most important philosophical works, and we do not remember any where to have noticed any evidence of concern on the author's part to prove the existence of an "Infinite and Eternal Spirit." On the contrary, we are every where forbidden by him to regard the Infinite and Eternal, or the Absolute, as either Spirit or matter. Both of these "antithetical conceptions" are held to be purely finite, relative, phenomenal. The absolute is simply "the unknown reality which underlies both," (see *First Principles*, last sentence of the book, *et passim.*) The absolute we are constantly reminded is "wholly unknowable." It is neither Infinite and Eternal Spirit, nor Infinite and Eternal Matter, but simply an altogether indefinable and incognizable somewhat. "That through which all things exist" is in Mr. Spencer's language, "The Unknowable."

The Unknowable is further held to manifest itself to us only as an "inscrutable force" whose operation is exclusively confined to the evolutionary and mechanical "redistribution of matter and motion." Since this operation takes place under the form of rule or law, it is held to conflict with, and render impossible, the supposed "free will," and hence the truly *spiritual nature* of man.

The case is therefore as follows: That there is an absolute reality, we are held to know through "a dim" or wholly "indefinite consciousness," which is called the "*raw* material of mind," but which utterly refuses to be grasped, defined, or known. The "Infinite Something," which is thus demonstrated for us, is, so far as our definite knowledge extends, and hence practically, an "Infinite Nothing." Strictly known to us are only phenomena aspect, which we term spiritual, ideal, or mental. But no scientific interpretation of these is possible, no knowledge proper is possible concerning them, except so far as they are reducable, directly or proximately, to terms of the redistribution of matter and motion in physiological processes. All our definite knowledge, therefore, is both in its data and its substance, exclusively physical and materialistic, and even the "indefinite consciousness," by which we are held to be assured that an Absolute Something exists, in as regards both its subject and object, also physical; it is certainly not spiritual.

Now, if God, provided he exist, is necessarily a spirit; if man, as the subject of religious emotions and relations, must also be a free spirit; and if, as is the case, there is found in Mr. Spencer's philosophy *no recognition of either God or man as a spirit*, then it is obvious that much ground is given by Mr. Spencer for the supposition that his doctrines—considered *per se*, or independently of their author's intentions—*are virtually atheistic and anti-religious*, and those who honestly entertain this supposition are entitled to be met, not simply with a vigorous *assertion* that they are in error, but with a dispassionate and objective demonstration that they are so.

The whole basis of Mr. Spencer's theory of knowledge is, as is well known, sensational and physical. From such a basis it is and has always been found impossible to rise to the recognition of the absolute as spirit, or man as spirit, or to *comprehend religion otherwise than as a necessary historic incident in the development of ideas.* But the whole basis of human knowledge is not sensational and physical. Free religion implies this, and the grander historic forms of philosophy demonstrate it. The *pre-eminent* intention of knowledge in physical science is indeed sense. The attempt to make this criterion universal leads necessarily to agnosticism with reference to the non-sensible (the Spiritual, Living and Powerful). But it is not *science* which dictates this attempt, and *so Mr. Spencer's agnosticism is not to be charged to science.* The rather, it is due to a purely arbitrary determination on his part, supported, it is true, by the influence of a conspicuous line of predecessors in the history of British speculation. The fact that many theologians have been equally—and some of them—*e. g.*, William of Ockham—even more absurdly agnostic than he, is not to Mr. Spencer's credit, but to the theologians' discredit. Besides, the agnostic theologians have generally made vigorous affirmation, on the authority of the heart, of that which to their heads was inscrutable. They have, like Kant, practically affirmed that which seems theoretically incomprehensible. However, all this belongs to the sadder side of the history of human thought. Philosophy and theology have existed and still exist in larger, more positive, and more fruitful forms, founded on a completer science of knowledge, which recognizes the spiritual factor in knowledge, or the knowing agent, and so, necessarily, the spiritual nature in the absolute object of knowledge or God.

