of excavated material, most of which will come from the Culebra cut. Bunau-Varilla claims that he can cut the Gordian knot by dumping the greater part of it into the Gamboa lake. Now Gamboa lake, as will be seen from the accompanying map, is to be formed by the construction of a huge dam, whose crest will be 200 feet above the sea level, and which will extend entirely across the Chagres Valley at the point where the river Chagres first intercepts the line of the canal. All of the various schemes for the control of the heavy and sudden floods of the Chagres contemplate the construction of a reservoir, whose waters shall be held normally at such a level that there will at all times remain sufficient unoccupied space back of the dam wall to contain and hold all the waters of a Chagres flood. The minimum normal stage of the water in Lake Gamboa is plus 160, and there is sufficient capacity between that level and plus 200 to contain the river floods. Bunau-Varilla argues that, this being the case, the interior of the dam below the 160-foot level might be turned to good account by using it as a dumping ground for the excavated material. Accordingly, he would connect the waters of the lake with those of the summit level by a double flight of five locks. The material excavated by the dredges would be dumped into scows, which would be towed along the excavated canal in the channel opened parallel with the navigation channel, and after ascending the flight of locks, would be towed into Gamboa lake and unload themselves by opening their bottom gates. Bunau-Varilla estimates that eight dredges, working at the summit level, would in seven years dispose of the 110,000,000 cubic yards that would have to be excavated between the Obispo and Paraiso lock. There would be two chains of five locks, one for ascending and the other for descending. They would be able to take in one lockage four scows, 200 feet long, 40 feet wide, and drawing 14 feet of water. As each scow could carry 750 cubic yards, each lockage would lift 3,000 cubic yards, which would correspond to the passage into Gamboa lake of 96,000 cubic yards every twenty-four hours, or 30,000,000 cubic yards a year. Basing his figures on an estimated cost of excavation for hard rock of 65 cents per yard, for soft rock of 35 cents, and for earth of 20 cents per yard, he gets a total cost for excavating a 500-foot wide canal of $232,500,000. To this he adds for the cost of harbors, dams, electric power, etc, $17,500,000, and twenty per cent for emergencies. He finally arrives at a total cost of $300,000,000 for his "Straits of Panama," which would take twenty-four years to construct, including four years for the building of the preliminary 130-foot-level lock canal. The comparatively low estimated cost of the canal is explained by the fact that the excavation is done by the under-water method instead of the dry method, and that the power would be furnished by the impounded waters of the Chagres River, whose energy would be electrically transmitted throughout the whole length of the canal.

We offer no criticisms on the above remarkable scheme, which would probably have had a better chance of recommending itself to the Advisory Board, did its successful execution not depend so absolutely upon methods of excavation and disposal that have yet to be tested upon a grand scale.

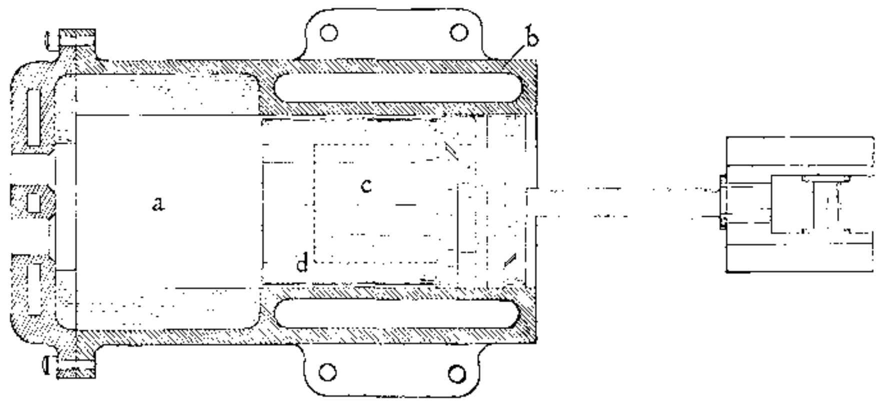
A RATIONAL METHOD OF COOLING GAS-ENGINE CYLINDERS.

