SCIENTIFIC AMERICAN

ESTABLISHED 1845

MUNN & CO. - - Editors and Proprietors

Published Weekly at

No. 361 Broadway, New York

TERMS TO SUBSCRIBERS

One copy, one year, for the United States, Canada, or Mexico.........$3.00
One copy, one year, to any foreign country, postage prepaid, £0 16s. 5d. 4.00

THE SCIENTIFIC AMERICAN PUBLICATIONS

Scientific American (Established 1845) ....$3.00 a year
Scientific American Supplement (Established 1876)............... 5.00 "
American Homes and Gardens....................................... 3.00 "
Scientific American Export Edition (Established 1878)........... 3.00 "

The combined subscription rates and rates to foreign countries will be furnished upon application.

Remit by postal or express money order, or by bank draft or check.

MUNN & CO., 361 Broadway, New York.

NEW YORK, SATURDAY, APRIL 6, 1907.

The Editor is always glad to receive for examination illustrated articles on subjects of timely interest. If the photographs are *sharp*, the articles *short*, and the facts *authentic*, the contributions will receive special attention. Accepted articles will be paid for at regular space rates.

THE SCIENTIFIC AMERICAN GOLD MEDAL FOR SAFETY DEVICES.

One of the most encouraging signs of the moral uplifting of the race is the unmistakable growth in these later days of the humanitarian sentiment. The dignity of the human body, the sanctity of human life, are swiftly emerging to their full and proper recognition. The reproach has lain too long at our doors that, as a people, we were so madly bent on the pursuit of wealth that we cared little who might fall by the way, if only the goal were swiftly and grandly won. To the question: "How much then is the life of a man worth more than that of a sheep?" we have made answer by rolling up a record of over half a million annual maimings and killings that may well put us to the blush.

Therefore it is gratifying to realize that the movement set on foot by the American Institute of Social Service for the promotion of an American Museum of Safety Devices is meeting with marked success.

In view of the fact that a very large percentage of these accidents is absolutely preventable, the editors of the Scientific American have decided to offer a gold medal, annually, for the best device for the protection of life and limb, produced during the year; said award to be given by the American Institute of Social Service, after the Board of Experts has passed upon the devices submitted.

THEORY AND PRACTICE.

In the current issue of the Supplement we publish two investigations of the conditions existing, or presumed to exist, on the curve on which the recent derailment of an electric train took place on the New York Central tracks near this city. The first of these is concerned with the pressures of the driving wheels against the outer rail; the second determines the shearing strength of the spikes, which, by yielding, permitted the rail to be displaced. The investigation of the lateral pressure exerted by the drivers, which was made by George F. Swain, Professor of Civil Engineering of the Massachusetts Institute of Technology, shows that, under the conditions assumed, the leading outer driver, at a speed of 70 miles an hour, would exert a pressure against the outer rail not exceeding 3,500 pounds. The investigation of the shearing strength of six spikes showed that they gave way under an average shearing load of 19,740.5 pounds. This would indicate that, under the conditions assumed, there was a factor of safety of between five and six against failure.

Now, while Prof. Swain's calculations are absolutely correct, and it is shown that theoretically it was impossible for the electric locomotives to have sheared the spikes; as a matter of fact, the conditions assumed for his calculation never exist, and in the very nature of things cannot exist, in actual railroad operation—a fact which is recognized when Mr. Swain states in his report, that it is "not necessary to call attention to the uncertain elements involved." The low pressures arrived at would obtain, only if the curve were laid out with absolute mathematical exactness; if the superelevation of the outer rail were, at every point in the rail, of the exact theoretical amount for the curvature and the speed; if the density and elasticity of the rail were perfectly uniform; if the outer edge of the base of the rail were bearing snugly against every spike; if the ballast beneath every tie were tamped so as to give an absolutely equal amount of reaction of the ballast against each tie; and lastly, and perhaps most important of all, if the electric locomotive were built with absolute fidelity to the design, and all the parts of it were functioning with the accuracy of a high-grade watch; then, and only then, would it be safe to accept Prof. Swain's figures as indicating the actual pressures developed.

