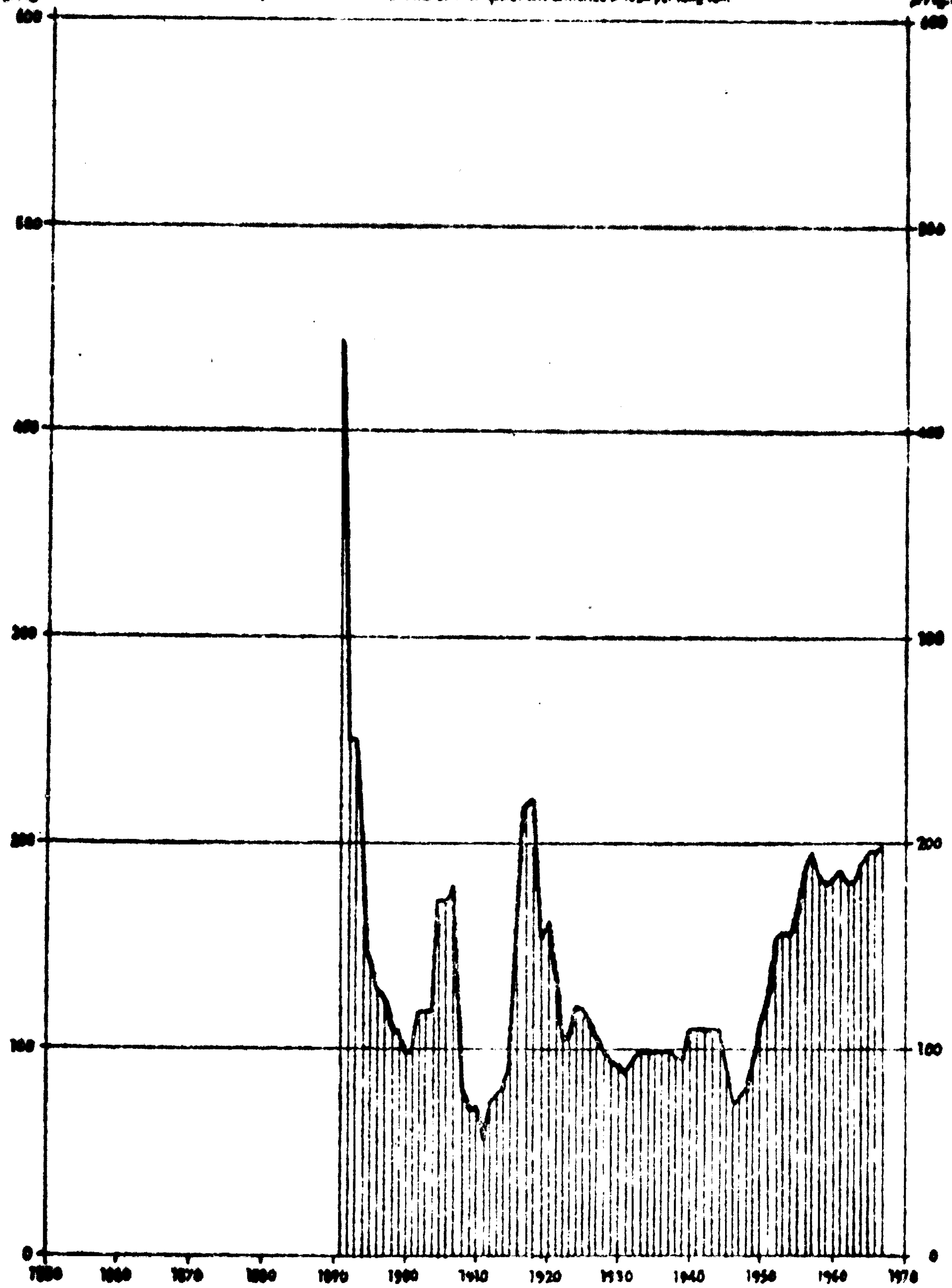
the necessary know-how for the effective utilisation of the metal.

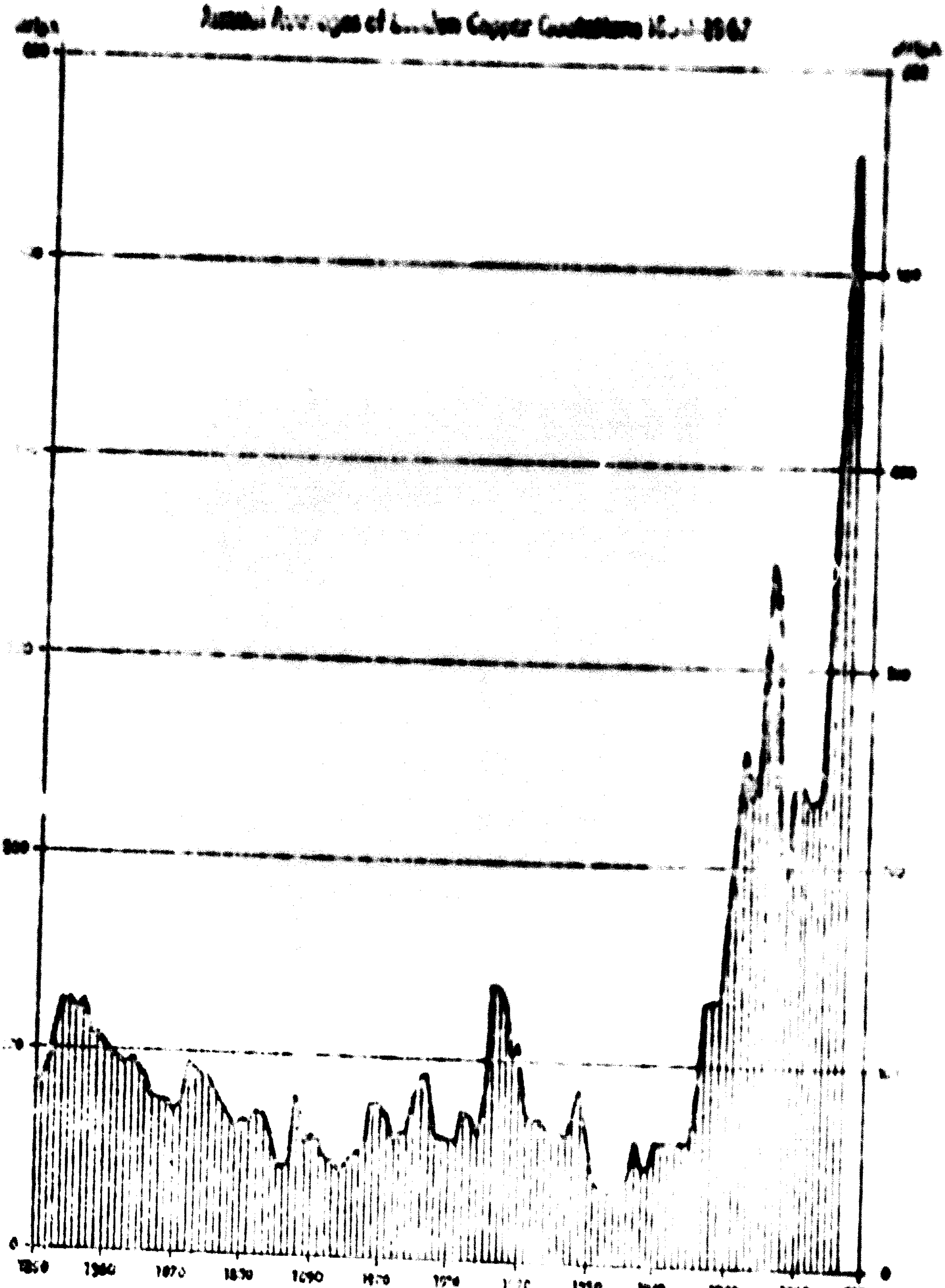
In this respect UNIDO can play an important role by (1) initiating sample survey for assessing the accumulation of various types of secondary non-ferrous metals and preparing feasibility report for their economic and effective utilisation (2) Carrying out market survey, (3) Helping the local people to develop their own skill in setting up the industry on regional basis and also providing the necessary training facilities in the factories of highly developed countries.

The capital cost of setting up melting or a refining unit for non-ferrous metals is rather negligible compared to the value of the finished metals that can be turned out from such a plant. This will not only open up new avenues of employment for the local people but the products can be exported to industrially developed countries at price much cheaper than even virgin metal and thus helping the developing nations to earn more and more foreign exchange for their further development activities.

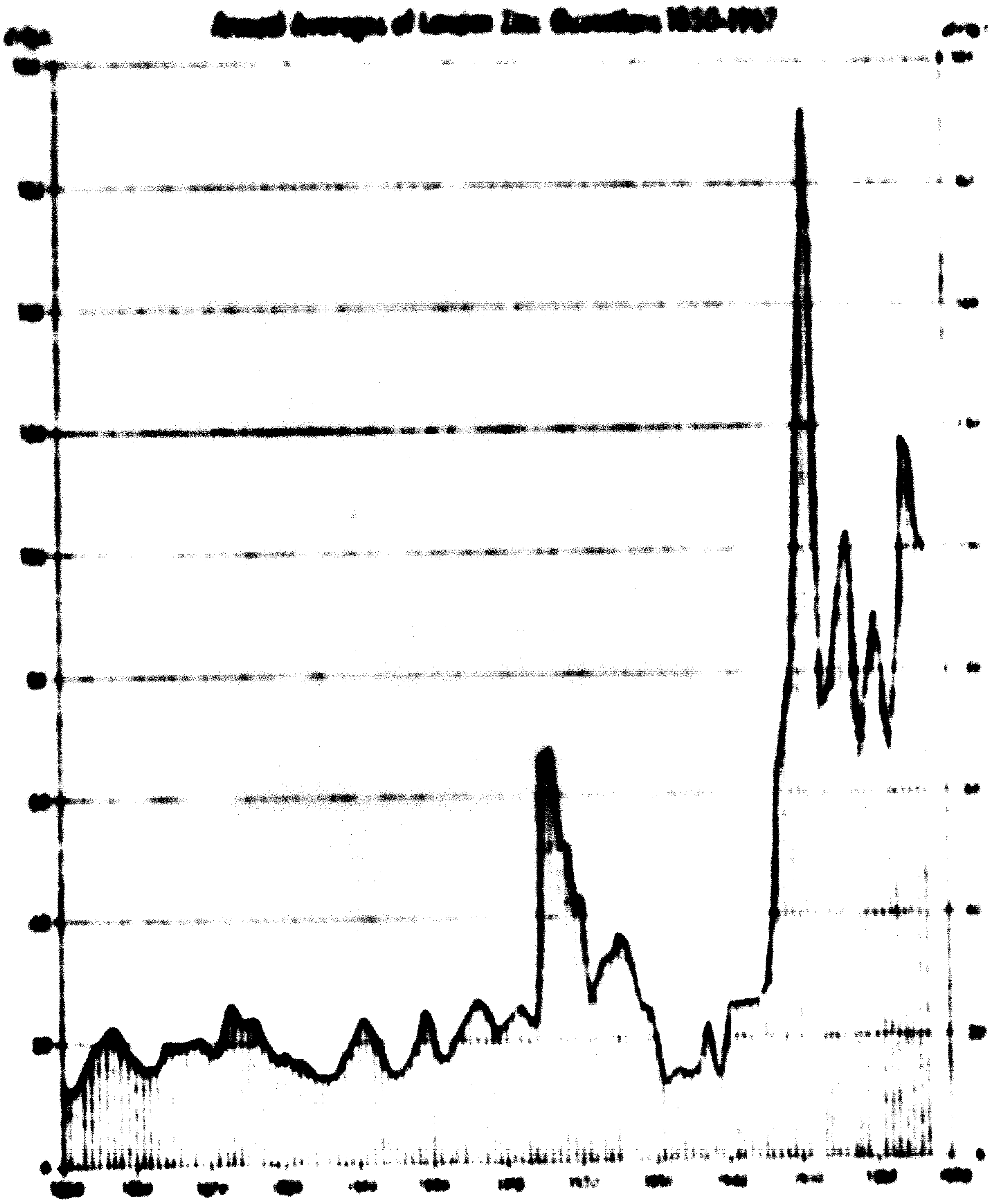
**Annual Averages of London Aluminium Quotations 1890-1967**

The quotations 1890-1912 are the German quotations converted into £ per long ton.