BY S. M. HOWELL.

It is a matter of common observation in gas-engine practice, that an air-cooled cylinder will develop somewhat more power than could be secured from a water-jacketed motor of equal size, and under otherwise equivalent conditions. In other words, the engine without water cooling is the superior in point of economical performance. This experience agrees perfectly with the well-known simple theory upon which the production of power is dependent in all forms of the internal-combustion motor. The gas engine is a heat motor, pure and simple, producing power solely by the development and conservation of a high degree of heat. The working fluid is a mixture of air and certain inflammable gases, and the whole is violently expanded by the instantaneous burning of the contained gas and the intense heat thus generated. It must follow, therefore, that a water jacket or any device which operates to dissipate the heat of combustion, prior to the moment of the exhaust, will also lower the pressure and curtail the power of the engine in a corresponding degree. In the case of the water-jacketed engine, the cylinder walls have a comparatively low temperature, and rapidly abstract heat from the burning charge, thereby reducing the pressure and diminishing the power of the stroke. But the so-called air-cooled engine, having a much higher temperature, will therefore develop a higher pressure, and for a time at least, or until the cylinder becomes excessively hot, will produce more power. The amount of heat lost through the walls of a gas-engine cylinder by the use of a water jacket varies with the conditions. A high piston speed and high compression are factors which have a marked effect in reducing this loss; for the reason that in such cases the cylinder is smaller than would otherwise be required to develop the same power. This reduces the extent of water-cooled surface with which the ignited gases are in contact, and also, by reason of the quicker stroke, shortens the time of such contact.

The amount of heat absorbed by a water jacket may readily be determined in any given case by a simple calorimetric test of the water used, taking note of its volume, and its temperature as it enters and as it leaves the jacket. But I have observed, in making experiments of this kind, that the figured result does not always account for the deficiency which exists in the power of the engine, as compared with the heat which should theoretically be developed, and that too after making fair allowance for all other apparent losses. In explanation of this, it may be urged that the full temperature and the total amount of heat generated by the complete burning of the fuel, is not, in the case of a gas-engine cylinder, fully developed. The combustion is more or less imperfect by reason of contact with an extended metallic surface at a comparatively low temperature. If this is true, then we have also an indirect loss caused by incomplete combustion, and chargeable to the use of water cooling.

The hydro-carbon liquids or gases, which are the usual fuel of gas engines, consist essentially of hydrogen and carbon. The hydrogen is readily inflammable, and under ordinary circumstances is capable of but one reaction, resulting in the formation of the vapor of water. The elastic force of this vapor, powerfully compressed within the confines of the cylinder by the heat of combustion, forms a large part of the working fluid by the pressure of which the piston is driven. The trouble would seem to arise from a deficiency in the burning of the carbon element. Carbon in burning may form either of two combinations—carbon dioxide or carbon monoxide. The former is always the result under fairly favorable conditions, but in some cases, notably those in which the flame is confined within narrow limits and in close contact with metallic surfaces, the heat is so rapidly withdrawn that the temperature falls, and the process degenerates into incomplete union with the oxygen of the air, and the formation of carbon monoxide, the difference being that the amount of heat liberated by this degenerate reaction is less than one-third that which would result from perfect combustion of the carbon and the formation of carbon dioxide. A familiar instance of this defective form of combustion is seen in the attempt to pass a gas flame through a sheet of gauze or cloth made of fine metallic wires, or to conduct a flame through small metal tubes. In these cases, the cross-sectional area of the passages is very small, and the extent of cold metal comparatively large, with the result that the temperature falls below the kindling point, and the flame is extinguished or reduced to the monoxide reaction described above. That these instances have a parallel in the conditions which exist in gas engine practice, seems probable. It is obvious, however, that such an effect must be more marked in the case of small engines than in those having large cylinders, and could be determined in any case by a careful analysis of the exhaust.



