by inserting a tool under one of the edges of the deposited copper. It is no more costly by the centrifugal process to make thin sheets than thick ones; copper foil can be made in five minutes direct from crude copper.

Tests of Tubes and Sheets.

Copper tubes produced by this process without any drawing have given a maximum stress of 17 tons, and tubes after drawing have withstood a pressure of 3,000 lbs. per square inch without showing any signs of distress, as shown by the following test made by Mr. David Kirkaldy:—

Diameter outside.	Thickness of Metal (mean)	Length.	Weight per Foot.	Subjected to a Pressure.
Inches.	Inch.	Inches.	Lb.	Lbs. per sq. in.
1.123	0.063	4.94	0.814	3,000

Sheets made without any rolling have given a maximum stress of 28 to 30 tons and more per square inch according to the peripheral speed at which the mandrels were revolved. The following are some tests made by Mr. W. Harry Stranger :—

Dimensions	Area.	Reduction of Area at Fracture	Extension on 8 ins.	Elastic Limit (Yield Point) On Original Area	Maximum Stress On Original Area	Remarks.
Inches	Sq. in.	Per cent.	Per cent.	Tons* per sq. in.	Tons* per sq. in.	
1.109 x 0.006	0.0066	31.8	21.1	20.4	25.5	Fair break in centre
1.135 x 0.007	0.0079	17.7	20.4	28.4	28.4	Fair break in centre.
1.114 x 0.005	0.0055	—	6.3	22.4	34.6	Specimen broke outside datum points on slightly larger area.
1.124 x 0.008	0.0089	—	14.4	22.6	27.7	Specimen broke outside datum points on slightly larger area.
1.114 x 0.01	0.0111	18.9	12.0	—	27.3	Fair break.
1.121 x 0.011	0.0123	24.4	20.0	18.2	27.3	Do. Do.

Bending test. Strip bent three times upon itself. No cracks.

* Tons of 2,000 lbs.

Fig. 6 shows the result of some mechanical tests on copper pipes made by the centrifugal process and subjected to hydraulic pressure, giving results far above those required by the Board of Trade.

The formation of copper trees and nodules was another difficulty that had to be overcome, but which had been reduced to a minimum in the centrifugal process, for the reason that impurities held in suspension in the electrolyte have no opportunity of settling on the cathode, and all gas bubbles are swept from the surface on which the copper is being deposited.

Production of Copper Wire by Centrifugal Process.

The production of copper wire by electrolytic means is a more difficult problem than the production of copper tubes and sheets. Various processes have been suggested and tried from time to time, such as the electro-deposition of copper on thin wire, until it has obtained a considerable thickness, and then drawing the thickened wire down to a comparatively fine wire. Swan and Saunders have both experimented with such processes but so far they have not been worked commercially.

Elmore's process consists of producing copper tubes by his burnishing process, cutting them into long spirals and then drawing them into wire.

Other experimenters have tried placing an insulated spiral strip on a cylindrical mandrel so as to produce long copper spirals, but such an arrangement only allows of a very low current density being employed, on account of the nodules which form on the edges of the strip, even at very low current densities, rendering the strip unsuitable for drawing down into wire.

Copper wire is made by the centrifugal process in the following manner:—A mandrel similar to that used for making copper sheets is employed, around which a spiral scratch is made, the pitch being determined by the size of wire required.

The effect of the spiral scratch (which need only be very light but must be angular), is to cause the crystalline structure of the copper to form a cleavage plane, as shown in Fig. 7. The copper divides exactly at the apex of the scratch, that is, the copper deposited in the scratch is equally divided and forms a small V-shaped fin on two sides of the copper strip. If the scratch is not angular, but rounded at the base, the copper will not divide, as the crystals are radial, as shown in Fig. 8. After the desired thickness has been obtained, approximating the pitch of the spiral scratch, the mandrel is removed from the depositing cell and placed in a vertical position on a lathe, and the copper strip is unwound at an angle of about 45 degrees to the face of the mandrel. During the process of unwinding, the small fin or burr is removed by passing the wire through a suitable die and then through a wire-drawing machine provided with three or more draw-plates to reduce the strip to the desired diameter. By employing a mandrel of 6 or 7 feet in diameter, lengths of wire 4 or 5 miles long can be made in one operation.

Advantages of Electrolyte Process Over Smelting.

The advantages of an electrolytic process as compared to a smelting process are many, and the day is not far distant when copper will no doubt be leached direct from the ore and electrolyzed with insoluble anodes, to produce finished copper sheets and tubes in one operation direct from the ore without the intermediate process of smelting and refining.

The centrifugal process is a step in this direction, as it is capable of depositing copper from its solutions by using insoluble anodes in the form of finished tubes or sheets in one operation. The centrifugal process is at least ten times faster than any existing electrolytic process, and a high current density can be employed without deteriorating the quality of the copper. There is no risk of lamination, as no burnishers are employed. The plant is simple and free from mechanical complications, and the amount of copper locked up for a given output is small compared to other processes. The process is of interest to mechanical engineers, as it conclusively proves that to get a high tensile strength in metals combined with ductility, it is not essential to put a large amount of work into the metals as hitherto

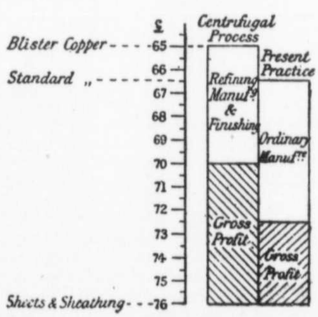

Fig. 9—Sheets.

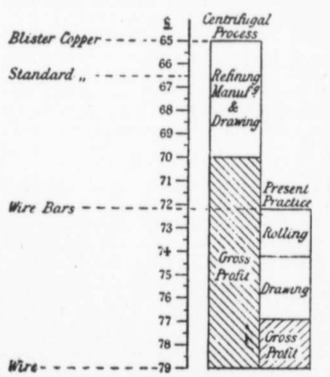

Fig. 10—Wire.

Comparative Cost of Producing Copper by the Present Method and the Centrifugal Process.