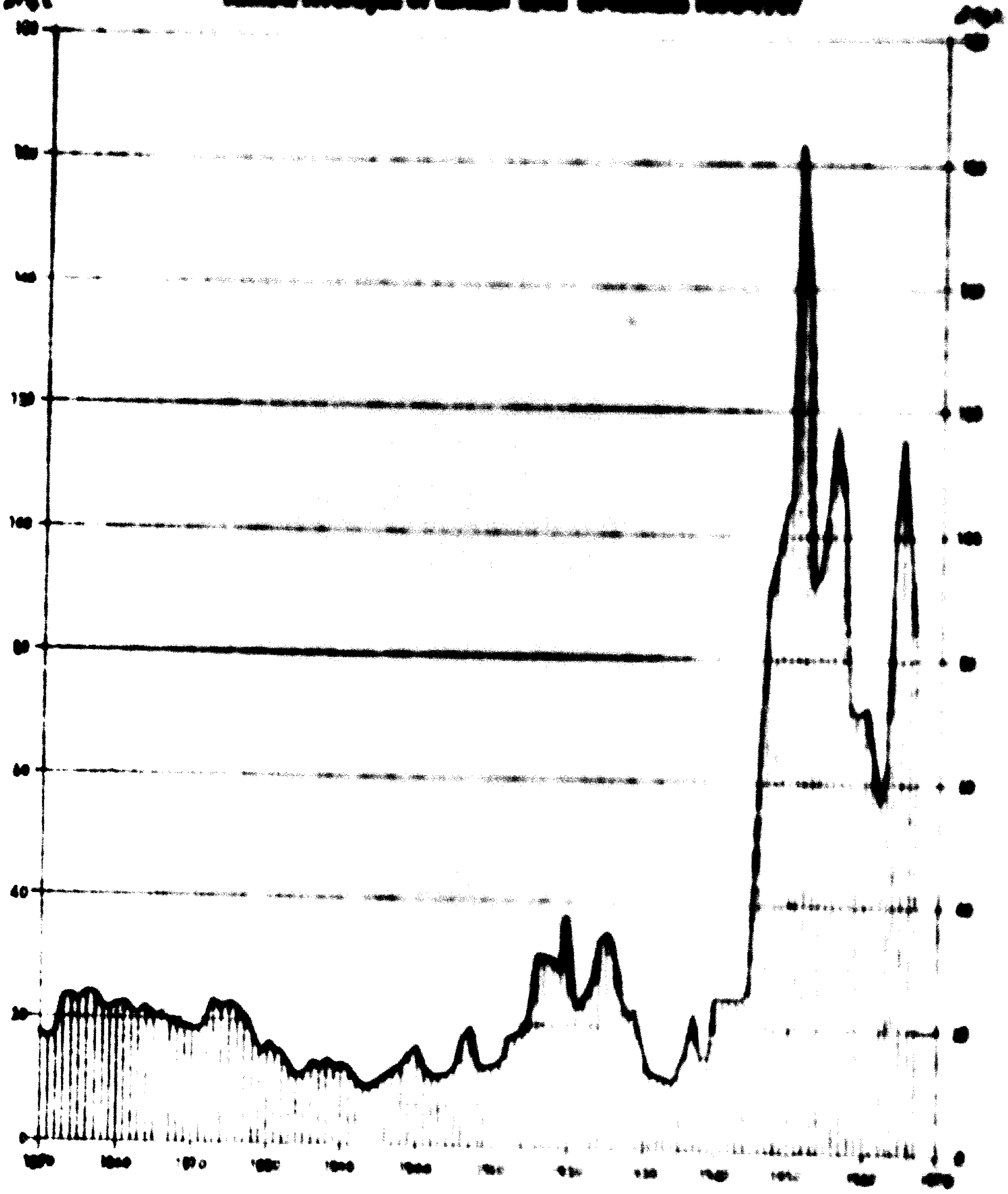




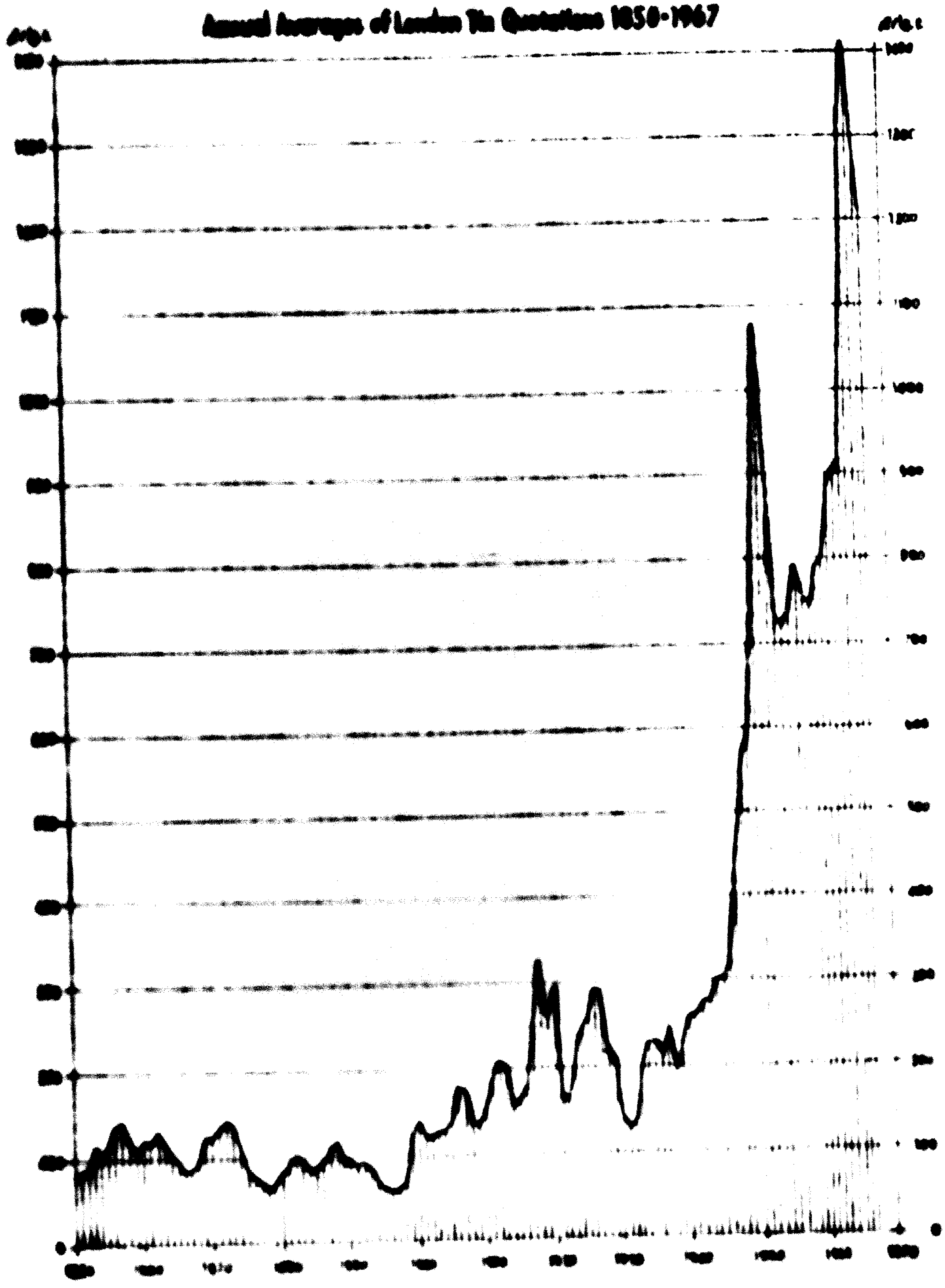
Annual Averages of London Zinc Quotations 1850-1967



Annual Averages of London Lead Quotations



Annual Averages of London Tin Quotations 1850-1967



**Introduction**

One of the striking features of Industrial development during the past decade has been the rapid growth of non-ferrous metal industry as shown in Table I for six major non-ferrous metals:

**Table I**

| | Production in million metric tons | | Consumption in million metric tons | |
|---|---|---|---|---|
| | 1958 | 1967 | 1958 | 1967 |
| Aluminium | 3.55 | 7.93 | 3.12 | 7.77 |
| Lead ( refined) | 2.62 | 3.33 | 2.36 | 3.29 |
| Copper(refined) | 4.09 | 5.99 | 4.13 | 6.09 |
| Zinc | 2.87 | 4.31 | 2.71 | 4.24 |
| Tin | 0.175 | 0.23 | 0.171 | 0.22 |
| Nickel | 0.222 | 0.45 | 0.196 | 0.48 |
| Total | 13.52 | 22.24 | 12.74 | 22.09 |
| + Scrap Recovery | 3.47 | 4.75 | 3.47 | 4.75 |
| Total | 16.99 | 26.99 | 15.99 | 26.84 |

Table I also shows the recovery of scrap metal, which constitutes about 20% of the production of primary metal. On account of fluctuations in price of the primary non-ferrous metals, use of secondary scrap non-ferrous metals is rapidly increasing. As per available data, the value of non-ferrous scrap metals annually despatched by the U. S. A.

currently amounts to $ 1.5 billion approximately. It is gathered that the metal dealers in the U.S.A. alone process annually about 2 million tons of non-ferrous metal scrap including 850,000 tons of Copper and Copper base scrap ; 450,000 tons of Lead scrap ; 350,000 tons of Aluminium scrap ; 210,000 tons of Zinc scrap plus substantial quantity of Nickel Alloy and other precious metal. The non-ferrous metal industry in the U.S.A. recovers from these secondary non-ferrous metallic scrap approximately 42% of the total available Copper, 40% of the total available Lead, 22% of the total available Aluminium, 20% of the total available Zinc. in the U.S.A.

While the extraction of primary metals from their ores progressively depletes the latter, recovery of secondary non-ferrous metals from their scraps is a continuously cyclic process. The development of the secondary non-ferrous scrap metal industry greatly progressed in the wake of World War II when the recovery of non-ferrous metals from their scraps became a vital necessity and led to proper collection, identification, segregation and processing of scrap resources.

<u>Secondary scrap non-ferrous metals industry in India.</u>

The prospect of secondary non-ferrous metals industry in India must be visualised in the current context of the primary non-ferrous metal in the country. At present the capital invested in the primary non-ferrous metal industry is Rs. 300 crores* employing about 50,000 workers in India. The performance of primary metal industry over the last few years is shown in Table - II.

* 1 Crore = 10 Million.

Table - II

| | 1951 | 1956 | 1961 | 1966 | 1968 | 1969-70 (Potential) |
|---|---|---|---|---|---|---|
| | | | | | | ( x 1000 tons) |
| Aluminium | 3.8 | 6.6 | 18.4 | 83.8 | 120.1 | 200 |
| Copper | 7.1 | 7.7 | 8.3 | 9.6 | 9.3 | 85 |
| Zinc | - | - | - | - | 19.9 | 80 |
| Lead | 0.9 | 2.5 | 3.7 | 2.5 | 1.6 | 60 |

It may be seen from Table II that in India there exists a wide gap between the potential demand and actual production. This gap is partly met by imports and partly by secondary metal and scrap utilization. The Imports of non-ferrous metals in India for 1967 are shown in Table III.

Table III

Import of Non-ferrous Metals in India during 1967

| Description | January to December | |
|---|---|---|
| | Quantity (tonnes) | Value ( in Rupees*) |
| Aluminium Foils | 60.122 | 8,32,431 |
| " Rods & Wirerods | 13,563.402 | 6,41,66,144 |
| " Ingots & Wirebars | 22,145,946 | 9,44,66,160 |
| " Scrap | 1.924 | 11,160 |
| " Alloy Rods | 337.407 | 28,28,372 |
| " Alloy Ingots | 242.205 | 10,42,749 |
| " Alloy Sheets | 17.317 | 1,73.610 |
| " Circles | 5.401 | 95.826 |

* 1 U.S. $ = Rupees 7.5

| | | |
|---|---|---|
| Aluminium Sheets & Strips | 206.245 | 16,60,851 |
| " Other sorts | 79.332 | 9,16,724 |
| Antimony (Regulus) | 18,528 | 1,22,003 |
| Brass Rods & Section | 124.602 | 12,87,893 |
| " Scrap | 6.919 | 35.827 |
| " Sheets & Strips | 199.937 | 23,64,597 |
| " Tubes & Pipes | 523.786 | 59,59,693 |
| " Wires | 41.726 | 4,44,806 |
| " Other sorts | 6.731 | 35.893 |
| Bronze Rods & Section | 14,697 | 2,26,321 |
| " Sheets & Strips | 66.519 | 12,13,930 |
| " Tubes & Pipes | 30,477 | 6,71,581 |
| " Wires | 165.437 | 41,65,508 |
| " Other Sorts | - | - |
| Copper Virgin | 33,433.180 | 30,43,84,690 |
| " Rods & Section | 138.410 | 23,13,112 |
| " Scrap | 684.515 | 65,29,115 |
| " Sheets, Strips & Plates | 195.436 | 26,49,724 |
| " Tubes & Pipes | 423.200 | 59,16,764 |
| " Wires | 225.862 | 29,74,421 |
| " Other sorts | 13.681 | 2,22,335 |
| Lead Ingots | 34,434.701 | 6,43,33,898 |
| " Antimonial | 51.427 | 1,63,443 |
| " Tubes & Pipes | - | - |
| " Sheets & Strips | 6,845 | 20,070 |
| " Other sorts | 2,500 | 14,991 |
| Nickel Pure | 876.687 | 1,51,21,484 |
| " Powder | 120.283 | 17,82,568 |
| " Other sorts | 67,681 | 14,98,565 |

| | | |
|---|---|---|
| Nickel Alloy Scrap | 566.896 | 32,52,253 |
| " Sheets & Strips | 332.805 | 43,67,672 |
| Tin Ingots | 3,647.882 | 9,35,77,087 |
| " Other sorts | 1.158 | 40,063 |
| Zinc Virgin | 56,787.795 | 12,82,21.700 |
| " Alloy | 7.590 | 25,702 |
| " Dross or Hard Spelter | - | - |
| " Sheets Strips & Plates | 304,212 | 10,96,959 |
| " Wire | 4.065 | 16,990 |
| " Other sorts | .149 | 299 |
| " Dust | 2,313.163 | 77,64.010 |
| Queiksilver | 154.779 | 1,74,50,542 |
| Other Non-ferrous Alloys | 69,699 | 11,10,130 |
| Total :- | 173,628,262 | 54,77,00,545 |

Say Rs. 55 Crores.