We say, then, that Mr. Spencer is by no means to be charged with intentional atheism or irreligion. To theism and religion he gives all the meaning which it is possible for him to give them on the basis of that physico-scientific theory of knowledge, which he sincerely believes to be the only possible one. But this meaning really falls absolutely short of meeting the actual requirements of theistic doctrine and living religion. And Mr. Spencer's doctrine in this regard is not that of science, whether "popular" or otherwise, but of a highly artificial and arbitrary "philosophy" It has no more necessary relation to the doctrine of evolution than to the doctrine of gravitation, both of which have been and are (in some form) unquestioningly held by many leaders in spiritualistic or positive (*vs.* agnostic) philosophy..

The dissemination of the eminently valuable results of Mr. Spencer's scientific labors is certainly in place in a *Popular Science Monthly*. But with what special propriety such a periodical should also be made the peculiar vehicle for the promulgation of his extra-scientific *philosophy* it is hard to see. It is not that we would have a line, which Mr. Spencer has written, suppressed or kept from the knowledge of the world. But regard for the honor and purity of * science, to mention no other consideration, is enough to make one ardently wish that it should not be constructively put forward as sponsor for doctrines whose basis is only quasi-scientific, and which, in truth, belong to another domain—the domain of philosophical inquiry.—GEORGE S. MORRIS, *Professor of Philosophy, University of Michigan; and Lecturer in the Johns Hopkins University.*

THE HOLLAND HYDROGEN FIRE APPARATUS.

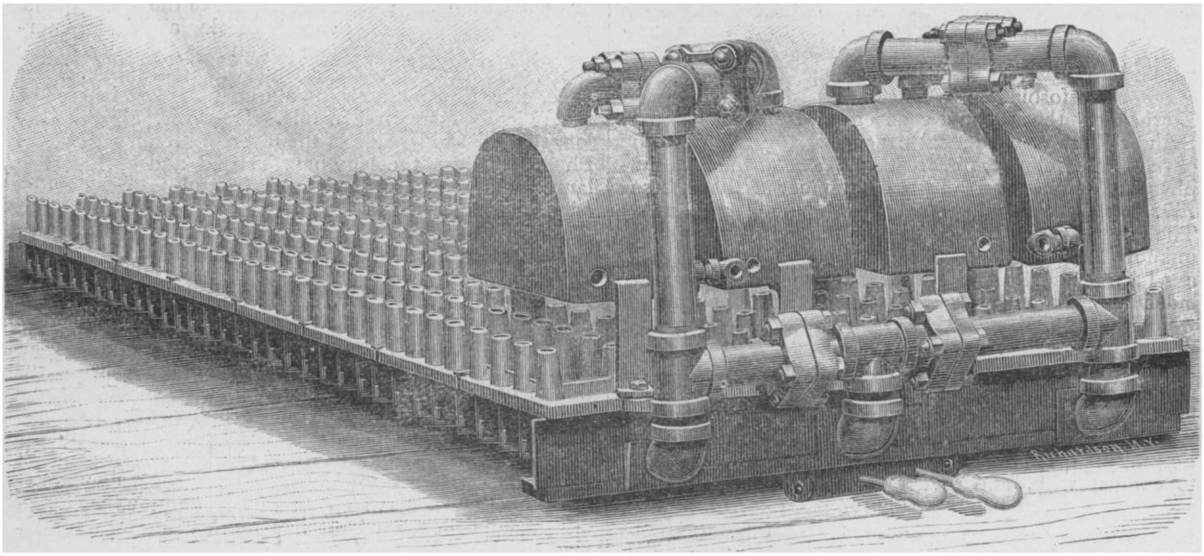
No little interest has been excited during the past year, both in the scientific and practical world, by the remarkable development of results from the Water Gas Apparatus of Dr. Charles Holland, in an ordinary locomotive, as reported by a careful and disinterested observer, through the daily press, and subsequently discussed from a scientific point of view in this journal.

A review of the subject, which has lost none of its importance in the light of further experience and deliberation, will be timely and interesting at the present date.

