MORRISON'S PRACTICAL ENGINEER AND MECHANICS' GUIDE

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WILLIAM A. MORRISON

MORRISON'S PRACTICAL ENGINEER AND MECHANICS' GUIDE

Trieste

MORRISON'S

PRACTICAL ENGINEER

AND

MECHANICS' GUIDE,

CONTAINING

A GLANCE AT THE EARLY HISTORY OF STEAM; ITS APPLICATION TO PUMPING; ITS LATER USE FOR RAILROADS AND STEAMBOATS; ITS MORE EXTENSIVE USE FOR GENERAL MACHINERY.

THE SETTING AND MANAGEMENT OF BOILERS:

THE MODERN STEAM ENGINE; HOW IT SHOULD BE MANAGED. DESCRIPTION AND APPLICATION OF THE INDICATOR. ILLUSTRATIONS SHOWING THE ADVANTAGE OF THE ENGINE BEING IN THE BEST POSSIBLE CONDITION FOR DUTY.

TABLES AND RULES

FOR DEMONSTRATING THE ACTUAL WORKING OF THE ENGINE, WITH METHODS OF CORRECTING THE DEFECTS. RULES FOR CALCULATIONS. TABLES FOR VARIOUS CALCULATIONS RELATING TO METALS AND OTHER MATERIALS. TESTS AND METHODS OF WORKING METALS. USEFUL PRACTICAL INFORMATION, RECEIPTS, ETC.

BY WILLIAM A. MORRISON,
MEMBER OF AMERICAN SOCIETY OF MECHANICAL ENGINEERS

SECOND EDITION--REVISED AND IMPROVED.
PUBLISHED BY THE AUTHOR.

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PREFACE.

In offering the second edition of this book to the Public, especially to that class known as Steam Engineers, the author desires to lay before them such facts and general information as he has gained by an experience of many years in the business. In doing this he wishes to help to elevate, and make more competent a large class, which in this age of Steam, has become an important element in the world's advancement, and upon which largely depends the safety of transportation of passengers and freight throughout the world. Also, in the busy hives of industry everywhere, much depends upon the economical production, care, and useful application of *Steam*.

In presenting this book, it is not claimed that the rules, tables and formulas for calculation are entirely new, the author is largely indebted to such works as Haswell, Winslow, Briggs, Bacon and Howard, for which he makes due acknowledgement.

But seeing from many years intercourse with the class of men herein named, the great need of a practical treatise on Steam Engineering, presented in such a form as would be readily understood by those directly interested, and especially beneficial to young engineers, he cannot but hope this work will reach the class for whom it is intended, and be found interesting and helpful to them.

Slight changes have been made in a few instances, and the page on electric lighting has been rewritten to meet the greatly reduced cost of electric lighting machinery, materials, and supplies. The book as improved, is submitted to the public with thanks by the author for their appreciation of the first edition.

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DEFINITIONS

OF THE SIGNS USED IN THE FOLLOWING WORK.

$=$ *Equal to.* The sign of equality; as 16 oz.$=$1 lb.

$+$ *Plus*, or *More*. The sign of addition; as $8+12=20$.

$-$ *Minus*, or *Less*. The sign of subtraction; as $12-8=4$.

$\times$ *Multiplied by*. The sign of multiplication; as $12\times8=96$.

$\div$ *Divided by*. The sign of division; as $12\div4=3$.

$\backsim$ *Difference between the given numbers or quantities;* thus, $12\backsim8$, or $8\backsim12$, shows that the less number is to be subtracted from the greater, and the difference, or remainder, only, is to be used, so, too, *height*$\backsim$*breadth* shows that the difference between the height and breadth is to be taken.

: :: : *Proportion*; as 2 : 4 :: 3 : 6; that is, as 2 *is to* 4, *so is* 3 *to* 6.

$\sqrt{}$ *Sign of the square root;* prefixed to any number indicates that the square root of that number is to be taken, or employed; as $\sqrt{64}=8$.