Tables III(a) and III(b) indicate that imports of Copper and Aluminium constitute about 60% of the total imports of non-ferrous metal as shown in the Import figures for 1966 and 1967 depicted below :

**India's percentage-wise imports of Non-ferrous metals (Including Semis) And Minor Metals during 1966-67 (Invalue)**

Table III(a)

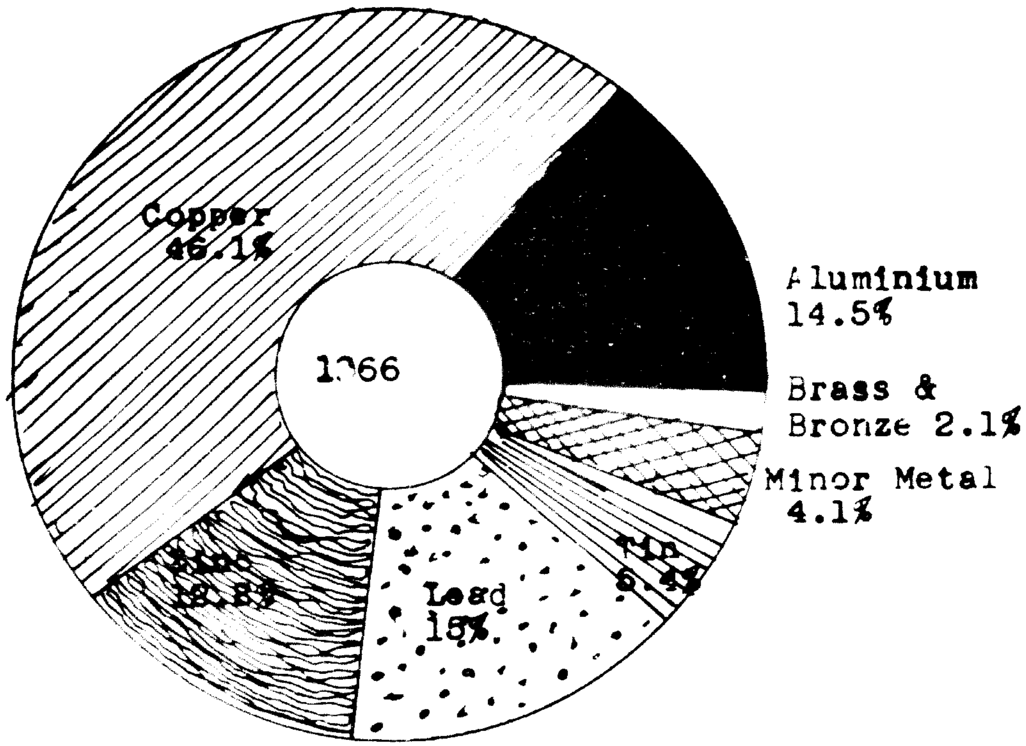
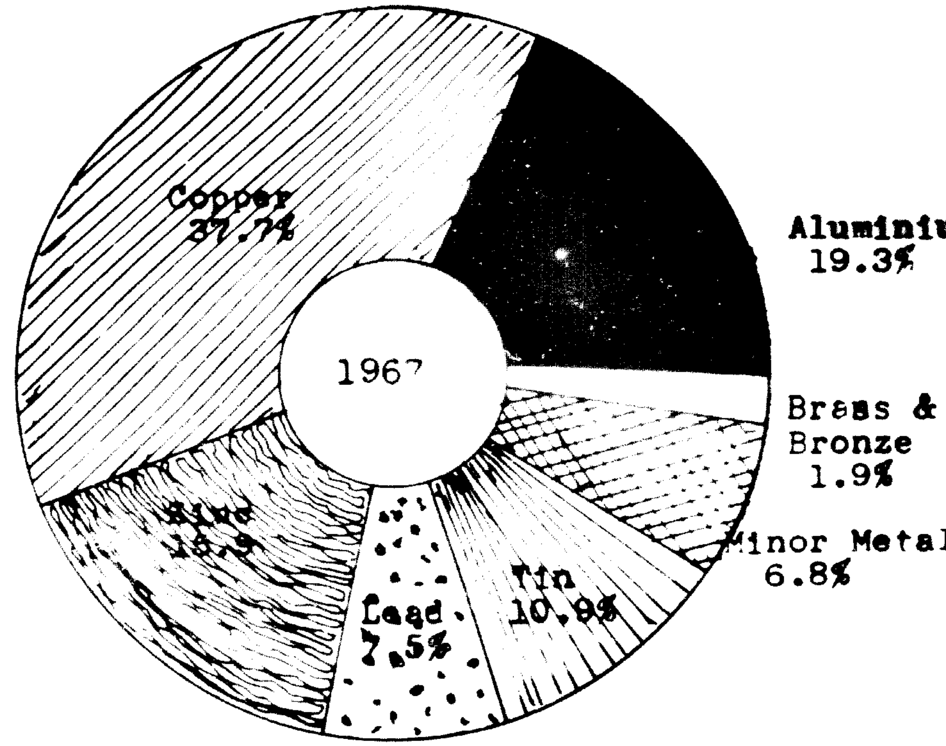
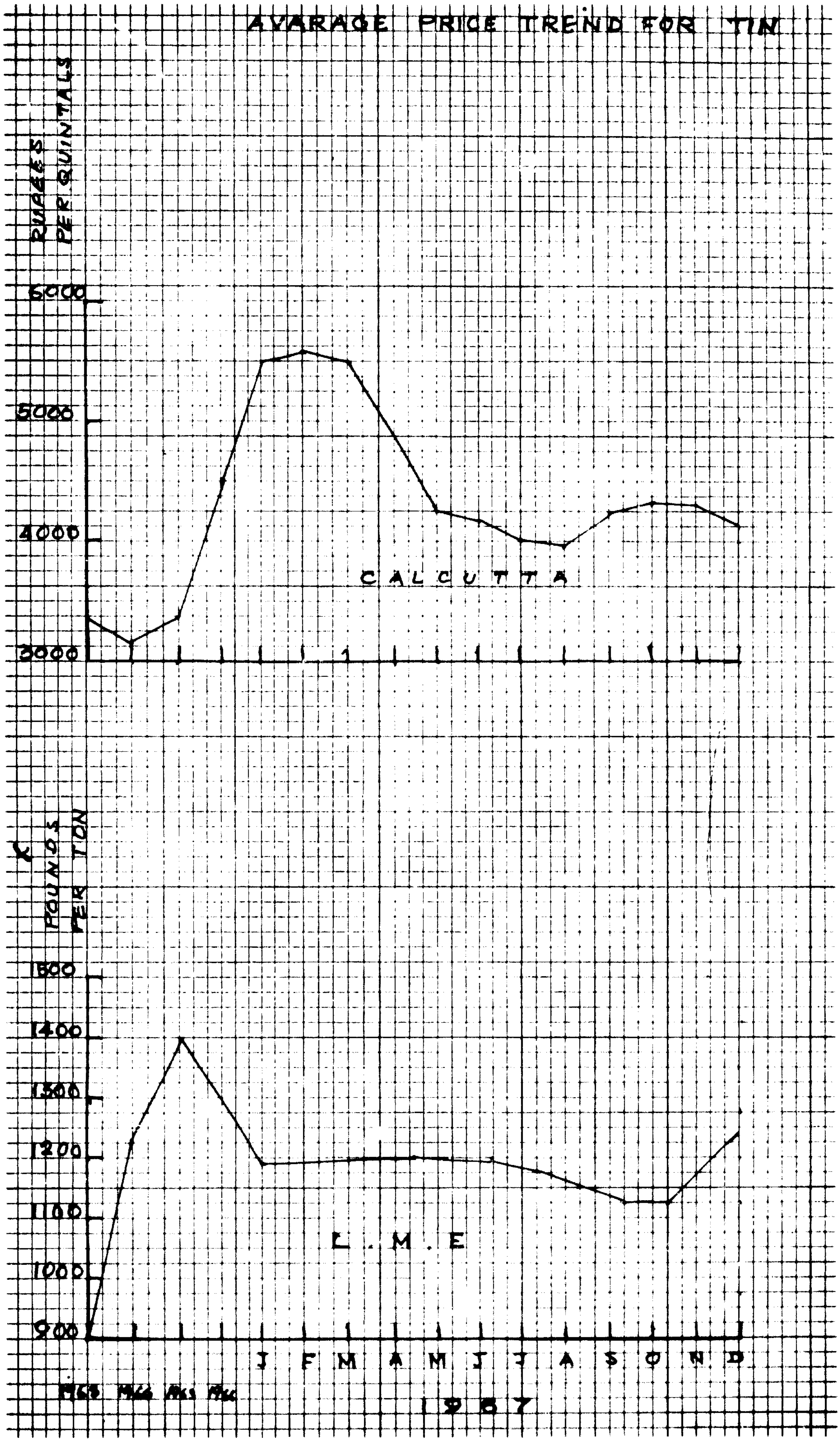
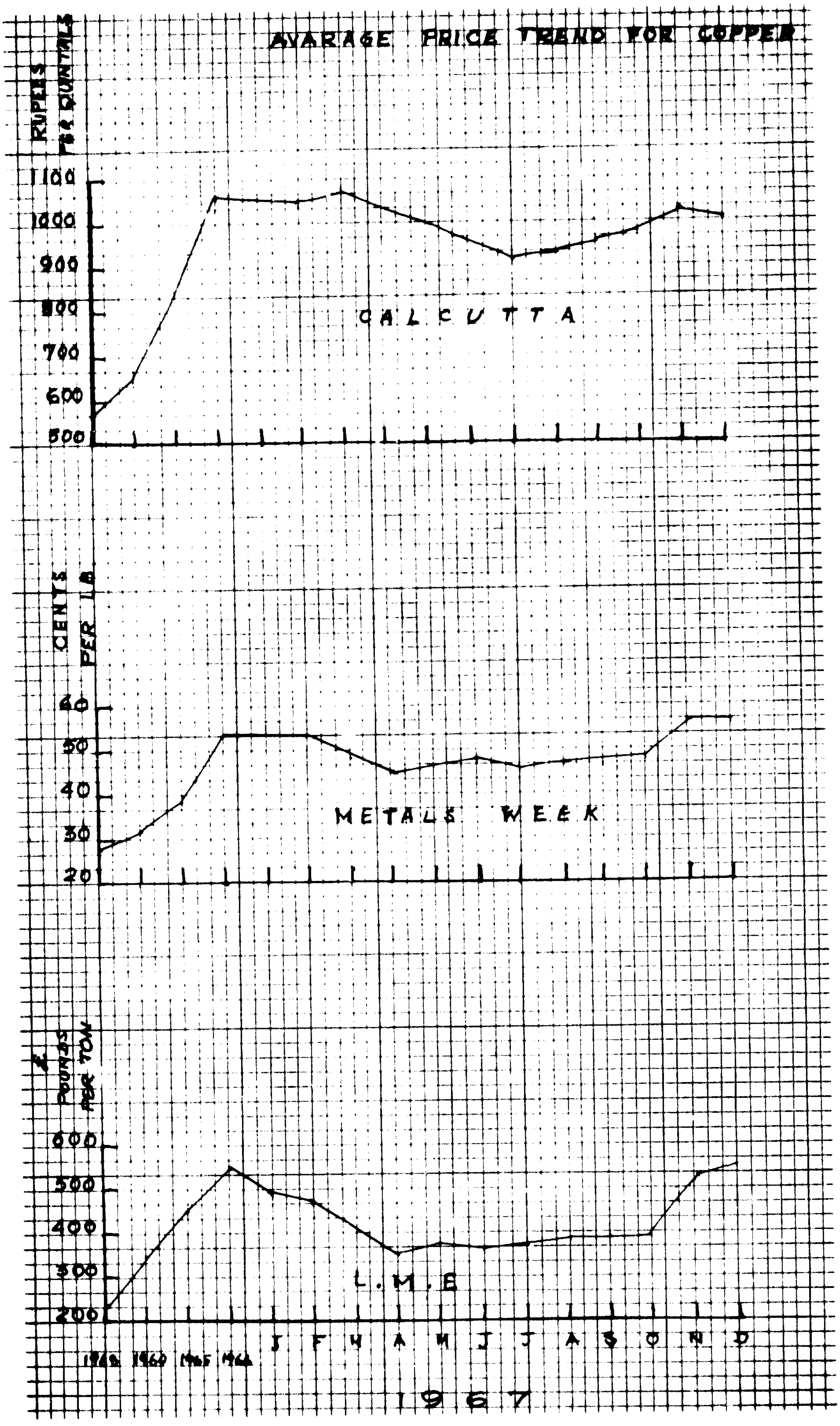


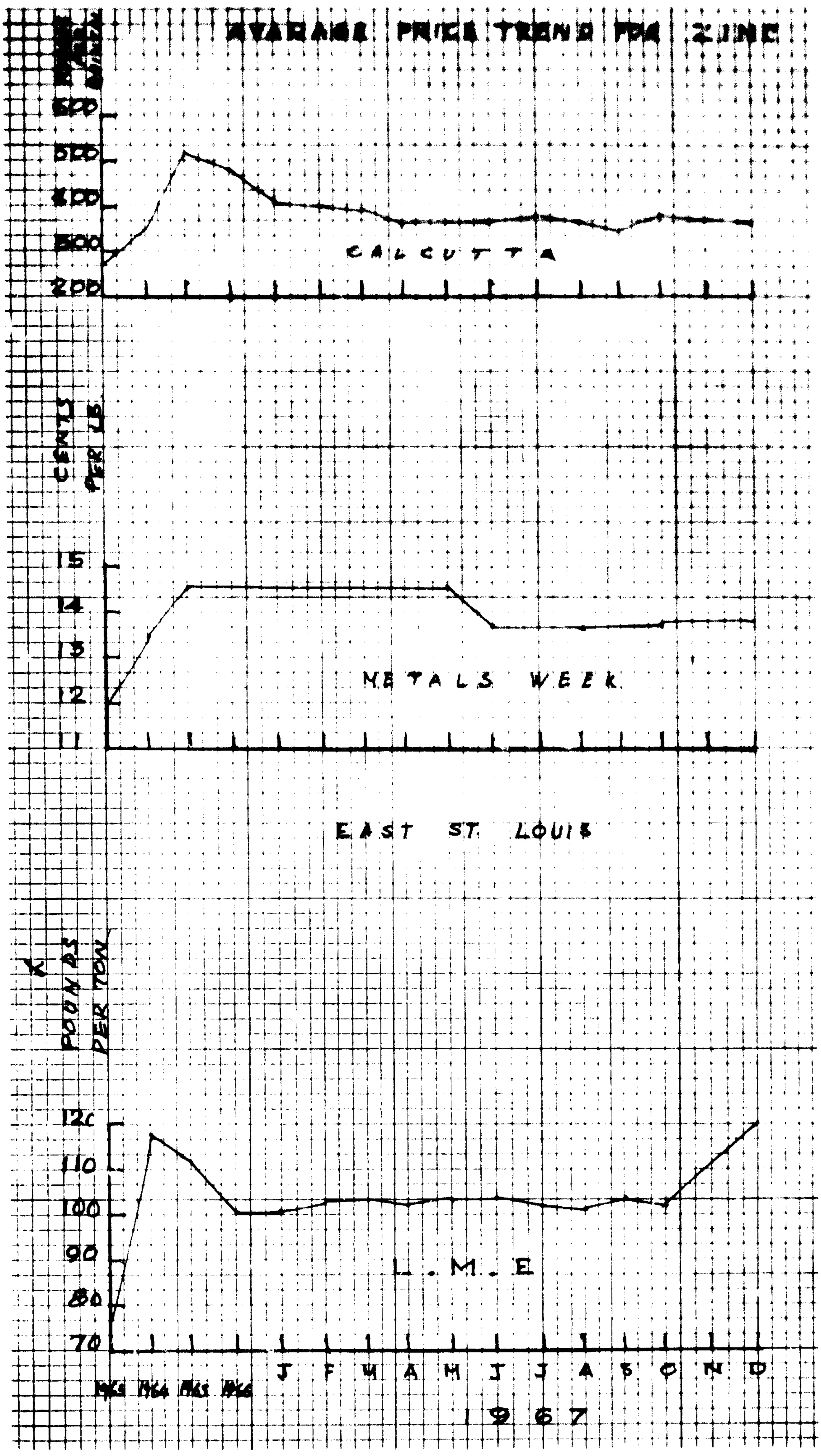

Table III(b)

