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Contents:

(Illustrations are indicated by an asterisk)

THE PRODUCTS OF COMBUSTION FOR MOTIVE POWER.

When fuel is burned in the furnace of a steam engine, there is a small proportion of solid matter left in the form of ashes, and the remainder is converted into elastic gases, which pass off at a high temperature into the smoke-stack. As these gases in being heated expand in the same way as the steam, they exert mechanical force, and many efforts have been made to use this force in driving machinery. The effort has not been successful in the case of the steam engine, though it has in that of the air engine.

A few years since a steamboat was run a few trips on the North river by an engine in which the gases from the furnace were driven into the cylinder; the furnace being, of course, air-tight, and the air being forced in by an air pump. It was said that great economy was obtained, but the ashes and bits of coal driven into the cylinder scratched the inner surface of the cylinder and the packing so much as to render the plan impracticable. The method was then tried of driving the gases through the boiler, in order that the ashes and unburned coal might be retained by the water. This saved the cylinder, but soon filled the boiler with ashes, and the scheme was abandoned. In Roper's air engine, illustrated on page 97, Vol. VIII. of the SCIENTIFIC AMERICAN, the products of combustion are worked through the cylinder, and an experience of some two years with a considerable number of engines seems to indicate a complete triumph over all mechanical difficulties.

Roper's engine may be regarded as simply a steam engine woked with air, all of its parts being equivalents of corresponding parts in the steam engine. The air is forced by an air-pump into an air-tight chamber where it is heated, and it is then admitted by a valve into a cylinder to drive a piston. This plan of an air engine was suggested several years ago at the Polytechnic Association in this city by Professor Seely, and it was recently described by Mr. Fairbairn, of England, as Joule's air engine of constant pressure. The mechanical arrangements, however, which have made it a practical machine are due to the inventor of Roper's engine. Prof. Seely proposed to use the products of combustion, but did not suppose that this could be done in a cylinder if anthracite coal was employed as fuel, and he expected to employ petroleum.

In Roper's engine the coal is placed in an open furnace inclosed in the air-tight chamber in which the air is heated. The air is forced into this chamber in two streams, a small one under the grate and a large one above, so that only a small portion of the air passes through the fire; thus avoiding a blast which would carry along ashes and unburned coal into the cylinder. The cylinder is upright, the packing is at the upper part of the piston, and the piston is elongated downward in the form of a hollow drum a little smaller than the cylinder, so that it is surrounded by an annular space, filled with air or gas, which is sufficiently confined to keep the ashes away from the packing. Leather is used for packing and lasts a long time.

The practicability of utilizing the products of combustion in the air engine having been thus experimentally demonstrated, the efforts of inventors will doubtless be again directed to the application of this improvement to the steam engine. A calculation, therefore, of the possible gain by such an improvement will be of interest at the present time.

When anthracite coal is employed as the fuel, the calculation is exceedingly simple, for the combustible portion of anthracite is so nearly pure carbon that it is sufficiently accurate for this inquiry to regard it as carbon.

Atmospheric air which is drawn or driven into furnaces to burn the fuel is composed of scarcely variable proportions of oxygen and nitrogen, with small quantities of carbonic acid and the vapor of water. According to Booth, the following may be considered as the average proportion of these substances by weight:—

Oxygen	22.76
Nitrogen	76.15
Vapor of water	1.03
Carbonic acid	0.06
	100.00

It will be seen that the aqueous vapor and carbonic acid are in quantities so small that they may be omitted from this estimate. If just the proper quantity of atmospheric air is introduced into the furnace to burn the coal, and if the combustion is complete, its oxygen will all combine with the carbon of the coal to form carbonic acid, and the nitrogen will remain uncombined. There will, therefore, be two gases to be expanded by the heat, carbonic acid and nitrogen.

In the Hecker and Waterman experiments, in working the engine as a non-condenser, $2\frac{1}{2}$ pounds of combustible per hour were consumed in generating a horse-power. To burn this quantity of carbon into carbonic acid would require $6\frac{2}{3}$ pounds of oxygen, and if this quantity were introduced in its mixture with nitrogen in the atmosphere, it would carry along with it 22·6 pounds of nitrogen. The 2·5 pounds of carbon combining with the 6·67 pounds of oxygen would form 9·17 pounds of carbonic acid. In the production of one horse-power per hour we, therefore, have 22·6 pounds of nitrogen and 9·17 pounds of carbonic acid.