$\sqrt[3]{}$ *Sign of the cube root;* and indicates that the cube root of the number to which it is prefixed is to be employed, instead of the number itself; as $\sqrt[3]{64}=4$.

^{2} *To be squared, or the square of;* shows that the square of the number to which it is affixed is the quantity to be employed; as $12^2\div6=24$; that is, that the square of 12, or $144\div6=24$.

^{3} Indicates that the cube of the number to which it is subjoined is to be used; as $4^3=64$.

. *Decimal point*, or *separatrix*.

— *Vinculum.* Signifies that the two or more sums, over which it is drawn, are to be taken together, or collectively, as forming one sum, thus, $\overline{4+6}\times4=40$; whereas, without the vinculum, $4+6\times4=28$; also $12-\overline{2\times3+4}=2$; and $\sqrt{\overline{5^2-3^2}}=4$. So, also, $\sqrt{(5^2-3^2)}=4$.

% *Sign of per cent.* Signifies so much per cent; as \$1.00 at 6%, or 6% of \$1.00=6 cents.

° ′ ″ Signifies degrees, minutes and seconds.

A GLANCE AT THE HISTORY OF STEAM.

Steam has been used as a motive power for upwards of two hundred years, but not until James Watt, near the latter part of the last century, made a successful application of it for driving machinery and pumping water, and later Robert Fulton and Oliver Evans applied it to the steamboat, and George Stephenson to the locomotive, was it considered a success. Although the early efforts of Watt were very crude, yet his principles of the steam engine are the base of the advanced successful steam engine of to-day. The same ideas of expansion, condensation and regulation by automatic cut-off, occupied his thoughts (although he did not make a success of the last), and were the controlling principle in all his plans and efforts.

From the cumbersome mass of the single acting steam cylinder, the ponderous beam and counter balance weight, and later the enormous fly wheel, have come the beautiful, symmetrical, compact, strong mechanism composing the structure of the engine of to-day; and instead of a machine requiring the consumption of 10 lbs. or more coal per hour, to produce one horse power, we have the modern high speed, high pressure, compound, condensing, jacketed cylinder, automatic cut-off engine, capable of running with best form of boilers, with 1¾ lbs. of coal per horse power, per hour.

THE SETTING AND CARE OF BOILERS.

As so much depends on the structure, setting and care of boilers, to produce favorable results, special attention is given to those points.

BOILERS.

The horse power of the boilers should be 20 per cent. greater than the maximum power of the engine, and when steam is used for heating and other purposes, a liberal allowance should be made. With the indicator we may determine very closely the performance of the engine; with the boiler it is very uncertain and vague what may be going on in the furnace, and inside the shell we cannot so easily determine. The engineer must depend largely upon his judgment. Close observation may, however, teach much. The Horizontal Return Tubular boiler as the kind most generally used, is referred to here. The mistake is frequently made of crowding the grate up too close to the shell. A vessel of water when held close to the flame of a lamp, will speedily be covered with smoke, and take a longer time to boil than if kept clear of the flame. Therefore, a plenty of room should be allowed for the complete combustion of the products of the fuel, and to prevent a deposit of unconsumed carbon on the relatively cooler surfaces of the boiler. The grates, therefore, should not be less than 25 inches to 30 inches below the shell. If the boiler front will not admit of it they may be pitched back somewhat, but not to exceed 1½ inches to the foot. Have grates of such construction as will give abundant air space.

The width of the furnace inside should be at least 6 inches more than the diameter of the boiler, and of sufficient depth to allow ½ of one square foot of grate surface to each horse power of the boiler. The bridge wall should not be over 12 inches high, and for one-half the distance between the bridge wall and back end, carry a flat incline to within 10 inches of the shell of the boiler and thence run horizontal to the back. Do not attempt to conform to the curve of the boiler.