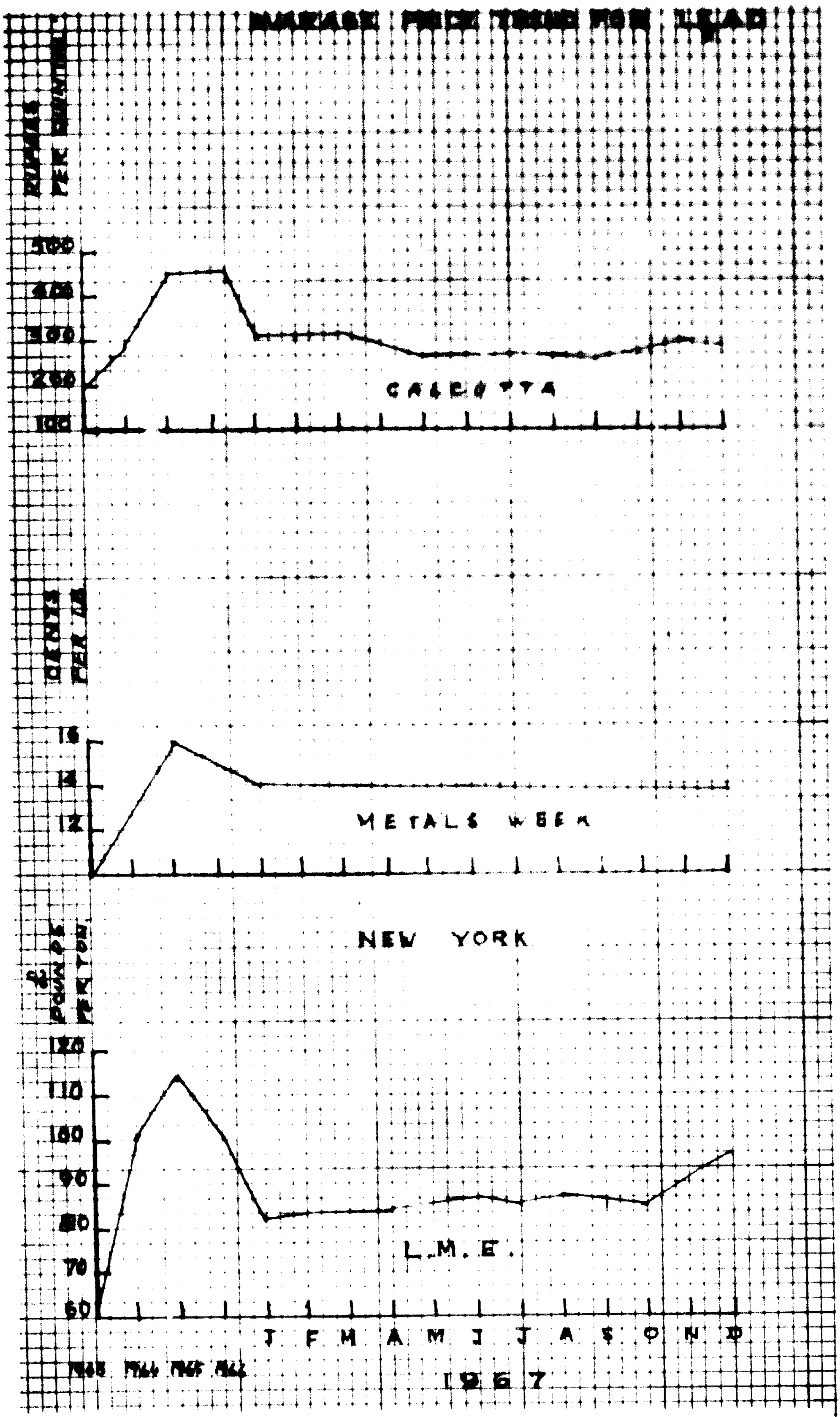


On account of the wide gap between demand and supply the prices of non-ferrous metals are much higher than the International prices as may be seen from the following graphs Nos. 1, 2, 3 and 4 for Copper, Zinc, Tin and Lead respectively :


AVARAGE PRICE TREND FOR TIN
RUPEES PER QUINTALS
6000
5000
4000
3000
CALCUTTA
£ POUNDS PER TON
1500
1400
1300
1200
1100
1000
900
L . M . E
J F M A M J J A S O N D
1963 1964 1965 1966
1967


AVARAGE PRICE TREND FOR COPPER
RUPEES PER QUINTALS
1100
1000
900
800
700
600
500
CALCUTTA
CENTS PER LB
60
50
40
30
20
METALS WEEK
£ POUNDS PER TON
600
500
400
300
200
L.M.E
1962 1960 1965 1966
J F M A M J J A S O N D
1967


AVARAGE PRICE TREND FOR ZINC
600
500
400
300
200
CALCUTTA
CENTS PER LB
15
14
13
12
11
METALS WEEK
EAST ST. LOUIS
POUNDS PER TON
120
110
100
90
80
70
L.M.E
1963 1964 1965 1966
J F M A M J J A S O N D
1967


AVERAGE PRICE TREND FOR LEAD
RUPEES PER QUINTAL
500
400
300
200
100
CALCUTTA
CENTS PER LB
16
14
12
METALS WEEK
NEW YORK
£ POUNDS PER TON
120
110
100
90
80
70
60
L.M.E.
J F M A M J J A S O N D
1963 1964 1965 1966
1967

Although vigorous efforts are going on in the country to step up indigeneous production of primary non-ferrous metals, there still exists a wide gap between demand and supply as estimated for 1970-71 vide Table VI :

**Table - VI**

**Short-fall in output of Base Metals in India.**
**1970 - 71**

| | Estimated demand | Targeted production |
|---|---|---|
| Aluminium | 300,000 tonnes | 200,000 tonnes ( approx.) |
| Copper | 225,000 " | 37,500 " " |
| Zinc | 225,000 " | 78,000 " " |
| Lead | 146,000 " | 10,000 " " |

If this wide gap were to be filled by imports, it will cost about Rs. 300 crores ( 1 crore = 10 million) annually in foreign exchange by 1975. Since India's foreign exchange position will not permit this import the only other alternative will be to develop her secondary non-ferrous metal industry as speedily as possible.

The pressure on the two major non-ferrous metals is due to massive electrification scheme during the Fourth Plan period with an outlay of Rs. 4000 crores, out of which Rs. 1750 crores will be needed for transmission, distribution and rural electrification. At present 50% of the total output of aluminium goes to theelectrical industry and about 50% of the projected demand for copper will be required by the cable industry alone.

While primary producers of aluminium are embarking on massive expansion programme, efforts are also being made to recover as much of the metal as possible by secondary metal refining industry.

The National Metallurgical Laboratory of India at Jamshedpur has taken up on priority basis - research and development work on (i) Recovery of Aluminium from the dross and other sources of pure metal scrap, (ii) Recovery of Copper from secondary metal by Electro-refining. In the future pattern of development of secondary non-ferrous metal industry in India the recovery of Aluminium from scrap by pyro-metallurgical process and copper from copper scrap by Electro-refining process should play dominant roles.

## Processing of Secondary Aluminium and Aluminium Alloys

Aluminium is normally not used in its pure form except for the manufacture of foils, and electrical conductors. For the production of components of automobile and other structurals and machinery, it is alloyed with copper, silicon, zinc, magnesium etc.

In its purest form aluminium has the following properties :

| | |
|---|---|
| Specific gravity | = 2.70 |
| Melting point °C | = 660.7 |
| Specific Heat ( water = 1) at 20°C Cals. | = 0.214 |
| Co-efficient of Linear expansion per °C | = 0.000024 |
| Tensile strength a) (Annealed wire No. 10 SWG) in lbs/sq" in | = 14,000 |
| b) Harddrawn -do- | = 20,000 |

## Aluminium Scrap

The quality of aluminium scrap can be divided into the following two broad categories.

### Production of secondary Aluminium and Aluminium Alloys :

Secondary aluminium alloys are made by melting aluminium and aluminium alloy scraps. The production of secondary aluminium and aluminium alloys has grown to be an important wing of the aluminium industry. In the remelting of Aluminium bearing scraps, no refining can be done as in the case of copper. It is essential therefore to identify, select and segregate different types of aluminium scraps.

### Character and Quality of Aluminium Scraps :

Aluminium bearing scraps available for secondary recovery may consist of (1) Aluminium Scraps or (2) Aluminium Alloy Scraps.

A. Aluminium Scraps may consist of Aluminium drosses, skimmings, furnace splashings and drippings as well as different kinds of scrap pieces resulting from manufacturing operations. Aluminium Alloy Scrap may consist of borings and turnings arising out of the machining of alloy castings, such as automobile cylinders heads, gear cases, exhaust manifolds and such other structural components.

(a) Aluminium Dross and Skimmings.-

At the National Metallurgical Laboratory of India at Jamshedpur research and development has recently being undertaken to recover aluminium from aluminium dross and skimmings, an outline of which is given below :-

Aluminium dross from aluminium melting furnaces assayed 27.7% Al., 43.7% $Al_2O_3$, 2.07% $SiO_2$, 4.91% C, 1.05% Fe and 2.3% alkalies. The principal gangue was alumina with small amounts of quartz and graphite. Metallic aluminium was mostly present in rounded grains, generally having a coating of oxide. Electrostatic separation of the ground deslimed sample produced a concentrate assaying 57.3% Al. with a recovery of 31.7%. Flotation after grinding the sample to 57%. - 200 mesh and using Oeleic acid emulsion and pine oil produced a concentrate ( as flotation tailing) assaying 57.4% Al. with recovery of 39% Al. Use of more collector and increased flotation time, yielded a flotation tailing assaying 85.67% Al. with a recovery of only 10.3%. The recovery in all the tests was low due to the fineness of the metal s which were mostly in the dust float and slime.

A sample of aluminium foundry dross containing 49.9% metallic Al, 22.43% Al. as oxide, 0.47% Si. 9.6% $SiO_2$, 2.2% Fe, 1.9% C, 0.11% Mn, 1.68% Mg, 1.06% Ca, 0.80% CaO and 0.64% alkalies was successfully treated for recovery of aluminium. Various methods investigated include melting of briquetted dross with and without desliming as well as with flux addition, grinding followed by gravity separation, grinding in presence of dilute chromic acid or a mixture of $HNO_3$, chromic acid, HF or an alkali fluoride in order to remove oxide coating from the metal surface and also for surface brightening.

It was observed that direct melting of dross with or without flux additions resulted in considerable oxidation losses. The heavy proportion of gangue material such as the thick coating of oxide on the metallic surfaces could be removed by grinding and washing. Grinding in presence of chromic acid in a rod mill improved the metallic aluminium content to 79%. Further improvement in the grade was achieved by acid treatment of this product. Based on the investigations, a flow-sheet for upgrading the aluminium dross has been formulated and given in Fig. VII. The recovered aluminium powder could be directly used for thermit reaction and other pyrotechnic applications.

(b) Aluminium Furnace Scrap

Aluminium Furnace Scrap includes splashings from tappings and pourings, drippings and skimmings from crucibles. Such scraps are normally returned to the melting shop and are hardly available for recovery by secondary smelters.

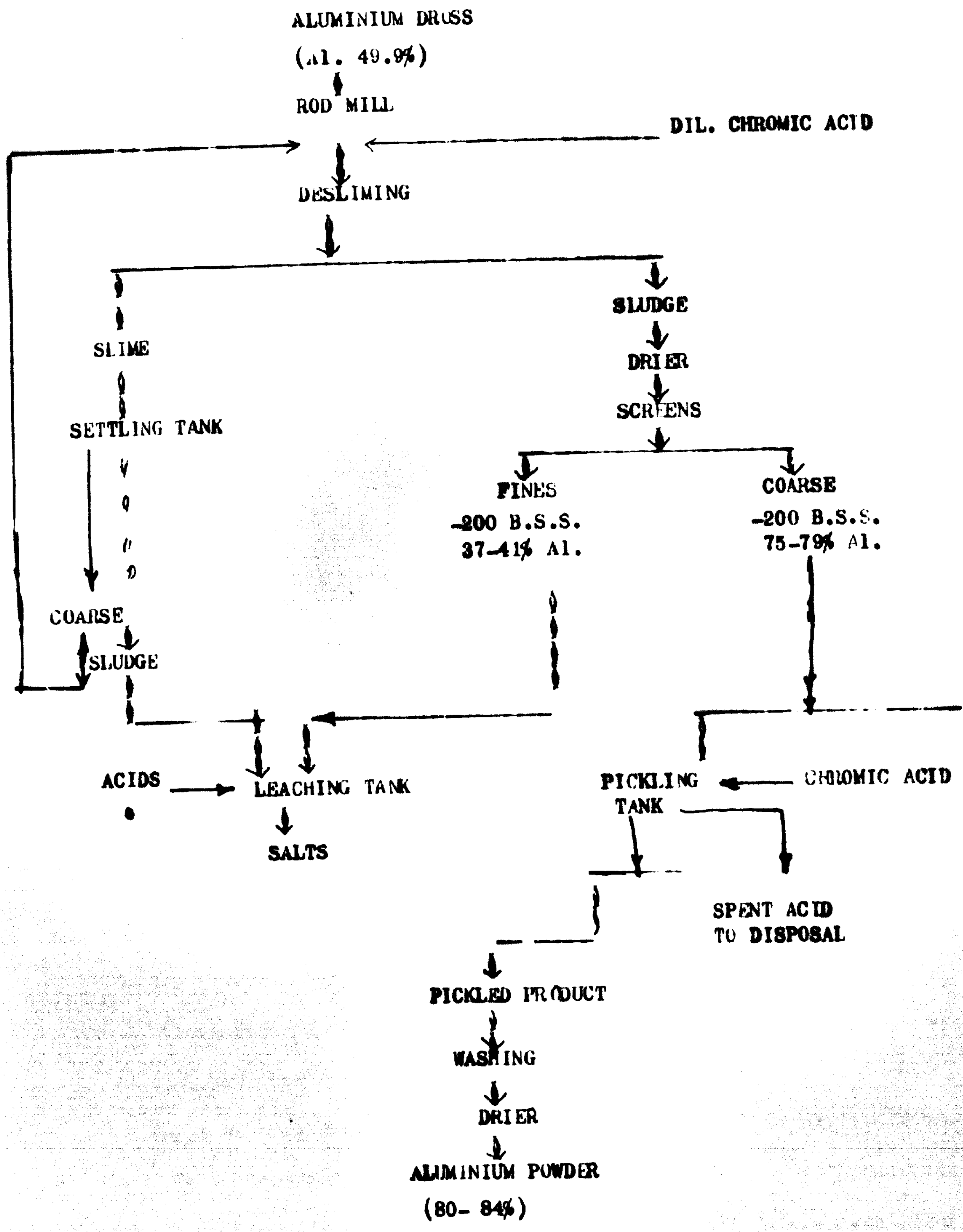
(c) Aluminium Rolling Scrap

During the process of rolling aluminium ingots and slabs into sheets, discards take place through buckled sheets, defective sheets due to occluded impurities, end trimmings and such other cuttings that may arise during the rolling process. Such scraps are also recycled to the melting shop for melting.