A NOVEL WATER-JACKETED, HIGH-PRESSURE CYLINDER FOR A COMPOUND GAS ENGINE.

In regard to other methods of cylinder cooling, little need be said. Aside from the various methods of air cooling, the injection of water directly into the cylinder seems to be the only alternative. But this method, unless very sparingly applied, is worse than the use of an external jacket. It was one of the first cooling systems tried in the early days of the gas engine; and although modern designers sometimes attempt to revive it, it has usually proven unsatisfactory. This is evidently for the reason that the water in direct contact with the burning charge must greatly modify its temperature, while the cylinder walls would be only indirectly affected, and might still be insufficiently cooled. Then, too, the introduction of too large an amount of water into the cylinder of a gas engine, resulting of course in the immediate production of a body of steam, antagonizes combustion, and renders the ignition more difficult, and in the case of a four-cycle engine, has a tendency to destroy the vacuum produced by the retreat of the piston, filling the cylinder with steam on the suction stroke, and thus interfering with the inspiration of the charge. And still it is true that a small quantity of water, if properly regulated, may be injected into the cylinder of an air-cooled motor with much advantage. In this case it moderates the excessive heat of the contact surfaces, and assists lubrication by saponifying the oil and loosening any carbon deposit, which may otherwise adhere to the cylinder walls.

But after demonstrating the disadvantages of water cooling, the fact still remains that red-hot metal surfaces can not be continuously worked under heavy pressure in air-tight contact. Some means must be adopted whereby the destructive effects of heat on the cylinder and piston may be obviated. Thus it seems that in the present state of the art, the efforts of the gas engine designer are opposed by a conflict of natural conditions, and that he must so construct his engine that durability will be secured at the sacrifice of economy. But let us see if there is not a remedy.

In the figure which accompanies this article there is shown the high-pressure cylinder and piston of a compound gas engine, built upon a system which has for its object the utilization of the greatest possible amount of available heat in a cheap liquid fuel, viz., crude or partly refined mineral oil. It may be noticed that this cylinder consists of two parts, viz., the combustion chamber *a*, the internal walls of which are protected from the heat by a lining of refractory material, indicated by the dotted surfaces; *b* is the cylinder proper, wherein the piston and rings work in air-tight contact. This part of the cylinder is water-jacketed in the usual manner. The admission and exhaust valves are located in the head of the combustion chamber, this member being also partly jacketed to protect the valves. The piston *c* is the elongated type, that is, of somewhat more than the usual length, and having the rings near the forward or open end, the other end being covered by a thick cap *d*, of the above-mentioned refractory material. The elongation or extended part of the piston, with its refractory cap, is slightly smaller than the bore of the combustion chamber lining. This allows the elongated part to reciprocate within the combustion chamber, and to effect the necessary displacement without actual contact. Leakage past the piston is stopped by the rings at the opposite end which works within the cool part of the cylinder proper. The exhaust passes into a second and larger cylinder on the same shaft, where it delivers its remaining power in the well-known manner common to all compound engines. The cycle may be either two or four, but in either case, pure air alone will be admitted on the charging stroke. This air is compressed on the return stroke to a very high degree—300 to 500 pounds per square inch. The oil begins to enter (forced in by a pump) at the commencement of the power stroke, and without the use of any igniting device whatever, is instantly fired by the heat of compression, maintaining the required pressure throughout the stroke, in the manner of those engines which operate upon the well-known continuous combustion system.

A gas engine constructed upon these lines would possess the following advantages: It would be perfectly adapted to the use of the cheapest liquid fuel known. The injurious effects of heat upon the working faces of cylinder and piston would be avoided. The losses incident to the use of the water jacket would be totally eliminated. The conflicting requirements encountered in the present methods of design would be obviated. The engine would be as durable as any other, and its thermal efficiency would be the highest possible in a heat motor.