It is a disadvantage to return the smoke and gases after passing the tubes over the top of the boiler. The temperature of the steam inside of the boiler at 80 lbs. pressure is about 320°. Any reduction of the gases below that temperature, would actually cool the boiler. Not infrequently the temperature in the flue after leaving the tubes, may be less than 300° Fahrenheit, which would act as a wet blanket upon the boiler, and would result in loss. Any apparatus placed in the flue for the purpose of utilizing the heat, in heating feed water, must result in loss, unless the flue is unnecessarily large. A boiler correctly proportioned should exhaust the heat from its gases down to about 400° temperature by the time they are through the tubes, and after that they should be got into the chimney as quickly as possible to assist the draft. The height of the chimney should be 26 times the diameter of the flue. This rule may be varied somewhat to suit different localities. Boilers should not be too long. The best experience shows that the length of tubes should be from 45 to 50 times their diameter. The steam space or length of a boiler containing 2½ in. tubes, should not be over 10 ft. long; 3 in, tubes, 12 ft. long; 4 in. tubes, 16 ft. long; and this without reference to the diameter of the shell, add to this length whatever may be required for the flue, or breeching, as usually termed. Keep the shell of the boiler as hot as possible on the outside; do not close the side walls too low down upon the boiler; let the hot gases remain dead as high as possible on the sides and even over the top (except immediately over the grate surface), if convenient to arch it over, having the ends properly protected and enclosed. The boiler is thus kept at a more equal heat, giving dryer steam and adding to its long service, by not causing so much unequal expansion and contraction. Have all exposed surfaces of pipes and boilers well protected with non-heat-conducting material. These points are not claimed as original, but on the contrary they are borrowed from the best engineering practice in the country.

The economy or evaporating capacity of the boilers may be expressed in the number of pounds of water evaporated into dry steam with one pound of coal.

With good hard or soft coal, a tubular boiler set as above, a good draft, and skillful firing, will evaporate 9 to 10 lbs. of water with 1 lb. of coal. The average result is at least 35 per cent. below this.

With these data and a knowledge of the economy of the engine, a close approximation of the fuel consumption may be had. Tubes should not be nearer than 3 in. to the shell, allow sufficient space between for circulation. Have room at the bottom for large manholes to admit of examinations and thorough cleaning. Tubes near the bottom of the shell are of little value for heating.

To determine the horse power of a boiler, add together all the heating surface, including the tubes, in square feet and divide by 12, which will give the relative horse power. A boiler for first-class automatic engine, should be large enough to evaporate 30 lbs. of water to each horse power of engine per hour; plain slide valve 40 per cent. more to be of sufficient power.

There are several practical points in reference to the management of boilers which are too much overlooked. One of the most important is a properly made fusible plug and put into the boiler in the right place. It should be made of the best steam metal, filled with U. S. standard Banca tin. For a horizontal tubular boiler, it should be placed at the highest point of fire contact at the back end, above the tubes; for an upright tubular boiler, in the crown sheet of the fire box; in a locomotive boiler, in the back corner of crown sheet in fire box, or at back end. It should be examined internally and externally as often as once a year, and renewed if necessary, but should not be used more than two years without renewal. The safety valve should be lifted once a week and examined as to condition. Observe if the weight is placed right. The boilers should be blown off under pressure twice in the 24 hours, in the morning before starting the engine, and after stopping, or during the night. A surface blow-off is a good thing when the water is bad and much foreign matter is held in solution, particularly if much oil is used in the steam cylinder. Blow out the tubes with steam jet once a week and use a suitable brush or scraper often. Do not allow bunches of oil and dirt to collect on the tubes or shell. Never pump cold water into the boilers if it can be avoided; it is contrary to good engineering and exceedingly injurious to the boiler. Keep the feed water as near the boiling point as possible with a suitable heater, or other convenient methods. As a general thing it is not advisable to go above it. Run your boilers as equal as possible with the water about 6 in. above the tubes. Keep the fires thin (about four inches), and even on the surface. Circumstances may vary these conditions, which will require much good judgment. Examine carefully as often as possible the internal condition of your boilers. See that they are kept clean, and any necessary repairs required have attended to at once. Engineers that attend strictly to these things, save themselves a vast amount of time and anxiety and promote the interests of their employers, and, last but not least, add security to the whole community.