Carbonic acid is once and a half times heavier than atmospheric air, and air at 32° is 770 times lighter than water. As water weighs $62\frac{1}{2}$ lbs. to the cubic foot, a cubic foot of air weighs 0.0812 lbs. and a cubic foot of carbonic acid 0.1218 lbs.=8.21 feet to the pound, and 75·29 cubic feet to 9.17 pounds.

The specific gravity of nitrogen is ·972=12.7 cubic feet to the pound, and 287 cubic feet to 22·6 pounds.

Thus if the air is introduced at 32° the quantity of the gas resulting from the combustion per horse-power per hour will be 362 cubic feet under the pressure of the atmosphere. If this is heated 493° its pressure will be doubled, giving a working pressure of one atmosphere. If this gas was worked through a cylinder of 1 foot area and 1 foot stroke it would give 362 strokes, lifting 15×144=2160 lbs. 1 foot at each stroke=781,920 foot-pounds in 362 strokes, or in an hour. This divided by 60 gives 13,032 foot-pounds per minute.

If, however, the air-pump worked throughout its stroke against the pressure in the air chamber, and if the heated gas in the working cylinder was not worked expansively, one half of this power would be consumed in forcing the air into the chamber. Consequently we should have but 6,516 foot-pounds per minute, an addition of 19·74 per cent to the horse-power produced by the steam.

An invention that would save 20 per cent of all the fuel burned in steam engines would be of immeasurable value. The most prominent obstacle to be overcome is the difficulty of introducing coal into an air tight chamber against pressure.

EXPERIMENTS WITH TOOLS NEEDED.

Theory is one thing and practice another, and sometimes it happens, very awkwardly, that the experience of the workshop refuses to agree with the laws philosophers lay down. Just at this time the interest in the economy of working steam is very great; whether it shall be used expansively or non-expansively for some purposes is still a mooted point, but the experiments now going forward will settle this vexed question, we hope, at once and forever.

There is another and a very important point in the economy of the workshop, which is the power required to drive tools. Let us know what is the best form for a roughing tool. Out of half a dozen turners but one will be found who has a tool that cuts at all, the rest merely grate or tickle the top of the metal, so that some few miserable raspings are taken off. That this is a manifest loss to the company or proprietor is evident, and proceeds solely from a want of knowledge of the right principles. To obtain the knowledge in question we must experiment, not guess, and we think that a series of trials with a view to ascertain the best form of edge for a roughing tool would not be time thrown away.

A good plan would be to take a small lathe and a train of gearing similar to those used for churn powers. Let a pulley be applied to this gearing and a belt from it directly to the lathe. A weight suspended from the drum of the gearing would represent the power. Now let a tool be put in the slide rest and set to work with a stated feed, speed, and depth of cut. The time required to run one inch, or more, should be accurately noted, and the tool removed and replaced by another. This in turn should be carefully watched and the result recorded. In this way the diamond-point, the round-nose, the side-tool, the "no kind of tool," would all find their appropriate places, and the results would show very satisfactorily, if the experiments were well conducted, how much power was required to cut one inch, with given feed and speed and depth of cut. Of course the same shaft should be used for all the tools to cut on. The conditions would not vary with larger cuts and heavier feed. Another point gained would be the knowledge of how much horse-power, expressed in foot-pounds by the fall of the weight in a given time, was required for a certain number of lathes of a known length of shears and swing. Roughing off work is the heaviest that is done on a lathe, if we except cutting screws of quick pitches, and the expression would be the maximum power required for a machine shop.

Much other interesting and valuable information might be obtained which does not now occur to us, for instance the loss of time and money through working with dull tools, or those that were too soft, etc., and we hope that some enterprising foreman or manufacturer will think it worth while to institute these experiments.

CLUMSY PACKING RINGS.

Nearly every observant engineer must have noticed how badly proportioned the packing rings of ordinary stationary engines are for their work. It is not at all uncommon to see the packing in cylinders as small as eleven inches in diameter, one and a quarter inches thick in the aggregate, or five-eighths thick for each ring. Some of them are even more than this. Such rings cannot be packed steam-tight without causing a great strain on the cylinder, which is injurious both to it and the springs. It is almost impossible to make springs stiff enough to stand the pressure they are subjected to, and set screws are therefore put in the springs to keep them up to their work. It is plain that this is one cause of the scratched cylinders and broken rings that we often see, for when packing is properly constructed it will last for years with very little repair. The stiffness of rings made on such heavy patterns is so great that they can hardly be sprung together by the force of a strong man's arm; for rendering a