THE LOCOMOTIVE ENGINE: INCLUDING A DESCRIPTION OF ITS STRUCTURE, RULES FOR ESTIMATING ITS CAPABILITIES, AND PRACTICAL OBSERVATIONS ON ITS CONSTRUCTION AND MANAGEMENT

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BY ZERAH COLBURN.

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INTRODUCTORY NOTICE.

THE absence of any purely practical work on American Locomotives has induced the preparation of the following pages devoted to that subject. It is believed the book will afford to the student a clear idea of the nature and mode of application of steam power, while to those engaged in the manufacture and operation of engines it will afford much useful matter connected with their construction and management.

Much care has been bestowed to render plain and distinct those parts of the book which are devoted to the principles of locomotive science, and the rules and illustrations have been adapted to the wants of those who have but little time or taste for the pursuit of abstract investigations. While this feature will constitute a chief merit of the work in the hands of such persons, it will make it none the less definite and exact for the purposes of the designer and engineer.

The particulars of many recent engines, and improvements connected therewith, have been presented, embracing the patterns of a majority of all the builders in the United States. For many of these we are indebted to the manufacturers of engines, while others have been procured for the purpose from the engines themselves; those machines being selected which presented some new or favorable features in the proportions of their parts or in the arrangement of their machinery.

It is therefore hoped that the book may impart some benefit to those who read it, and that it may serve to this purpose until the appearance of a better one from those whose opportunities for information would enable them to treat the subject in a manner more suited to the various requirements of its nature.

THE

LOCOMOTIVE ENGINE.

SECTION I.

The Properties of Steam and the Phenomena connected with its Generation.

The most prominent of the properties possessed by steam are, its high, expansive force, its property of condensation by an abstraction of its temperature, its concealed or undeveloped heat, and the inverted ratio of its pressure to the space which it occupies.

Steam is the result of a combination of water with a certain amount of heat; and the expansive force of steam arises from the absence of cohesion between and among the particles of water. Heat universally expands all matter within its influence, whether solid or fluid; but in a solid body it has the cohesion of the particles to overcome, and this so circumscribes its effects that in cast iron, for instance, a rate of temperature above the freezing point sufficient to melt it, causes an extension of only about one-eighth of an inch in a foot. With water, however, a temperature of 212°, or 180° above the freezing point, (and which is far from a red heat,) converts it into steam of 1700 times its original bulk or volume.

All bodies may exist in either one or all of three different states, viz.: the solid state, the liquid state, and the aeriform state, or state of vapor. Water, for example, may exist as ice, liquid, and steam; and the condition which it assumes depends on its pervading temperature.

Steam cannot mix with air while its pressure exceeds that of the atmosphere, and it is this property, with that which makes the condition of a body dependent on its temperature, that explains the condensing property of steam. In a cylinder once filled with steam of a pressure of 15 lbs. or more to the square inch, all air is excluded. Now as the existence of the steam depends on its temperature, by abstracting that temperature (which may be done by immersing the cylinder in cold water or in cold air,) the contained steam assumes the state due to the reduced temperature, and this state will be water. And, as the water cannot occupy the volume which it did under its former temperature, it follows that its reduction in volume must remain a vacuum. A cylinder, therefore, filled with hot steam, may be condensed by an abstraction of its heat, and a vacuum will be produced in the cylinder with a few drops of water at the bottom, which may be pumped out by an air-tight pump, leaving the vacuum perfect.

When this principle is employed in removing the atmospheric pressure opposed to the back of the piston in a steam engine, such an engine is termed a condensing engine; and in such engines more work may be done with the same pressure of steam, than by a non-condensing engine, as the absence of the weight of the air, or the negative pressure on the back of the piston is equivalent to a positive pressure on the other side, and contributes by so much to the useful effect of the engine. Locomotive engines, however, and most American stationary engines, discharge their steam without

condensing, and to overcome the atmospheric resistance they carry higher steam; they are therefore called high pressure engines.

The next property of steam which we have mentioned, is that of its latent or concealed heat. An unknown amount of latent heat exists in every element in nature: thus iron becomes hot by merely hammering it on an anvil; air gives off heat enough to light fire by being compressed into a syringe, and so on. The beating of the iron does not *create* the heat which it excites, neither does the compressing of the air; they both merely *develop* the heat, which must have a previous existence. In these examples the heat which is excited is freed by the *motion* communicated, — and we have no means of knowing its amount; — but the latent heat of steam, though showing no effects on the thermometer, may be as easily known as the sensible or perceivable heat. To show this property of steam by experiment, place an indefinite amount of water in a closed vessel, and let a pipe, proceeding from its upper part, communicate with another vessel, which should be open, and, for convenience of illustration, shall contain just 5½ lbs. of water at 32°, or just freezing. The pipe from the closed vessel must reach nearly to the bottom of the open one. By boiling the water contained in the first vessel until steam enough has passed through the pipe to raise the water in the open vessel to the boiling point, (212°,) we shall find the weight of the water contained by the latter to be 6½ lbs. Now this addition of one pound to its weight has resulted solely from the admission of steam to it; and this pound of steam, therefore, retaining its own temperature of 212°, has raised 5½ lbs. of water, 180°, or an equivalent to 990°; and including its own temperature we have 1202°, which it must have possessed at first.

The sum of the latent and sensible heat of steam is