Concerning the advantage of compounding, it should be observed that the exhaust from an engine operating upon the above system has a very high pressure (100 pounds per square inch) and the gain by this means would therefore be considerable.

Regarding the character of this proposition for a new gas engine, it is virtually a composition of at least three expired patents, and its value therefore does not consist in the novelty of its elements, but in the peculiarity of their combination. Certain other known devices might also be involved in its final construction, but this would depend upon the mechanical details of the arrangement by which the oil was delivered to the cylinder, rather than on the operative principle of the engine.

The temperature of the linings and piston cap—owing to the constant inspiration of fresh air through the inlet valve—would never exceed a dull red heat, and the valves would not become much hotter than is ordinarily the case in any gas engine.

The drawing shows the piston at the extreme end of its outward stroke, the length of which is in this case, about equal to the cylinder bore.

It is not essential the compression pressure should be as high as 500 pounds (mentioned above), as the charge would be self-igniting at a point considerably below this figure.

The Current Supplement.

The opening article of the current SUPPLEMENT, No. 1568, deals with the Rhodesia railways in South Africa. The article is very fully illustrated. Mr. Houston Lowe presents his views on factors in painting woodwork. The excellent article on the dimensions of the marine steam turbine is concluded. This is by far the most important contribution to the literature of the steam turbine which has thus far appeared. Interesting from the naturalist's point of view, is an interesting article on the manner in which animals feign death. Notwithstanding the tendency of scientific knowledge and general enlightenment to dissipate superstition, some people still believe in the divining rod. The whole subject is discussed thoroughly in an excellent article by George M. Hopkins bearing the title "Unscientific and Scientific Divining Rods." In the industrial progress of this country there is no feature more remarkable and striking than the growing use of concrete building blocks. Mr. S. B. Newberry reviews the subject thoroughly, and gives some helpful suggestions. Lieut. Henry J. Jones continues his discussion of armored concrete. The electric conductivity of a vacuum is the subject of an article by Prof. J. A. Fleming.

BROMELIA FIBER.

BY CHARLES RICHARDS DODGE.

Among the collections of fibers from tropical America, shown at expositions held in our own and foreign countries, has frequently appeared a long, silky vegetable fiber, of a greenish cast of color, and showing great strength, though only an expert might particularly notice the small hanks into which the fiber is made up. When a specimen is unwrapped, however, the fineness of the fiber, and its extraordinary length, become apparent, for six feet is a common length, and I have seen examples that were very much longer. So strong is the fiber that it is difficult to rupture even a few filaments, by direct strain, without cutting into the hands.

I have seen the fiber, in very small quantities, in different portions of Mexico, where it has been sold, locally, as high as one dollar per pound. It is produced from the long, narrow leaves of a "wild pine-apple" belonging to the genus *Bromelia*. The nomenclature of the species is so confused, however, that I hesitate to name it, for the fiber has been variously labeled, in the museums and at expositions, *Bromelia sylvestris*, *B. pita*, *B. pinguin*, *B. karatas*, and *Karatas plumeri*. Its most common names are pita, pinuella, pinguin, and silk-grass, though "pita" is meaningless, and "silk grass" is applied to so many other fibers that the name is worthless. The better names are pinuella and karatas.

In the region of southern Mexico, from Oaxaca to Vera Cruz where the plant grows in great profusion, the fiber is used largely for fine woven textures, where strength and durability are essentials, such as hunting bags and various forms of pouches. It is also used for sewing thread, and was formerly employed for sewing shoes. The fiber is cleaned by hand, and the great length of the thin, narrow leaf, which is armed along its edges with sharp spines, makes it a tedious operation; hence the high price of the fiber.