(d) Aluminium Fabricating Scrap

Fabricating scrap arises during fabricating operations on aluminium sheets and other semi-finished form of aluminium such as shearings, clippings, trimmings and punchings. Scrap aluminium wire and cable are fairly pure as these are required for electrical purposes. Bare wire and cable scraps are good for remelting but aluminium wire of small diameter which is electrolytically insulated with a thin film of oxide and related scrap wire may be difficult to remelt.

**Flow sheet Fig. No. VII**



## B. ALUMINIUM ALLOY SCRAP

Most of the aluminium alloy scrap available for secondary melting consists of borings, turnings, drilling arising out of machining operations on aluminium alloy castings. Since the major part of the aluminium alloy sand castings or gravity die castings are automobile components subjected to machining operations, such as turning, milling, drilling, it is customary to apply a coolant compound during such operations, and as such, their surfaces are normally covered with whatever lubricant is used along with sticking shop floor dust and dirt. Furthermore, if the same machines are utilised for machining iron and steel or brass components and the shops are not very careful in sweeping out the aluminium scrap before taking up the machining of components of other metals, the mix up is a usual feature. When such borings in mixed up condition are sent to the junk yard, it is customary to take a test to determine the content of aluminium. A typical laboratory report of boring is given hereunder :

| Constituent | Percentage |
|---|---|
| Oil | 3 |
| Dirt | 6 |
| Magnetic Iron | 3 |
| Metallic content | 88 |
| Copper | 8.4 |
| Iron | 0.9 |
| Zinc | 0.4 |
| Aluminium | Remainder |

A typical flow sheet for the processing of borings and turnings is given below :-

Boring, Turnings etc.

↓

Picking Belt ( Dirt, rags, wood etc.)

↓

Magnetic Separator ( Iron to waste)

↓

Storage Bin

↓

Pig Metal | Dross

↓

Screen

↓

Course Material

__Heavy Aluminium Alloy Scrap__ :

Considerable heavy aluminium scrap arises due to scrappings of old motor cars. If the weight of aluminium castings per motor car is assumed at 50/60 lbs. one can easily account for the arising of aluminium scrap in any country due to scrapping of old and rejected automobiles. Heavy scrap of this nature is ideal for remelting in the production of secondary aluminium alloys. Due to standard specifications of the alloys used in such components, the composition of the alloys can be determined fairly accurately.

**Duralumin Scrap :**

Duralumin - this metal was first developed by Messrs. Durenn Metallwerke A.G. (Germany) where heat treatable light aluminium alloys were first produced and hence the name 'Duralumin'. Duralumin is basically of three kinds (1) Ordinary Duralumin (2) Zinc Duralumin (3) Special Duralumin. The ordinary Duralumin has the following compositions :

| | |
|---|---|
| Copper | - 3.5 to 4.5% |
| Manganese | - 0.5% |
| Magnesium | - 0.5% |
| Aluminium | - Rest |

**Miscellaneous Scrap :**

The amount of miscellaneous scrap including old aluminium wire, aluminium foil, discarded utensils, vessels, collapsible tubes and stamped articles sometime find their way to the junk yard and thereby to the secondary melters. Such scraps should be further examined before charging in the furnace and any processing necessary to make them useful is a spot decision to b taken by the melters. Clean sheet cuttings arising out of sheet work can be conveniently briquetted for charging directly in the Furnace. Having thus ensured the pedigree types of scrap, it is essential to consider the type of melting Furnace that should be employed for the melting of secondary alloys.

**Classification of Different Type of Furnaces available for melting of secondary non-ferrous Metals and Alloys :**

For the melting of non-ferrous metal in general the following types of Furnaces are used and are classified below :

A. <u>Crucible Furnace</u>

i) Fuel Fired Type

- a) Pit type - as per illustration No. 1
- b) Coke fired
- c) Oil fired
- d) Gas fired

ii) Tilting type

- a) Coke fired
- b) Oil fired
- c) Gas fired

B. <u>Electrical Furnaces</u>

i) Resistance heated Type

ii) Induction type

- a) Low frequency coreless type
- b) High frequency coreless type
- c) Mains frequency " - as per illustration No. 2
- d) Main frequency central core or channel type - as per illustration No. 3

iii) <u>Arc heated type</u>

- a) Direct arc
- b) Indirect Rocking arc

C. <u>Rotary Furnace</u> ------------ as per illustration No. 4

- a) Fuel fired
- b) Gas fired
- c) Oil fired
- d) Pulverised fuel fired

Illustration No.1

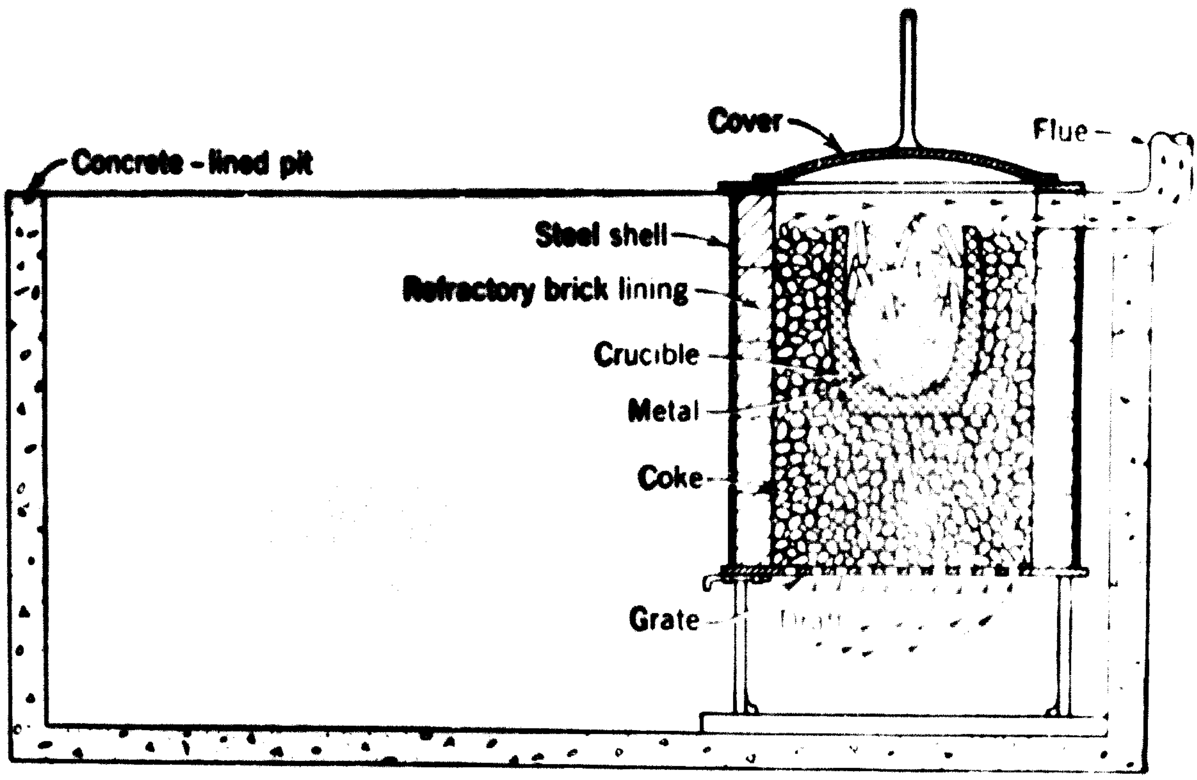
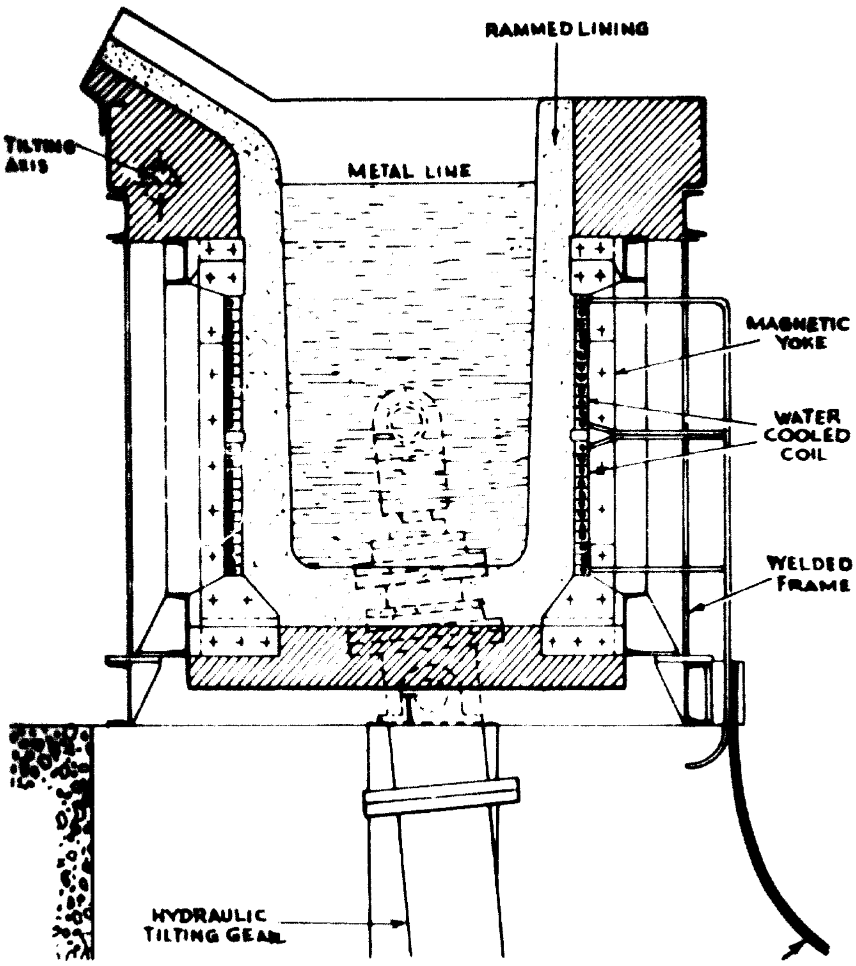
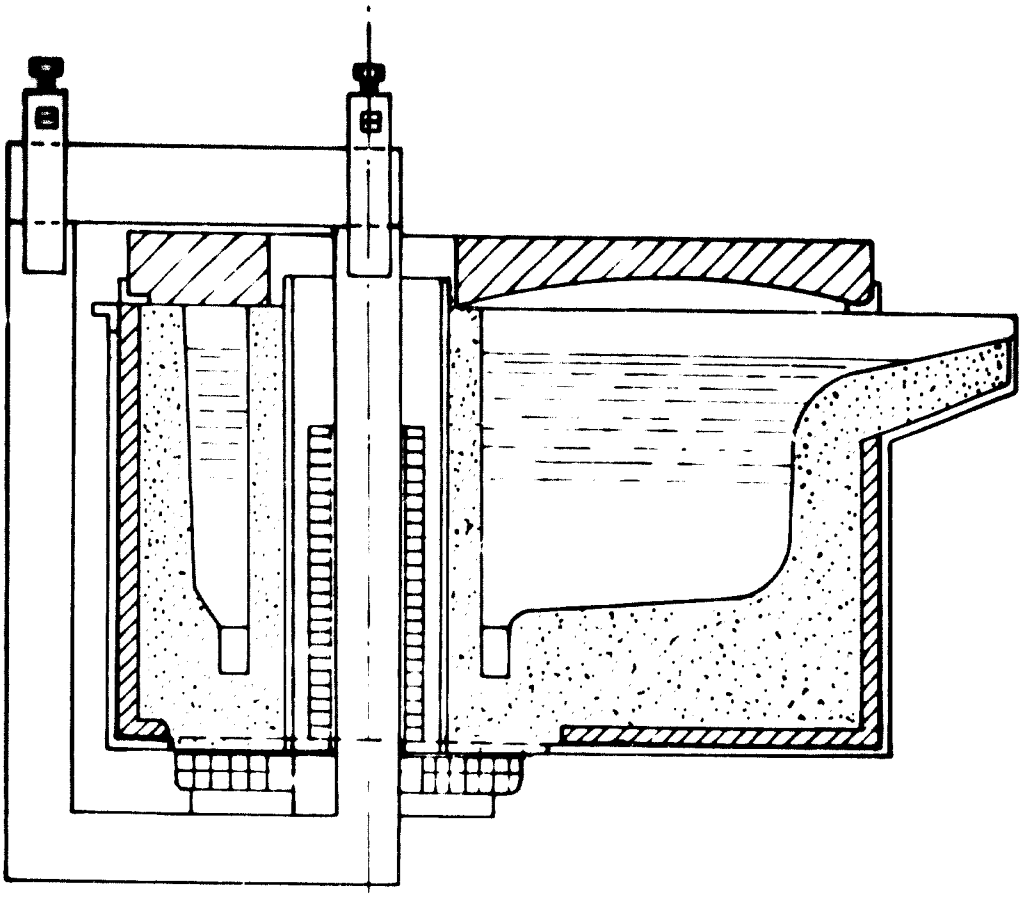


**Illustration No.2**



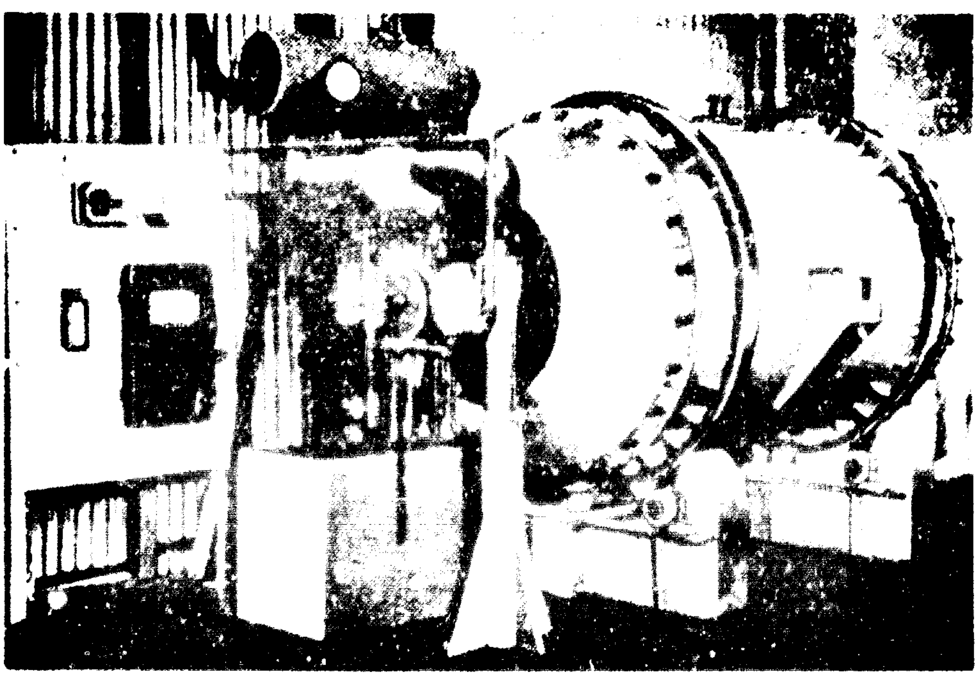

TYPICAL LOW FREQUENCY CORELESS INDUCTION FURNACE.

