THE BOILER

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STEPHEN CHRISTIE

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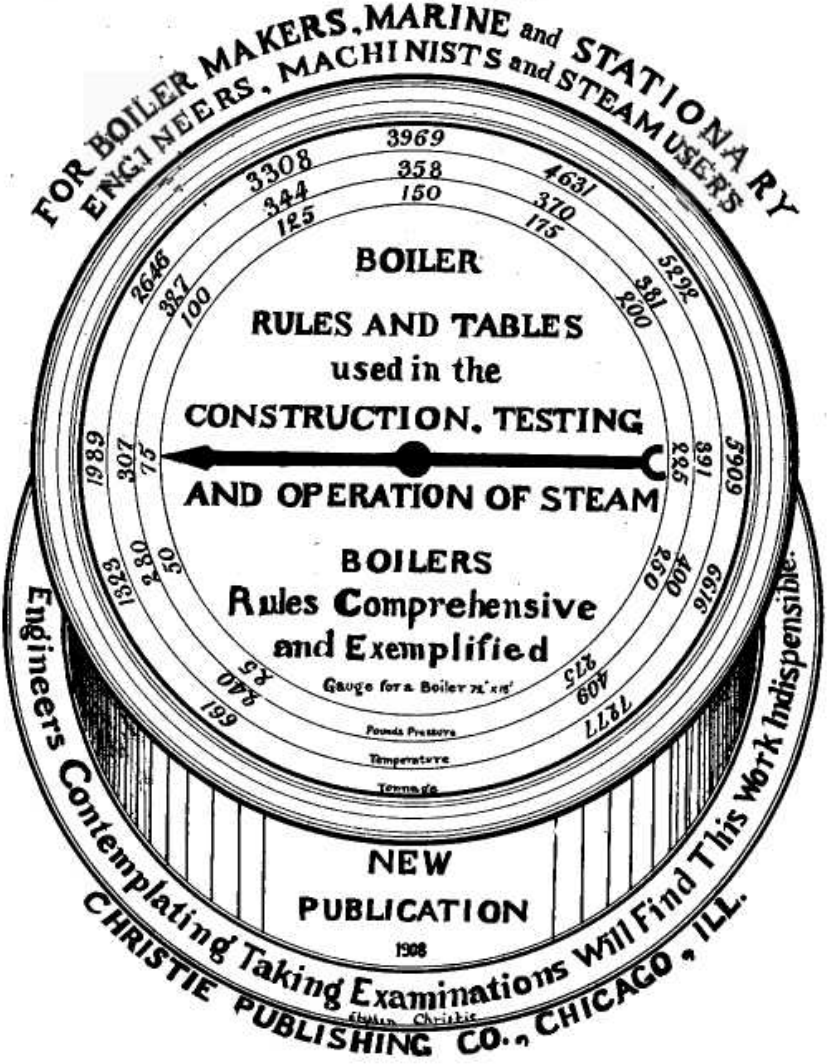

PREFACE.

THE writer, after many years of experience in connection with boilers, as a boiler maker, master boiler maker, and boiler inspector, has, in his vocation, found it necessary to use rules, tables and formulas in conjunction with his work and duties and has profited by those of older and wider experience in the craft and, having had ample opportunity, inclination and resource for research for comprehensive, concise and condensed formulas and rules governing his daily duties, has compiled this work.

The author does not claim originality; it is the intention to make the subject as clear as possible, to make it a pleasant study so that the layman can master the many rules that may seem too intricate and attention has been given to the most practical part of estimating values in connection with steam boiler designing.

Many valuable and scientific books have treated the subject of steam boilers and some exhaustively and from them I have learned. I have quoted from those authors' fund of information and from personal experience, and it will be my aim to make this compilation clear and free from any technicalities that would in a measure confuse the student and sincerely hope it may accomplish the mission intended, to interest those whose duties, labors and interests are in connection with the steam boiler.

STEPHEN CHRISTIE.

CHAPTER I.

MATERIALS.

It has been stated by historians that Tubal Cain was an iron worker, no doubt an artificer in plow shares and pruning hooks, but that in remote antiquity, when metals were few in number and knowledge of their uses limited, and it is doubtful if the steam boiler was among the articles made.

Historians record the nature of metals during those early ages as gold, silver, brass, iron, tin and lead, and also state that bronze had been in use before iron, thus we may favor doubt about boilers of some description being in use during those ages of antiquity.

Aristotle seems to be the earliest authority quoted on the subject of iron, saying "that iron was purified from acoria by melting, and after repeated treatments by melting became purified." What state of purification in relation to iron working tools or metals was not stated.