I have just been informed by a correspondent in Mexico that an effort is being made to clean the leaves of the wild pine-apple by machinery, and some fair examples of the fiber have been turned out experimentally, in small quantities, so that future experiments are looked forward to with interest. The difficulties in the way of machine extraction are largely due to the thinness and the length of the leaf, a machine powerful enough to scrape off the hard epidermis inclosing the fiber layer being too harsh in its action, thus injuring the fiber. The production of well cleaned, unbroken fiber by machinery, and in commercial quantity, would no doubt give our manufacturers a new textile which might enter into some of the present uses of flax, while the peculiar silkiness and the color of the fiber would adapt it to the manufacture of many beautiful woven articles such as fancy bags, and even belts for summer wear. It would doubtless make superior fishing lines, and with further preparation and bleaching there is no saying but that the fiber might be employed in a wide range of woven fabrics of great beauty. Savorgnan, an Italian authority, states that in Brazil and Guiana, where a similar (if not the same) plant abounds, the fine silky fiber is manufactured into many "articles de luxe." In an old work on Mexico a species of Bromelia is referred to which is said to yield a very fine fiber six to eight feet long, "and from its fineness and toughness it is said to be commonly used in belt-making works. It also finds application in the manufacture of many articles such as bagging, wagon sheets, carpets, etc., besides being a valuable material for making nets, hammocks, cordage, and many articles in common use." This undoubtedly refers to the common form of Bromelia which is the subject of this article.

A species of shorter-leaved Bromelia grows in Paraguay and Argentina, producing a somewhat similar fiber, which is known as Caraguata, the product of *Bromelia argentina*. The filaments from this species are rarely longer than four feet, and while the fiber is soft and strong, it does not compare with the pinuella fiber from the region of Oaxaca, Mexico. In "The Capitals of Spanish America," by William E. Curtis, (page 638) a beautiful lace called "Nanduty," made by the women of Paraguay, is referred to. The fibers employed are described as very fine, and as soft and lustrous as silk. "Lopez had his chamber walls hung with this lace, on a background of crimson satin, and the pattern was an imitation of the finest cobweb. It is said to have required the work of 200 women several years to cover the walls." The name "pita" has been given to the fiber used in the manufacture of this lace, and the name, taken in connection with the description of the fiber given above, would seem to indicate that it was derived from a wild pine-apple, or Bromelia.

Bromelia fiber is closely allied to the famous piña, or pine-apple fiber of the Philippines, from which are manufactured such marvelously beautiful textures—such as fabrics fit for ball dresses, and handkerchiefs of gossamer fineness. There is little doubt, with as careful preparation, some of the wild pine-apple fiber might be employed in the same manner.

BROMELIA FIBER AS IT GROWS IN MEXICO.

The plant shown in the illustration was photographed in the old Borda garden of Cuernavaca, Mexico, where it is known as the piñuela. The masses of leaves in front have been broken off, and only those in the center show the full length. In British Honduras the leaves are said to grow from 5 to 15 feet in length.

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The rusts of cereals in damp seasons often destroy these crops or greatly reduce the yield and quality of the grain over immense areas, thus causing serious loss and suffering, and often famine. Many species of rusts have been discovered, some more destructive than others. The parasites causing the disease have been in some cases carefully studied, but much of their life history and habits remains yet to be learned. One of the most important facts discovered is that some of the most destructive forms, like the black rust of wheat (*Puccinia graminis*), have several distinct stages, formerly believed to be entirely separate fungi and to have no connection with each other. When De Barry found, however, that the cluster-cup rust of the barberry was a stage of the wheat rust and that the wheat was infected from the spores of the barberry rust a common observation of farmers was explained, namely, that wheat rust is most severe near barberry hedges. Laws were passed requiring the destruction of barberry hedges, and this particular form of wheat rust was then greatly reduced. The investigation also demonstrated that the black-rust stage on wheat could not infect the plant directly, but could infect the barberry, producing the cluster-cup rust of that plant. The spores of the barberry rust were found not to infect the barberry, but the wheat plant, producing first the form known as the red rust on the leaves and developing later on the same plant into the black rust.