THE STEAM ENGINE.

In regard to the Stationary Steam Engine, there is a great variety of opinion among builders as to the form of construction, style of bed, dimensions and positions of bearings, form of valves, and methods of operating them, whether the engine shall be long or short stroke, high, low or medium speed.

But all are agreed upon these points: that the steam must be hot and dry, that it must come into the cylinder unobstructed, that it must be high pressure to get its expansive effects, and that it must do its work quickly to prevent condensation. Until George H. Corliss introduced his improvements about the year 1848, these points had not been reached, and many of them were unknown. When he made a successful application of the automatic cut-off to the main valve, as operated and controlled by the governor, so as to produce a perfectly uniform speed, and use at each stroke only as much steam as was required to do the work, and maintain the speed, he made a mark upon the steam engine which will not be obliterated so long as the steam engine is known. The result was that instead of using 6 lbs. of coal per horse power per hour, as heretofore, with best constructed engines, now only 3 lbs. were used.

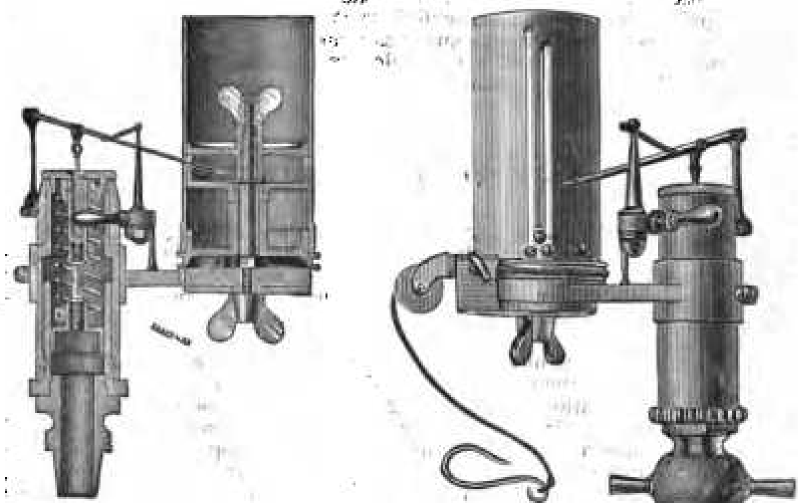
In the successful working of the engine the most important point, is to have the valves properly *set*. This matter is not understood sufficiently by those having them in charge. Both employers and employed seem to think that if the engine continues to run, and does the work reasonably well, that is about all that is required. This is far from the truth. The only correct method to determine the actual condition of the engine is by the use of the indicator. How many who call themselves *good engineers* know anything about the practical working or the value of this important instrument?

THE INDICATOR AND ITS USES.

It is my purpose in this work to treat of this subject in such a way as to make it plain to the average engineer, and, if he has sufficient intellegence, to gain a fair knowledge of the simple rules of arithmetic (if he has not that already), by which he can make use of the Indicator and put his valves in proper position for *effective* service, and make the necessary calculations to determine the power of his engine, under all conditions. If he cannot do this, he certainly is not competent to take entire charge of machinery of so much importance.

For the purpose of a full understanding of the subject, a cut of the Thompson Improved Indicator is here introduced, with full description; also a series of diagrams, and diagrams from the author's own practice, fully illustrating the difference between an engine in *good* condition and those struggling to do their work under serious difficulties.

INSIDE VIEW. OUTSIDE VIEW.



General Directions for Using the Thompson Indicator.

Make the connections as short and large as the circumstances will permit, never less than a half-inch pipe with three-fourths inch bends. If side pipe and three-way cock are to be used, open up the cylinder for three-fourths inch pipe (one inch is better) with one inch bends. See that the three way cock has full capacity so as not to choke the Indicator. Square up the ends of the pipes with the file, ream carefully so as to give a smooth,