At Flatbush, the apparatus was placed in the fire-box or furnace of a large (forty-ton) passenger locomotive, of the usual coal-burning pattern, with 16x24 inch cylinders, 5-feet 2-inch driving wheels, and a boiler 23 feet long. In place of the ordinary grate bars are laid three hollow bars or pipes the length of the furnace (8 feet), and from each side of each pipe rise burner-tips at short intervals, making 352 in all. On these pipe-bars, as sleepers, is laid a floor of iron plates studded with open thimbles, through which the 352 burner tips rise to within half an inch of their openings. Over the first 44 burners, next the door, are set four retorts—heavy, hollow blocks of iron—in a row. Two of these retorts receive naphtha, and two water or steam, through separate pipes, and when heated, unite and discharge their vapors through connecting pipes into the pipe bars under the iron floor, and thence through the 352 burners.

The observations at present available enable us merely to compare the firing-up of the same locomotive to the same pressure under substantially equivalent conditions,

* By "science" we mean, in accordance with the now prevalent usage, the mathematico-physical or descriptive science of sensible *phenomena*.



FIRING APPARATUS OF THE NEW HYDROGEN-BURNING LOCOMOTIVE.

first with the Holland Hydrogen Process, and afterwards with coal and wood. This comparison is practically sufficient in a broad sense, yet for more exact purposes it is to be expected that opportunity will soon be taken to obtain the result in pounds of water evaporated per pound of naphtha, and also to exhibit chemically a specimen of the gas. We learn that the boiler of the new hydrogen-burning locomotive, since built at Paterson, after having been tried with very small flue, has proved that the highly expansive and volum nous gas produced requires more room for its most advantageous combustion, and the small flues, are now being exchanged for larger. The prcduction of steam pressure was still more rapid and economical than in the Flatbush experiments, but the heat was so unequally distributed, and the fire so insufficiently vented, through the small flues as to make it evident that they were not adapted to do justice to gaseous fuel as had been expected. For the present, therefore, we are obliged to conte nt ourselves with the latest of the series of tables in which the compaiative results of Holland gas and common fuel have been reported.

STEAM, POUNDS.	Time; Minutes.	Naphtha, Gallons.	Naphtha, Per lb. Steam.	Naphtha, per Minute.	Total Naphtha.
10	104	9.9	.99	.054	9.9
20	22	3.21	.32	.146	13.11
30	9½	2.14	.21	.25	15.25
40	8	1.07	.1	.13	16.33
ENGINE MOVES OUT.					
50	10	1.6	.16	.16	17.94
60	5½	1.34	.13	.24	19.27
70	4	1.34	.13	.34	20.61
80	3½	.8	.08	.23	21.41
90	3½	.8	.08	.23	22.22
100	4	1.07	.1	.27	23.29
110	3	.53	.05	.18	23.83
120	3	.53	.05	.18	24.37
SAFETY VALVE BLOWING OFF.					
130	6	1.07	.1	.18	25.44
BOTH VALVES BLOWING OFF.					

This report concludes with a statement of the fuel used in firing up to 120 lbs pressure in the same locomotive, as follows, on June 20: Half a cord of hard wood, cost $3.75; a large quantity of loose pine stuff not measured; and two tons best anthracite steam coal, cost $10; out of which about half a ton was left after reaching the above pressure. Allowing half a ton of half-consumed coal left in the furnace, say one-fourth of a ton in value, the net cost was over $10, against 73 cents for identical work with the Holland gas; 24.37 gallons of naphtha, costing 3 cents per gallon, being consumed. The boiler was specially adapted for coal, but badly encrusted with scale, to the equal disadvantage of both fuels. The difference in direct cost was more than eleven to one in favor of Dr. Holland. The following description of his fire gives some data for an explanation of this surprising, and yet often repeated and verified, result:

The maturer process attained in the experiment of April 29 (and since usual) gave no light visible by day from without the cavern where it was pent, dark and stormy as the cave of Æolus. Raging, roaring, vibrating with a vehemence that shook the iron monster and the ground beneath, and vied with the increasing din of steam from the valves above and under, it was a kind of ghostly noise as well as heat, that to the more habitual organ of perception gave no sign, but seemed causeless or supernatural. In vain we peered through the mica in the door, or peeped and dodged at the small orifice from which a scorching heat spurted fully two feet. Smoke and smell had clean vanished from all parts long before; no unconsumed carbon anywhere escaped to lend the faintest lustre; the carbonic acid formed in the retorts of course came out transparent and inodorous, and so did the hydrogen, with the product of its combustion, the invisible gas called superheated steam; in short, there was nothing of a nature to be seen or smelt in all this *melee* of nature's great elements. Even the illuminating effect of heat upon iron was lost through the expulsive pressure of gases in the retorts, which doubtless projected the flame too far to heat the thimbles that no longer enclosed it, and now stood, like all else, invisible. All ended and came to light again (save the carbonic acid) in a delicate cloud of vapor that rose from the smokestack scalding hot, but too pure to soil white cambric.

To this description it is pertinent to add the following remarkable fact since observed in the trial of the new hydrogen-burning locomotive at the Grant Works, with the small experimental flues referred to as having been afterwards condemned. The fire had been turned down low and the valves set so as to allow the steam gauge to remain stationary at 120 lbs., which it did with perfect steadiness, showing the peculiar controllability of the heat in this process. After about half an hour of this test, the experiment of turning on double water (steam) into the two water retorts was tried, and the valves were set open for this purpose, without restoring the oil feed. The fire was evidently unchecked, and no further notice taken for a few moments, the engineer sitting with his back turned toward the boiler, as the weather was cold; when a violent discharge from the safety valve suddenly caused him to jump nearly to the middle of the tender from the unexpected shock. The steam had run up to 132 lbs., with which the valve was loaded, before a change had been noticed, and so continued blowing off indefinitely, showing a rate of evaporation many times multiplied by no other change than the addition of more water (steam) from the boiler.

The phenomena and effects of combustion above cited seem to justify the following statement of theory:

The Holland locomotive retorts liberate a pure hydrogen fuel from the mutual decomposition of certain proportions of naptha and steam. The regular temperature of the furnace keeps the retorts hot enough to disengage the oxygen of steam in the presence of the carbon of naptha, the chemical attraction of these two elements causing them to unite in the proportions of full combustion, and to form carbonic acid within the retorts. The released hydrogen is the only combustible ingredient left to issue at the burners. All the heat of both of these combustions—that of the carbon within the retorts and that of the hydrogen at the burners—is conserved and utilized in the same furnace for the making of steam.

The question now arises on the true causes of the enormous excess of calorific power developed by a given amount of fuel through the water gas process, as compared with the results of direct combustion of the same fuel. Assuming that the amount of carbon entering the retort takes oxygen from the steam with which it mingles, to the proportion of full combustion, and thus liberates just sufficient hydrogen to re-engage the same amount of oxygen; we have first to inquire what proportion exists between the amounts of heat generated by the union of that or any given quantity of oxygen with its proper complements of carbon and of hydrogen respectively. A number of authorities have determined this question experimentally, with results not widely different. According to Grassi, the number of pounds of water raised one degree by the union of one pound of oxygen with its full combining equivalents of carbon and hydrogen, respectively were 2,893 and 4,333. The direct gain by exchange, therefore, would be almost exactly fifty per cent. Numerous experiments by Bunsen and Fyfe are also said to have proved (in indirect accordance with those above referred to) that the fuel (hydrogen) obtained by the decomposition of water, yields a considerable excess of heat above that absorbed in producing the decomposition.