Illustration No.3



CROSS SECTION OF MAIN FREQUENCY INDUCTION FURNACE WITH CENTRAL CORE.

Illustration No.4



D. Reverberatory Furnaces

a) Oil fired

b) Gas fired

c) Pulverised fuel fired

E. Cupola or Shaft Furnaces.

Furnaces for secondary aluminium melting have not yet been standardised but when large productions are desired, reverberatory furnaces have been extensively used. However, in a developing country, selection of the furnace and its capacity will largely depend on the type of fuel economically available. In foundry practice, light aluminium alloys have been melted in different furnaces used for brass and bronze melting. Actually a great variety of furnaces are in use for melting aluminium and aluminium alloys, but the Pot furnace seems to be popular, particularly when contamination by iorn in the alloy does not adversely affect the property of the remelted final product. The fundamental consideration for selecting a particular type of melting unit are (1) the melting losses should be low.

(2) The melting should be rapid and (3) the cost of fuel should be low (4) Melting and operating efficiency should be high. The efficiency of a Furnace can be approximately calculated by the fellowing formula if the calorific value of the fuel is known.

$$\text{The Furnace efficiency} = \frac{\text{Theoretical amount of fuel}}{\text{Actual amount of fuel}} \times 100\% \text{ in percent.}$$

Aluminium has a high specific heat and high latent heat of fusion - much higher than brass, copper and other non-ferrous metals in general. Hence despite the fact that the melting point of 70:30 brass for example, is much higher than that of 92:8 Aluminium Copper Alloy, it requires about twice as much fuel to melt the latter.

Furnace Atmosphere.-

The furnace atmosphere can be (1) Oxidising (2) Reducing (3) Neutral. In melting aluminium and its alloys, it is desirable to maintain a reducing atmosphere. Normally speaking the atmosphere in fuel furnaces is oxidising and in Electric Furnaces it is reducing. In the case of direct arc furnace, however, the temperature of the metal may be so high near the electrodes striking arc with the liquid metal, the carbon monoxide may interact with aluminium producing aluminium oxide and free carbon.

The usual constituents found in a furnace atmosphere are the following :

1. Carbon Dioxide ($CO_2$)
2. Carbon Monoxide ($CO$)
3. Cyanogen ($CN$)
4. Hydrocarbons ($C_2H_4$)
5. Methane ($CH_4$)
6. Sulpher Dioxide ($SO_2$)
7. Nitrogen ($N_2$)
8. Hydrogen ($H_2$)
9. Oxygen ($O_2$)
10. Water Vapour

Out of the above 10 items of gases, the last three namely (1) Hydrogen (2) Oxygen and (3) Water vapour adversely interacts with the molten metal producing injurious effect.

Gas Occlusion :

The occlusion of gases by aluminium and its light alloys during melting is significant from the point of view of casting and working than from the point of view of melting lossess. While dealing with furnace atmosphere, it has been indicated that different types of atmospheric gases exert injurious effects on the molten metal during melting. Out of all the elements previously mentioned two constituents namely (1) Hydrogen and (2) Oxygen can cause major defect in the metal and the castings.

(A) Hydrogen :-

It is now an established fact that hydrogen is responsible for pinhole porosity in the metal. Hydrogen may enter the molten metal through various sources such as (1) corrossion products, (2) atmosphere moisture absorber at the surface of the molten metal (3) products of combustion of the furnace fuel (4) moisture from hygroscopic fluxes and (5) protection dressing on stirrers, plungers, and scrappers etc. Hydrogen is soluble in both solid and molten aluminium but its solubility depends upon the temperature as shown below :

| Temperature | Phase | Solubility CC/100 grams |
|---|---|---|
| 400°C | Solid | 0.001 |
| 600°C | " | 0.026 |
| 660°C | " | 0.036 |
| 660°C | Liquid | 0.6 |
| 700°C | " | 0.9 |
| 750°C | " | 1.2 |
| 800°C | " | 1.7 |

The solubility of hydrogen in molten aluminium increases with higher temperatures and under equilibrium condition it is proportional to the square root of the partial pressure of hydrogen in the atmosphere directly in contact with the molten metal. Because the solubility of hydrogen in solid metal is very low, a large amount of hydrogen may be evolved during solidification. Some alloying elements, such as copper and silicon decrease the solubility of hydrogen while titanium, iron and magnesium increase the solubility of hydrogen in molten aluminium. It is advisable to take certain precautions as listed below to prevent hydrogen pick up by the molten metal.

(1) The charge material must be clean, free from dust and dirt and possibly dry.

(2) A slightly oxidising atmosphere in the furnace may react with the hydrogen that may be present in the furnace atmosphere.

(3) Fluxes should be kept in sealed containers as most of the fluxes are hygroscopic

(4) Tools such as skimmers, plungers spoons etc. must be thoroughly dry before use.

(5) The charge should be melted as quickly as possible and the melt should not be overheated or held up unduly. The above precautions do not necessarily mean that hydrogen pick up is completely prevented. Hydrogen pick up by the metal still takes place and to remove the last trace of hydrogen, a number of patented fluxes containing chlorine can be immersed into the molten aluminium bath and after decomposition, the chlorine bubbles through the liquid bath effectively removing the hydrogen from the melt. "Hexachlorethane" is the most popular compound available in solid state. This is the most commonly used method of degassing aluminium and aluminium alloys. Tablets containing Hexachlorethane are marketed by the flux manufacturers in various trade names.

(B) <u>Oxygen</u>:

Oxygen reacts with aluminium even in solid state to form a tenacious layer of the oxide. When the metal is molten, the oxide formation is more rapid and agitation of the surface leads to an accumulation of oxide as surface dross. In the absence of high temperature and violent agitation, the amount of oxide formed is dependent on the surface condition of the charge metal. The oxide so formed may either remain suspended in metal or sink to the bottom of the metal bath. The specific gravity of aluminium at 800°C is 2.34 while that of aluminium oxide is 3.85. Hence, from the point of view of specific gravity alone the dross should sink, and the fact that some of the oxide does sink is shown by the reverberatory furnace practice in melting substantially pure aluminium, when fairly large accumulation of oxide builds up on the furnace bottom after a few days of continuous melting.

<u>Fluxes</u> :

The formation of oxide can be prevented by the use of fluxes added during melting. A dedrossing flux placed on the surface of the molten metal wets the oxide and penetrates between the metal and oxide and thus reduces the amount of metal held in the dross. Oxide suspended in the melt can be brought into contact with the flux by gently stirring the metal under the flux or bubbling a reactive gas such as chlorine as referred to in the case of hydrogen. When the metal is ready for pouring the flux and dross should be carefully skimmed from bath surface.

<u>Melting Pots, Crucibles and Furnace Lining material</u>:

The question of the material - composing the melting pot in pot or crucible furnaces or of the lining in open flame furnaces is of is of special importance in aluminium alloy melting due to the complex chemical reaction taking place between metal and the lining material. In foundry practice both graphite clay cruciles and cast Iron melting pots have been used. The composition of the cast iron normally used is as follows :-

| | |
|---|---|
| C | 3.15% ( Total carbon) |
| | 0.5% ( combined carbon) |
| Mn | 0.4 - 0.5% |
| Si | 2.5 - 3% |
| S | 0.1% max |
| P | 0.3% max |

In iron pot melting, the iron content of the resultant alloy is always higher than when melting in crucubles or in contact with a refractory lining owing to the dissolution of iron by the aluminium. If any irom oxide falls into the molten bath of aluminium then following reaction takes place :

$$Fe_2O_3 + 2\ Al = Al_2O_3 + 2\ Fe.$$

The reduced iron with the aluminium and the aluminium oxide is found in the dross. It is customery therefore, to have the inside walls of the Iron Pot washed by a high temperature refractory wash. It is rather difficult to adhere the refractory wash to the surface of the pot permenently.

A relatively small tonnage of aluminium alloys is melted in graphite clay crucibles either in pot or in crucibles furnaces.

In the case of fixed and stationary open flame furnaces, reverberatory furnaces and electric furnaces refractory fire clay bricks are used. Other types of refractory bricks or ramming mass may be tried but the following factors should be borne in mind.

1. The chemical composition of the material melted
2. The chemical composition of the refractory
3 The interaction of the metal with the elements of the refractory material.
4. Cost of the refractory.

For general information, the chemical compositions of most popular casting alloys as per B.S..S. and corresponding ASTM specifications are given in the Table VIII.

**Table - VIII**

**Nominal Composition of Alloys in Common Use in Great Britain and the U.S.A.**

| British Specification and Alloy Numbers | Cu% | Mg% | Si% | Fe% | Mn% | Ni% | Zn% |
|---|---|---|---|---|---|---|---|
| LM-1-M | 7 | | 3 | | | | 3 |
| LM-4-M.DTD.424A Normal 117 | 3 | | 4½ | | | | |
| LM-5-M.DTD.165A Birmabright | | 4½ | | | 0.5 | | |
| LM-6-M.BSS3.L.33 Alpax | | | 10-13 | | | | |
| LM-7-M and P.BSSL51 CeralB.RR50 | 2 | 0.1 | 2½ | 1 | 1 | 1¾ | |
| LM-S-W and WP DTD.727,735, 716, 722 HID40 | | 0.4 | 4½-6 | 0.6 | 0.5 | | |
| LM-9-p and WP,DTD.716 245A. Alpax | | 0.4 | 10-13 | | 0.5 | | |
| LM-10-W.BSS.L.53 HID 90 Noral 350 | | 10 | | | | | |
| LM-11-W and WP Noral 226,DTD.298A 304A,361A | 4½ | | | | | | |
| LM-12-WP | 10 | ¼ | ½ | ¾ | ½ | | |
| LM-13-WP- Noral 162T | 1 | 1 | 12 | ½ | 2 | | |
| LM-14-M and WP BSS.2L,35 Noral 218,Y alloy | 4 | 1½ | | | 2 | | |

**Copper and Copper Alloys:**

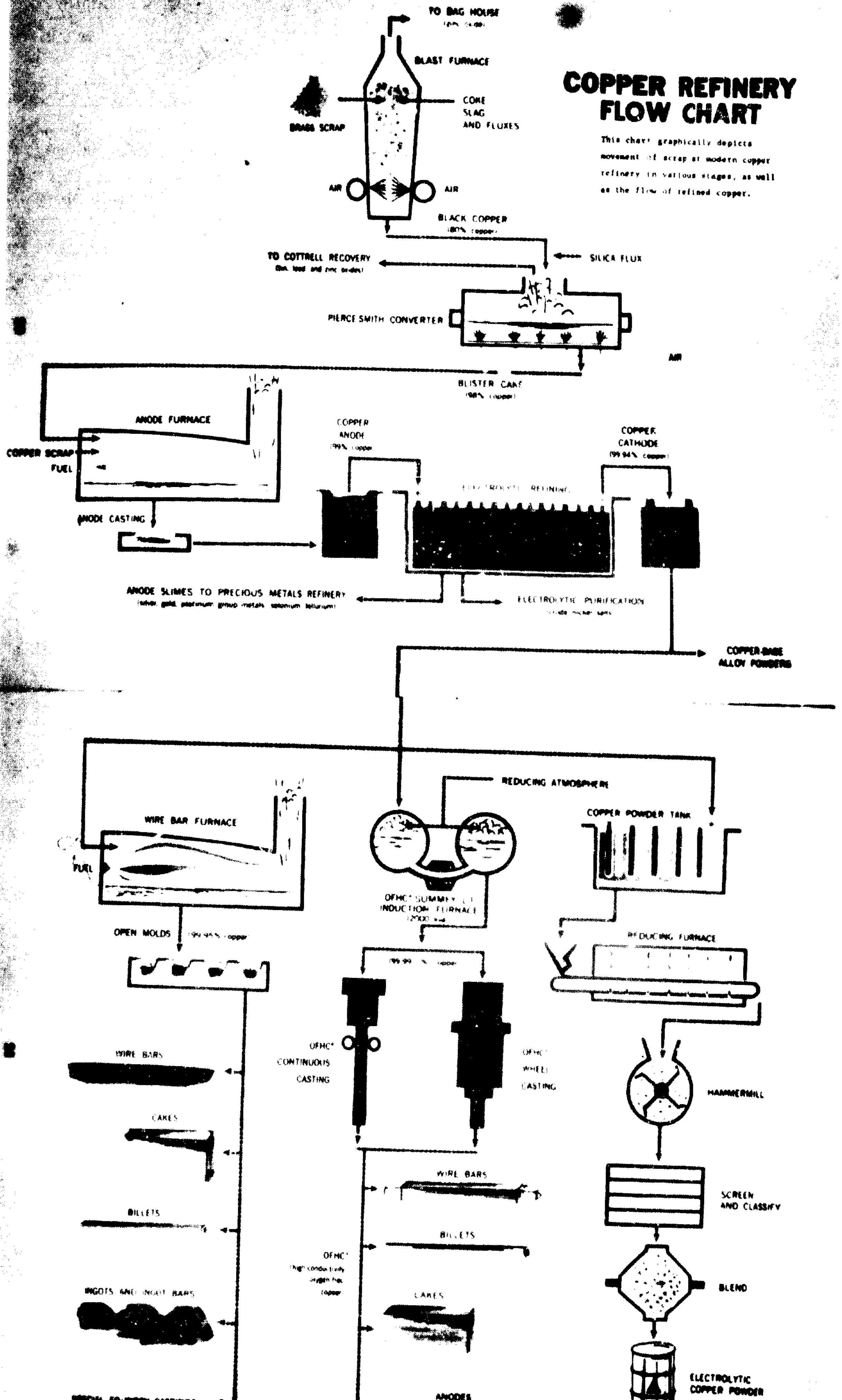
The world's production of copper as given in Table 1 records a production of about 6 million tons next to aluminium.