Daimachus, an early writer on the subject mentions different kinds of steel and the purposes to which they were used, and severally suited, viz.:

Chalybdie for carpenter tools.

Lacedoemonian for files and drills and stone cutters' tools.

Lydian for knives and razors.

Thus ancient history records some notice of materials used in boiler construction, but it is doubtful if ancient process of manufacturers or knowledge of material construction brought it up to anything like the state of perfection that could be used in steam boilers of today.

This chapter was not intended to treat on metallurgy only to touch upon materials as now used in these days of high pressure boilers.

Manufacturers assume great responsibilities in selecting material for boilers, hence care in selection.

Boiler making today is a science, demanding scientific education and knowledge gained by research, investigation and reasoning.

The writer can go back mentally to the days when boiler making was apparently in its infancy, this when comparing the boilers of to-

day with the demands for power and when the very low pressures were then well suited to the low grade material manufactured; designs crude, seams out of all proportions, bracing out of reasoning, and the ignorant mechanic, whose only evidence of work was strong in arm, wrought defects without thought of effects.

There is evolution and revolution in boiler making today.

High pressures are necessary, also care in selecting materials and designing boilers. The construction for the demands today are high pressures; due to competition, economy and fuel and space. It is necessary then to have all parts equal in strength, different parts favored with material of specific quality, such as braces, tubes, fire sheets, where circulation is least; corrosion, expansion, contraction or pitting active will necessitate increased thickness of plate; again, to secure complete circulation, combustion of fuel, etc.; to arrange heating surface in proportion to grate area and steam space, to make the form of boiler such that it can be constructed without mechanical difficulty or great expense.

Designs must be made to give strength, durability under the action of hot gases and corrosive elements, to be accessible, for cleaning, repairing and to provide safety appliance of ample proportions and applied properly. Thus the necessity of the greater education in boiler designing and construction and knowledge of material used.

Material for boiler purposes as well as other uses invariably contains in combination some proportion of various elements, and although these may appear small, have very marked influence upon its strength, ductility and working qualities, thus making it necessary to have both chemical as well as physical tests. In the manufacturing of boiler material the process of carburization changes the nature and properties of contained carbon, thus wrought iron contains from 5 per cent to only a trace per cent of carbon, and steel including all kinds of iron contains not more than 1.75 per cent of carbon and varies in fusibility, hardness, susceptibility to tempering and malleability. The first two properties being increased by increase of carbon, while the others are diminished.

All ores go through the process of reduction, and the more impurities they contain the greater amount of work is necessary to treat them; these include carbonic acid, water, combustible and earthy matter.

CAST IRON.

In cast iron these qualities looked for are taken from the fuel and mode of smelting, this materially as much as the character of ore. To convert cast iron into bar, forged or malleable iron, it has to be refined by smelting with coke or charcoal; this process eliminates the oxygen and carbon which may be left, thus bringing it to a state of refined metal, this is forged under hammer, passed through roll and drawn into bars, cut in lengths and formed into bundles or piles, again reheated and once more hammered and rolled into any shape. Cast iron has in its makeup carbon-silicon; this is a slag and its presence makes iron and steel hard and brittle, but up to 6 per cent is harmless providing 3 per cent. of manganese is present with it. Manganese, of which 5 per cent is sufficient to make iron cold short, is valuable in iron to be converted into steel.

Sulphur and phosphorus, when 8 per cent is present, make iron and steel crystallized and unfits it for plate for boiler purposes.

Arsenic increases the hardness in steel at the expense of toughness, as does carbon with it in form of graphite. The gray iron contains most graphite and carbon, making it more fusible and softer than white iron. The latter contains more combined carbon; these constituents vary, thus having various influence on the mechanical properties, and, after repeated fusings, loses its carbon.

THE ELEMENTS IN CAST IRON ARE AS FOLLOWS:

ELEMENTS.	PERCENTAGE.
Combined carbon	.15 to 1.25 per cent
Graphite	1.85 to 3.25 " "
Silicon	.15 to 5. " "
Sulphur	0 to .05 " "
Phosphorus	0 to 1.3 " "
Manganese	0 to 1.5 " "
Iron	90. to 95. " "

Cast iron is not reliable for boiler construction unless for very low pressure, while it resists corrosion it is brittle and to get strength great thickness is necessary.

From cast iron to steel, plate is susceptible to the widest variation in its character; cast iron as extracted from ore, is melted with comparative facility and according to mode of operation in foundry, may be rendered so hard that it requires special tools to work it.