We have made a close scrutiny of the Holland apparatus and its operation for domestic purposes, as exhibited in this city, at the offices of the Heat, Light and Power Company, No. 18 Vesey street. An even pressure of both water and naphtha is secured by an elevated tank for each purpose, at the top of the room. The pipes running from these tanks to the cooking-stove and range are laid in full view, and strict tracing and examination of their course and connections at every point showed that there was no other possible source of supply, of any kind, for the retorts and burners. The oil tank measured 25⅞ inches in diameter, and was computed to hold nearly 2.22 gallons to the inch in depth. In running the cooking-stove, with the oven constantly at a sharp baking heat, the oil was lowered only $\frac{1}{16}$ inch in half an hour, or about one quart (¾ cent) an hour. The whole interior of the store, which had been used a year last May, was free, not only from ashes and soot, but from discoloration, which, obviously, much assisted the effectiveness of the fire, as compared with the coating of non-conducting material accumulated in using crude fuel. It was found impossible to obtain a trace of smoke or odor from the flame upon a white handkerchief; so that, of course, the usual free carbon, hydro-carbon, carbonic oxide, and other gases of crude fuel, could affect neither the atmosphere nor the flavor of food cooked in direct contact with the flame. In the large cooking-range, a third pipe is introduced for the distillation of illuminating gas, simultaneously with the ordinary use of the range. The adjustment and operation excited much admiration. In the progress of the oil through successive coils of this pipe, within the fire box, the several hydro-carbon mixtures it contains are converted, by successive gradations of heat, into a single homogeneous and fixed gas, which resists the most extreme cold of our climate, without condensation, and runs free from sulphurous and other impurities, requiring only dilution with air. After burning a scant $\frac{1}{16}$ inch of oil, the time being taken, the gas-making pipe was opened by simply turning a cock, and in exactly one half the time enough gas was made and measured to amount to 12.55 cubic feet, if diluted to twelve-candle power; when the total oil out was found to be exactly $\frac{3}{32}$ inch, showing a barely perceptible difference from the rate of consumption without making gas, but too fine to measure with the instruments at hand. Roughly allowing it to be $\frac{1}{64}$ for the gasmaking, the cost of the 12.55 feet would be .0347 gal., or about 2¾ gal. per 1,000 feet. This is ¼ gal. in excess of more exact measurement previously taken by gas experts.

But the rough experiment with the locomotive evidences a gain of fully one thousand per cent. from the exchange of carbon for hydrogen, estimating the fuels by cost, in a practical way; although the liquid fuel is of course the dearer of the two, and the gain over the intrinsic value of the exchanged carbon, if it could be ascertained, would therefore be still greater. Fifty per cent from the exchange, then, is at best but five per cent of the total gain, and the remaining 95 per cent must be otherwise accounted for. Nor is there any lack of good reasons for even this enormous difference. In the first place, the carbon is consumed in pure oxygen from steam, no atmospheric air having access to it in the retorts, and therefore the large absorption of heat by the nitrogen of the air that feeds the coal fire, is wholly saved in the water gas process. The consumption is also perfect both of the direct and the produced fuel, against a semi-consumption in the coal furnace. Thirdly, the combustion of the carbon, with all its heat antecedent and consequent, is closely confined in the retorts, from which the heat can escape only by radiation into the boiler, with the exception of the very restricted vent of the hot gases through the burners. Fourthly, the hydrogen obtained issues from the burners at a very high prior temperature, whereas the coal enters the furnace cold. Finally, the hydrogen flame is a vastly more advantageous heating agent than any form of crude fuel, from its unequalled intensity and rapidity of action, and also from its direct contact with the iron, as against the slower processes of radiation and conduction employed by the coal in the furnace. The rapidity with which heat is imparted increases in a geometrical ratio to the increase of it sintensity, and since the hydrogen flame is many times hotter than incandescent carbon, this concentrated heat must have a vastly greater effect, unit for unit, in any given time of passage through the flues. Considering that 90 per cent of direct waste is a moderate allowance in the ordinary firing of a locomotive, it would seem on the whole that we are justified in expecting yet greater economy from this process rather than in theoretically distrusting the results so far reported.

PROGRESS IN MIXED METALLURGY.

By WILLIAM C. CONANT.

Of the fundamental mechanic arts substantially developed before Science or History had a name, Metallurgy was the beginning and the common parent. 'When Adam was yet in middle life, the genius of Tubal-Cain divined and explored the capabilities of the workman's metals, copper, tin, zinc, and iron; fused and mingled them, wrought from them the tools of every craft, and became "the instructor of every artificer in brass and iron." It were hopeless, therefore, to question subsequent records of Time for the era or the occasion of any of the more essential developments in this art of arts. So far as the native surface metals are concerned, it is probable that all the more important metallurgical processes were understood, for substance, long before the flood. Copper and tin, the principal ingredients of bronze, being found comparatively pure at the surface, were naturally the earliest