The smelting, refining and alloying of scrap copper metal are carried out by the secondary metal producers ; in the latter case the basic raw materials are discarded materials of copper and copper base alloys.

Secondary refining of copper has been rapidly developed in highly developed countries to fill up the gap that exists between the demand and supply of primary copper. In this connection it will be interesting to study a " Flow Chart" developed by the National Association of Secondary Material Industries INC.,(NASMI) in U.S.A. graphically depicting the movement of scrap at a modern copper refinery which is reproduced hereunder:

# COPPER REFINERY FLOW CHART

This chart graphically depicts movement of scrap at modern copper refinery in various stages, as well as the flow of refined copper.



In a developing country non-ferrous metal industry such as the cable industry needs heavy tonnage of high purity copper and it is therefore, necessary to take positive action in setting up refineries to recover high purity copper from scrap. In the foregoing chapters it has been shown that the gap between the demand and supply of electrolytic copper in India is about 60,000 tons annually which is likely to increase in the near future. This will necessitate setting up in India on Regional basis a Copper Refinery of moderate size which will be economic in its operation. India with her vast network of railway system and a fairly developed electrical engineering industry can provide the required scrap metal. At the present time the scrap metal industry is not fully organised but an infra structure for the same exists in the country which should be further re-inforced for developing a fully integrated secondary copper refining industry.

It is in this context that th subsequent observations will be made which should serve as guide lines for organising the secondary metal industry not only in India but also in other developing countries where such scope exists.

The first step towards organising such an industry will be to ensure a regular source of supply of raw materials which in this case is nothing but a bewildering variety of copper bearing scraps.

A great deal of effort is therefore needed in sorting, blending, sifting, degreasing, baling, briguetting, and segregating composition wise in preparing the furnace charge which will give a product of the desired grade and composition. The scrap from different alloys may be so mixed up that it may be too costly to suitably segregate it. The borings, turnings and swarf get easily mixed up. However, bearing in mind the requirement of raw material for (a) Refineries for the production of high purity copper and (b) Ingot makers for the production of various types of standard metal ingots, the segregation of scrap can be made in approximately 6 broad categories as follows :

1. No. 1 Copper Scrap :

The scrap in this category must be exclusively copper scrap of highest purity, clean and free from any contamination. Sometimes it is extremely difficult to detect other alloying elements and as such, the origin of the scrap must be ascertained before putting the mat rial in this group. Some time wires are coated with some kind of varnish having identical colour of copper. Such scraps, thin wires and also all kinds of borings, copper clad wires etc. should not be mixed up with this category of scrap.

No. 1 copper scraps are meant for direct use in the wire bar furnace for simple remelting and converted into first quality copper with a minimum of refining.

2. No. 2 Copper Scrap :-

This variety of scrap is meant for melting in the reverbetory or rotary type of furnaces for sale as fire-refined ingots or into Anodes for passing through electrolysis for the production of high purity copper cathodes. In this category of scrap, wire scrap with insulation previously burnt off may be accepted. Care must be taken to ensure that the adhering ashes are properly removed.

3. No. 3 Copper bearing scrap :

Mixed copper and alloy scrap containing 40 to 75% copper for use in either reverberatory or rotary furnaces for the production of anodes by suitable addition of comparatively pure copper scrap.

4. No. 4 Copper bearing scrap :

Low grade skimmings, ashes, residues, , mixed radiators etc. containing from 15 to 30% copper may be used for conversion in a copper shaft blast furnace into a black copper suitable for further refining.

5. No. 5 Copper bearing scrap:

The scrap in this category could be graded as alloy of gun metal castings such as Railway journal bearings, all types of gear wheels, gun metal bushes and related structural components from which the grade of the material can be easily recognisable. Such scraps are normally used by ingot makers.

6. No. 6 Copper bearing scrap :

In this category, scrap can be grouped as containing brass and bronze scraps and can be sub-divided into various sub-groups depending upon the composition for use by small scale founders. Therefore, many other varieties of copper base alloy scrap which can be economically segregated, provided the volume of scrap justifies the economics of the process. NASMT have prepared the list of such alloys which is given in the appendix.

**Future Pattern of non-ferrous metals scrap recovery in India :**

India annually needs about 80/100,000 tons of Electrolytic copper for her growing electrification schemes while the production of primary copper in the country is not expected to go up beyond 20,000 tons in the near future. In order to recover high purity copper an integrated plant consisting of an Anode Furnace and Electrolytic plant by utilising No. 2 and No. 3 Copper scrap may be considered.

To utilise a large volume of low grade copper scrap grouped as No. 4, for achieving comparatively higher output perhaps a blast furnace converter-cum-anode furnace with electrolytic refinery will be more appropriate under the present circumstances as per flow sheet attached.

Lately vigorous research work is being carried out in developed countries for direct electro-refining of copper from scrap.

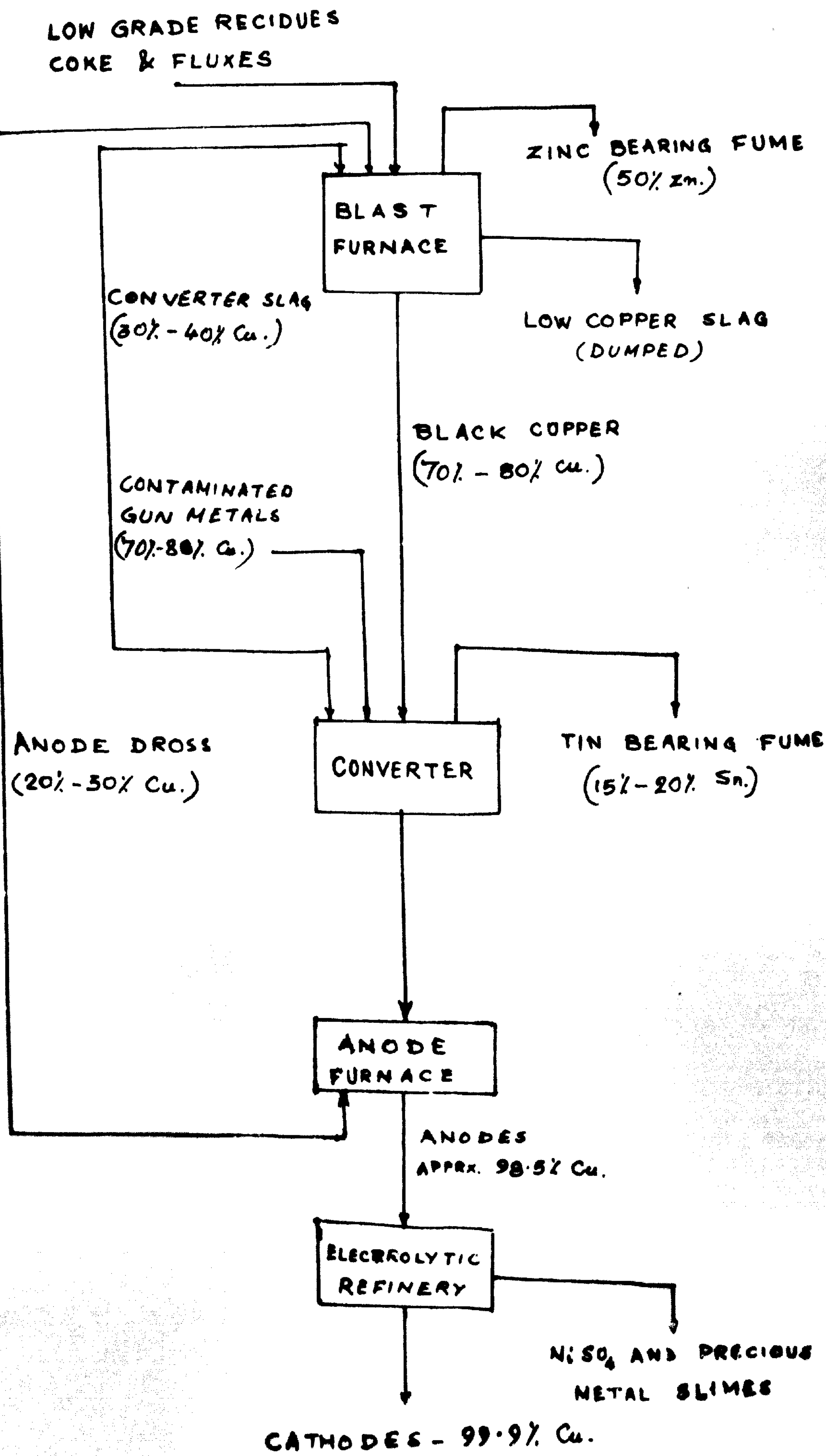
**Melting Practices :**

In the preceeding chapter, the different types of furnaces used for non-ferrous metal melting as a whole have been dealt with. The same furnaces can be utilised for the melting of copper base alloys also. The selection of the particular type and size of the plant will largely depend upon the desired output and local conditions prevailing in the area where the plant is expected to be installed.

Fuel fired crucible Furnaces are still extensively used due to the following advantages :

Flow Sheet for Refining Copper from Secondary Scrap Metals





1. Flexibility of operation

2. Rapid melting rate

3. Low melting losses on account of use of different types of proprietory Fluxes.

4. Easy way of changing metal composition without much of contamination.

5 Low capital cost.

The reverberatory furnaces are used for large melts from 5 to 30 tons or even more. Melting losses can be relatively more but the metal composition can be fairly uniform for a heavy metal charge. In modern design of reverberatory furnaces preheating of forced air for combustion and also preheating of metallic charge have reduced the melting losses. To eliminate loss of time of charging in the furnaces of large capacities, roof charging has also been introduced. Introduction of oxygen in the bath has been another factor which is being successfully introduced to promote oxidation during the melting.

In rotary furnaces, introduction of top charging of scrap by bringing the furnace into a vertical position has cut down the time for charging.

Electric Induction furnaces particularly channel type and also coreless type are becoming increasingly popular and also economically viable on account of atmospheric condition in the furnace which prevents any contamination either by oxidation or gas absorption ; the induced eddy currents promote the agitation and thus help the melting process. The change of melt composition can be carried out without much difficulty. Intermittent operation is possible in the case of coreless type of furnaces.

The present day ruling price of electrolytic copper scrap in India is Rs. 8/- per kg. and selling price is Rs. 17/- per kg. The difference in price between the scrap and finished electrolytic copper wire bars is therefore Rs. 9/- per kg. This margin will economically justify setting up even a small plant for producing approximately 1000 tons per year as indicated below :

Fixed capital for a production capacity of 1000 tons/year in the form of wire bar.

| | | |
|---|---|---|
| Land and Building (covered area – 10,000 sq. ft.) | Rs. | 2,00,000 |
| Plant/Machinery | | |
| a) Furnace for melting scraps (Reverberatory furnace) 3 tons/shift | Rs. | 50,000 |
| b) " " Cathode for wire bar casting (Reverberatory 3 tons/shift) | Rs. | 50,000 |
| c) Electrolytic Plants consisting of rectifiers, cells, including acid for 1st filling | Rs. | 10,00,000 |
| d) Handling Equipment | Rs. | 1,00,000 |
| e) Machine shop facility | Rs. | 50,000 |
| f) Quality control Lab. facility | Rs. | 2,00,000 |
| g) Transport vehicles etc. | Rs. | 1,00,000 |
| h) Moulds materials | Rs. | 1,00,000 |
| i) Misc. including installation ( civil, mechanical and electrical) | Rs. | 2,00,000 |
| | Rs. | 20,50,000 |
| Working capital (marginal) | Rs. | 6,50,000 |
| | Rs, | 27,00,000 |

**Production cost of 1000 tons of Electrolytic Copper in the form of wire bar**

| | | |
|---|---|---|
| 1. | Cost of high purity scrap with average copper content not less than 90% including collection/segregation etc. @ 8/- per kg. requirement – 1250 tons/year | Rs. 10,000,000 |
| 2. | Cost of melting for anode cast mostly fuel | 50,000 |
| 3. | " " Melting cathod for Wire bar | 50,000 |
| 4. | Casting cost for the above | 20,000 |
| 5. | Flux material including oxygen | 60,000 |
| 6. | Acid $H_2SO_4$ 1600 tons on the basis of Cu : $H_2SO_4$ = 1.6 | 1,120,000 |
| 7. | Electricity @ 0.50 KWH/kg deposit at the rate of 10 paise per unit | 60,000 |
| 8. | Salary and wages | 80,000 |
| 9. | Marketting & Technical development | 150,000 |
| 10. | Misc. in inspection, quality control, packing etc. | 100,000 |
| 11. | Interest on working capital | 350,000 |
| 12. | Depreciation on 10% of the fixed capital | 200,000 |
| | | 12,240,000 |
| | **Sale proceeds of 1000 tons of Copper @ Rs. 17/- per kg.** | 17,000,000 |
| | **Difference** | 4,760,000 |
| | **Per ton** | 4,760 |

**Quality Control**

As stated earlier the U.S.A. annually despatches non-ferrous metal scrap valued at $ 1.5 billion. To tackle business of this magnitude successfully, apart from organising the handling, processing of the metal and placing in the specially earmarked bins in the scrap yard, quality control must be meticulously enforced at every stage of operation commencing from the time the scrap is received in the yard. While skill of the man in sorting out different types of scrap by visual inspection such as filing and drilling tests to make an intelligent identification of the anticipated composition of the lot, the need of application for modern metallurgical testing equipment can not be over-emphasised.

In view of the high base cost of non-ferrous metal, it is justifiable to have a well equipped laboratory at the disposal of even a medium size scrap yard. The equipment that may be needed for the purpose are broadly outlined hereunder :

**Metal Spectroscope** :

This instrument covers the visual region of the spectrum and operation is affected by a simple visual analysis procedures. Normally standard charts for different metals are supplied with the apparatus.