Correspondence.

The Coiled Spring Problem.

To the Editor of the SCIENTIFIC AMERICAN:

In the late discussion as to what becomes of the coiled spring's energy when it is dissolved in acid, it has seemed to the writer that one point has been overlooked; namely, that the amount of heat liberated by the oxidation of the iron is so great, as compared with the heat equivalent of the stored mechanical energy, that no calorimetric method would be capable of measuring this additional heat.

A specific case may serve to make this plain. If a spring weighing 500 grammes is dissolved in acid, the oxidation of the iron will liberate 791 large calories (kilogramme-centigrade heat units). Although the writer has no acurate data of the stored energy in a coiled spring of the above weight, yet it would seem that 20 kilogramme-meters would be a rather liberal allowance. This amount of energy is equivalent to 0.0468 large calorie, or less than one ten-thousandth of the heat liberated by the oxidation of the iron.

While as a matter of theory it is apparent that the stored energy of the coiled spring must reappear as heat, yet the foregoing example makes it evident that it would be difficult, if not impossible, to demonstrate the fact. GREENLEAF W. PICKARD.

Amesbury, Mass., January 8, 1906.

Safety on Railroads.

To the Editor of the SCIENTIFIC AMERICAN:

Public sentiment in favor of the block signal has been thoroughly aroused of late, as a result of the alarming frequency with which serious accidents have occurred on our railroads. The general adoption of this form of safeguard is a step in the right direction, and it is to be hoped that it will be made compulsory throughout the country.

While the block signal is capable of a high degree of development, it usually takes the form of a simple visual signal, and as such is open to the serious objection common to all visual signals, that it has no power to enforce obedience to its behests. The method of controlling our great modern trains entirely by human agency, depending for guidance upon colored lights and movable semaphore arms, is absurdly primitive and ineffective. The all-important question as to whether the signals are to be obeyed or not depends absolutely on the engineer, who, like the rest of us, is subject to all the frailties of mankind. He forgets and becomes confused; his attention may be distracted at a critical moment; he may sleep or even die at his post, as has actually occurred several times within a few months; he sometimes does what is worse, deliberately "runs" signals to save time.

In view of these conditions, the writer desires again to urge the compulsory use of the automatic stop or "tripper," in connection with the block signal, as the only way in which a strict regard for the latter can be enforced. This must in no way be taken as a suggestion to relieve the engineer of any of his present responsibility. He should devote his entire skill and energy to the safety of his train, but his efforts should be supplemented by automatic devices, which will make it physically impossible for him to pass a danger signal whether he will or not.

The principle of automatism in safety appliances is recognized as an essential in modern mechanical systems, and may properly be regarded as a fundamental principle of safety. How the railroads have been permitted to ignore it in the matter of stopping trains is difficult to understand.

The reprehensible practice in vogue on many roads of regarding block signals, spacing signals, and time fuses as merely cautionary or informatory, and of running trains until the actual obstructions are encountered, deserves severe condemnation. It is a mercenary subterfuge to gain time at the expense of safety, and ought to be treated as such. A certain minimum distance between trains should be preserved in the interests of safety, and nothing should justify any encroachment upon this margin. A train arriving at an opposing block signal ought to be required to stay there until the block is cleared, even if a few minutes are lost in consequence. The saving in time should be effected by keeping the track clear, and not by disregarding danger signals.

The contention of the railroads, that their traffic could not be handled were trains required to stop at block signals, is not worthy of serious consideration. When reduced to plain language, it means simply that the earning capacity of the road would be somewhat diminished if danger signals were always regarded as they should be, and the practice of stealing time at the expense of safety were abandoned.

The block signal should be installed on every railroad, and a proper regard for it should be enforced by the law backed by the automatic stop.

WILLARD P. GERRISH.

Harvard College Observatory, Cambridge, Mass., January 1, 1906.