**Director Reading Spectrometer** :

This instrument is an optical electronic instrument used to determine the exact amounts of Mg., Si., Fe., Mn., Ti., Cr., and Cu in the alloy. Each element has its own individual dial and the instrument differs from ordinary spectrographic analyzers by the substitution of photoelectric tubes for the photographic plate and electronic circuits for the densitometer and calculating board. Sample discs are taken during the transfer from the melting to the holding furnace and again during each drop in the casting of extrusion ingots. Although the instrument is less flexible than wet chemical or spectrographic analysis, it has a tremendous advantage in speed since on entire analysis is accomplished within a few minutes after the sample is inserted into the machine.

or

An X-Ray Fluorescene Spectrometer

This apparatus can analyse upto 9 elements in about 10 - 15 minutes. The apparatus with its supporting apparatus and auxilaries may cost about $ 60,000.00

or

Conventional analytical chemical laboratory

The above equipment may determine the chemical composition. But there are other variable factors when scrap is received in mixed up condition. In such cases, the mixed up scrap should be melted in a crucible.

The laboratory therefore should be equipped with melting furnace of smallest capacity available, perhaps a high frequency coreless type of Induction furnace may be suitable for the purpose.

To check up the structure of the metal the laboratory should have a metallography section equipped with polishing machine and metallurgical microscopes preferably with photographic attachment.

The other pieces of equipment in the metallurgical laboratory are ageing ovens, vacuum equipment, a ph. meter, potentio meter, microhardness tester, balance and micro balance, oscilloscope and electrolysis board etc.

Above all, the laboratory should be manned by competent staff who will be able to interpret the results accurately. Scrap refining technology is subject to continuous evolution and change and as such a metallurgist connected with the Trade should keep an open mind to develop new methods and new technological processes as the circumstances may demand from time to time for maximum utilisation of the scrap metal. Accumulation of non-ferrous scrap is bound to increase in developing countries and regions.

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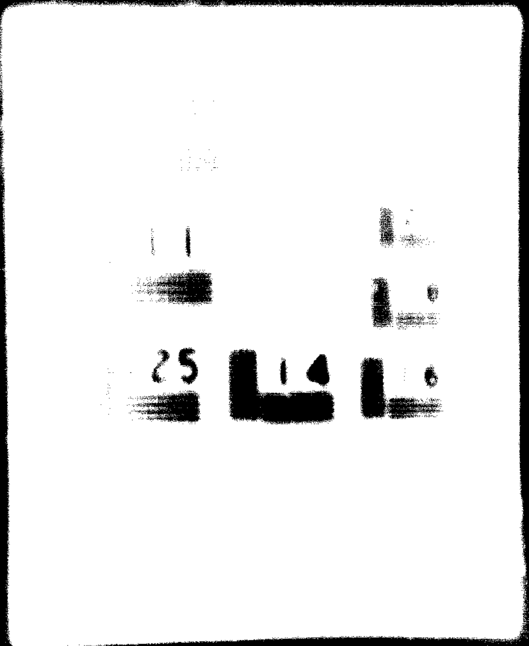

# APPENDIX

## COPPER-BASE ALLOY SCRAP

These are not intended to be specifications. For detailed descriptions of scrap items, see NASMI Standard Classification Circular for Nonferrous Metals ( NF - 66)

All analysis are nominal and approximate. Please refer to published specifications for permissible tolerances as well as other elements which, for simplicity, are omitted from the analyses stated in this appendix.

Nitric acid, where referred to, means approximately 38% solution.

| MATERIAL | TYPICAL ANALYSIS | IDENTIFICATION AND REMARKS |
|---|---|---|
| Composition* of Red Brass | 85-5-5-5 | 1) Coler - reddish gray<br>2) Test - Dissolve drillings or small piece in nitric acid, will show some white sediment indicating the presence of tin. |
| * Being progressively replaced by lower alloys such as | 83-3-7-bal<br>or<br>78-3-7-bal | |

| MATERIAL | TYPICAL ANALYSIS | IDENTIFICATION AND REMARKS |
|---|---|---|
| G-Metal | 88-10-0-2 | 1) Color - golden red<br>2) Test - Drillings dissolved in nitric acid show heavy white Sn deposite. |
| M-Metal | Cu 86.0-89.0<br>Sn 5.8 -6.5<br>Pb 1.0 -1.8<br>Zn 3.5 -5.0 | 1) Color - somewhat lighter than 88-10-0-2<br>2) Test - Drillings show less Sn deposit i[illegible] dissolved in nitric acid. |
| High-leaded Tin Bronze | 83-7-7-3<br>or<br>80-10-10-0 | 1) Color - gray reddish<br>2) Generally in form of small bushings and general utility bearings. |
| Machinery Brass | Cu 78-80<br>Sn 7.9<br>Pb 9-10 | Heavy Castings from machinery or rolling mill bearings. There are many grades - some have 10-18 lead. |
| Backs for lined journal bearings, carboxes | Cu 72-75<br>Sn 4-5<br>Pb bal | 1) Color - dull grayish blue leady<br>2) Tybe of parts |
| Lined carboxes | About 15% babbit, depending on wear<br>Sn in babbit, about 4% | |

| MATERIAL | TYPICAL ANALYSIS | IDENTIFICATION AND REMARKS |
|---|---|---|
| Cocks & Faucets<br>Leaded Semis Red Brass | 76-3-6-15 | Some faucets are red brass<br>Some are yellow brass<br>Remore zinc die cast handles<br>Remove porcelain. |
| Pump Brass | Cu 78-80<br>Sn 6 - 7<br>pb 14-16 | |
| Paper Mill Cloth<br>Bronze Wire Cloth<br>Foundrinier Wire | Cu about 88<br>Sn about 4-4-1/2<br>Zn. bal. | Usually composed of 1 strand<br>8% Phosphor bronze and I strand<br>85/15 (85 Cu 15 Zn) |
| Yellow Brass Castings | Cu 61-67<br>Sn 1<br>Pb 1-3<br>Zn 29-35 | 1 ) Color - Yellow |
| Aluminium Bronze *<br>*Some aluminium bronze alloys also contain Ni 4.0-5.0 | Cu 78-90<br>Sn none<br>Al 8.5-11.5<br>Fe 1.0 -5.0 | 1) Color - silverish yellow may be misleading<br>2) Test - Drillings magnetic They are lighter in weight than drillings from other brasses. |
| Manganese Bronze | Cu 55-60<br>Sn nil -1.0<br>Fe 0.40-2.0<br>Al 0.50-1.5<br>Mn upto 1.5<br>Zn Bal | 1) Color- yellow<br>2) Test - Drillings slightly magnetic. |

| MATERIAL | TYPICAL ANALYSIS | IDENTIFICATION AND REMARKS |
| --- | --- | --- |
| High Tensile Manganese Bronze or Manganese Brass | Cu 60-68<br>Fe 2.0 - 4.0<br>Al 3.0 -7.5<br>Mn 2.5 - 5.0 | 1) Color - greenish yellow<br>2) Test - Drillings stronger magnetic than ordinary manganese bronze. Drillings are faluffy and light. |
| Yellow Brass Pipe ( Also for Brass Mill use) | Cu 65<br>Pb 0.80<br>Zn bal | Yellow break |
| Red Brass Pipe (Also for Brass Mill use) | Cu 80 Zn 20<br>Cu 85 Zn 15<br>Cu 90 Zn 10 | Break is reddish. Usually has reddish sheen outside |
| Window Screens (Low Brass) | Cu about 80<br>Zn bal | Value depends on clean-ness Watch for plastic screens and stainless steel strand, usually the outer strand near frame. |
| Silicon Bronze and Silicon Brass | Cu 75-95<br>Si 1.0 - 5.0<br>Zn 5.0 - 16.0 | 1) Color - reddish<br>2) Test - Drillings dissolved in nitric acid from gelatin like deposit. |
| Automobile Radiators | Cu about 70<br>Sn about 3-3-1/2 | Remove iron.<br>Some are radiators with iron core Some are copper radiators. Some are aluminium radiators. Some have aluminium fins. Auto heater radiators usually lower in Sn. Watch for Harison radiators in lower waterbox ( from automobiles). These are Cupro Nickel outside with heavy iron inside. |

| MATERIAL | TYPICAL ANALYSIS | IDENTIFICATION AND REMARKS |
|---|---|---|
| <u>Old Condenser Tubes</u> | | |
| Admiralty Condenser Tubes | Cu 70<br>Sn 1<br>Zn bal | 1) Color of break greenish yellow<br>2) Test - Drillings dissolved in nitric acid s ow small Sn deposit.<br>3) Watch for sediment inside and whether tubes are sound. |
| Aluminium Brass Condenser Tubes | Cu 73-75<br>Al 2<br>Zn bal | No known positive identification<br>Test - Shows no Sn deposit. |
| Munts. Metal | Cu about 60<br>Pb upto 1/2<br>Zn bal. | 1) Color - Break shows dull yellow<br>Mostly condenser heads or condenser tubes<br><br>Tubes - watch for sediment inside and whether sound. |
| Naval Brass | Cu 58-60<br>Sn upto 1<br>Zn bal. | 1) Color - Generally more reddish than other brass<br>2) Test - Drillings dissolved in nitric acid show small Sn. deposit. |
| Nickel Silver or German Silver | Cu 55-65<br>Ni 10 - 18<br>Zn bal. | 1) Color - whitish<br>2) Non-magnetic<br>3) Nitric acid reacts quickly greenish color. |
| Leaded Nickel Silver (Key Stock) | Cu 65<br>Pb 2.25<br>Ni 7.50<br>Zn bal | 1, 2, 3 as above<br>Sheets are harder than unleaded and break faster when bent. |

| MATERIAL | TYPICAL ANALYSIS | IDENTIFICATION AND REMARKS |
|---|---|---|
| Dairy Metal | Cu 63<br>Sn 2.5-3.5<br>Pb 4-5<br>Ni 18-5-22 | 1) Color - grayish white<br>2) Non-magnetic<br>3) Reacts to nitric acid as above.<br>4) Mostly in form of castings and turnings. Turnins are heavy |
| Old Cupro Nickel | Cu 70 Ni 30<br>or<br>Cu 80 Ni 20 | 1) Color - grayish<br>2) Non-magnetic<br>3) Reaction to nitirc acid less intense than nickel silver.<br>4) Usually in form of condenser tubes orcondenser heads. Tube - Watch for sediment inside and whether sound Condenser Heads - Watch for caulking lead inserts. |
| Cupro Nickel | Cu 90<br>Ni 10<br>Fe upto 1.5 | 1) Color - reddish<br>2) Very slightly magnetic<br>3) Reacts to nitric acid |

## PROBLEMS OF QUALITY IN PROCESSING SECONDARY NON-FERROUS SCRAP METAL

### SYNOPSIS

For effective recovery and utilisation of secondary non-ferrous metal scrap, the necessity and importance of maintaining judicial quality control in several form in every step from the beginning of collection, identification and segregation followed by melting/electro-winning, has been discussed and high-lighted in the papers.

One of the striking features of the rapid growth of non-ferrous metal industry in recent years is the effective recovery and utilisation of secondary scrap to an extent of about 20% of the total production of important primary non-ferrous metals such as aluminium, lead, copper, zinc, tin and nickel. IN U. S.A., this figure rises even up to 42%. With increasing necessity for recovering secondary non-ferrous metal scrap, more attention is devoted in way of collection, identification, segregation and processing of the available resources. Being handicapped with non-ferrous ores and mineral deposits, the current Indian production of major non-ferrous metals covered by Al, Cu, Zn and Pb is hardly about tonnes and bulk of the country's demand is made through a large quantum of import. Thus the current import figure is about 1.7 lakh tonnes of non-ferrous metal, 60% being for Al and Cu along with a total foreign exchange value of about Rs. 55 crores which again is expected to rise to Rs. 300 crores with envisaged demand mainly due to massive electrification scheme during the Fourth Plan Period. After analysing the country's future demand and production pattern, the paper stresses on the importance of a planned programme for effective recovery and utilisation of secondary non-ferrous scrap metal by all possible means. This problem was correctly visualised by the National Metallurgical Laboratory of India at Jamshedpur by taking up on priority basis, research and development work on the recovery of aluminium from Dross and other Scrap sources and copper from secondary metal by melting and electro-

refining which may serve as a guide to large scale industrial exploitation of aluminium and copper from secondary non-ferrous scrap. The paper then describes the various sources of secondary aluminium and copper scraps and alloys with their character and quality and suggests several means of extracting and recovering them as useful metals and alloys. Various ways and means of recovering aluminium either as pure metal or alloy from Drags and skimmings, furnace scrap, rolling scrap, fabricating scrap, cold aluminium wire, foils, discarded utensils including various aluminium-alloy scraps available from boring, turnings, drilling, millings, duralumin, etc. have been thoroughly discussed. Suitable types of furnace with their operational characteristics for the purpose in view have also been suggested. The paper also incorporates similar discussions on the availability of direct copper scraps and other mixed copper-bearing scraps containing 15 to even 75% of copper with processes for their recovery by following various melting and electro-refining techniques. The effect of furnace atmosphere during melting of secondary scraps with particular reference to hydrogen, oxygen, water vapour and refractory lining in relation to maintaining the products-quality, has been clarified. Finally, the paper stresses on the importance of maintaining meticulous quality-control in processing secondary non-ferrous metal scrap at every stage of operation commencing from scrap source upto the finished product through application of modern metallurgical testing equipment like metal spectroscopy, direct reading spectrometer- x-ray florescence spectrometer and/or through Conventional analytical-chemical laboratory set up under the guidance of expert Metallurgist on the line.

## References

1. Journal of the Institute of British Foundrymen Australian Branch Vol. 10

2. Metallgesellschaft Aktiengesellschaft Metal Statistics 1958 – 1967, 88th Annual Issue.

3. Indian Foundry Journal Vol. 6 Nos. 1 – 12 June 1960 to May 1961.

4. The Metallurgy of Aluminium and Aluminium Alloys by Robert J. Anderson.

5. Advances in Extractive Metallurgy Proceedings of a symposium organised by the Institute of Mining and Metallurgy and held in London from 17 to 20 April, 1967.

6. Non-ferrous Production Metallurgy by John L. Bray.

7. Non-ferrous Foundry Metallurgy – Edited by A. J. Murphy.

8. Tin and its alloys – edited by Ernest S. Hedges.

9. Indian Foundry Journal – Vol. 14, No. 10, March 1968.

10. The effective Utilisation of Copper Transactions of a symposium, Bombay Calcutta, January 1968 – Indian Copper Information Centre.

11. Symposium on Metallurgy of substitute ferrous and non-ferrous Alloys. Paper and discussions from the symposium organised by the National Metallurgical Laboratory and held at Jamshedpur (India) in April 1968.

12. Proceedings of the Symposium on Recent Developments in Foundry Technology – 5th to 8th February, 1968 – organised by the National Metallurgical Laboratory, Jamshedpur(India) and I. I. F., Calcutta.

24. I. 72.