As a matter of fact, however, not one of the above-named conditions exists in actual practice, and in many of them, the divergence is apt to be very great indeed; moreover, where the divergence is of such a character as to permit what might be called the statical stresses of these calculations to be changed into dynamical stresses, that is to say, wherever slackness of adjustment, or irregularity of the vertical or horizontal contour of the rail, permits pressure to develop into momentum, the resulting stresses will immediately mount up far beyond the figures herein found for the condition of an ideal locomotive riding over an ideal track.

As illustrating what we mean, it is assumed in the investigations that the lateral displacement of the outer rail is resisted partly by the strength of the spikes, and partly by the friction of the base of the rail on the tie plate. The lateral pressure of the leading driver on the rail is found to be 8,400 pounds. The frictional resistance of the rail base on the tie plate is assumed to be 25 per cent of the vertical load of the driver, or 4,735 pounds, leaving a resultant pressure on the spike of about 3,500 pounds. But let us suppose that, as the combined effect of furious driving and of some irregularity in the track, such as a flattening of the curve, or a local sag in the grade, the locomotive should commence to surge heavily against the outer rail, and that the blow of this 95-ton mass, concentrated at a single point (the flange of the leading driver) should be sufficient, for an instant, to cause a slight canting of the rail, so that contact between base and tie plate was had only at the outer edge of the former where it impinged on the spike. In that instant of time, if the inner edge of the base rail lifted but a hair's breadth from the tie plate, the 4,735 pounds of frictional resistance would practically disappear (the laws of frictional area notwithstanding), and the spike would have to take nearly the whole 8,400 pounds of pressure direct. But the 8,400 pounds would no longer be a statical pressure, if we may apply the term, and the resultant dynamic stress, produced by the violently-lurching mass of the locomotive, might easily carry the figures up to two or three times that amount; in which case the 19,740 pounds resistance to shearing in the spike might be exceeded.

Now that such a condition is possible is shown by the fact that on the morning of the accident one of these electric locomotives, running around the curve, at about the point where the accident occurred, struck the outer rail a violent blow, rebounded, struck the rail a second time, and then after a few more oscillations settled down without leaving the tracks. The impact was so terrific that it was thought by those in the cab that a derailment was inevitable; and, on reaching the end of the run, the incident (as was stated before the grand jury) was telegraphed back by the engineman to headquarters. After such a terrific bombardment by a single locomotive, it is little matter for surprise that under a double-header running at what was probably greater speed, the spikes, possibly already partly sheared through, should have given way altogether.

As a matter of fact, we cannot call to mind in the whole field of engineering a single structural element regarding which it is so impossible to determine the actual stresses to which it is subjected as the modern steel rail carrying the heaviest and fastest modern traffic. It is at once the most important single element in the whole roadbed, the hardest worked, and, in respect of any serious effort, at least on the part of the rail mills, to bring it up to the requirements of modern traffic, the most neglected. The day is coming, if it is not already here, when that miserable blacksmith's contrivance, the common railroad spike, must give place to some form of screwed fastening with larger bearing surface and very much greater holding power.

THE FOUR-DAY LINER.

The possibility of the construction of a 30-knot liner, capable of crossing the Atlantic in four days, has recently been made the subject of discussion by the naval architect who was responsible for the design of the battleship "Oregon." This gentleman states that the plans are practically finished for the construction of a torpedo-boat destroyer of 625 tons displacement, and 12,000 horse-power, which is expected to be able to maintain a sea speed of 30 knots an hour. This will be sufficient to carry such a vessel over the transatlantic course of 3,000 knots in about four days' time. The interest of this destroyer lies in the fact that it is to be furnished with producer-gas engines, and that it will represent the first attempt to apply this system of propulsion to a high-speed vessel. According to the designer, the machinery will weigh only 210 tons, or about thirty-five pounds per horse power.

It is a far cry, however, from a 625-ton destroyer to a 20,000- or 30,000-ton transatlantic liner; and although the sponsor of this gas-plant vessel declares that he can produce 30,000 horse-power for a total weight of 500 tons in engine and gas plant, and that with a supply of only 850 tons of crude petroleum fuel, it would be possible to build a boat that would maintain a speed of over 30 knots for 3,000 miles, it is certain that such a vessel would be altogether too small to have any commercial value in the transatlantic trade.

Let it not be supposed, however, that we have any wish to disparage the enthusiasm of those who believe in the future of the producer-gas engine steamship. On the contrary, producer-gas engines, in the limited degree in which they have been installed afloat, have shown the same fuel economy and other desirable qualities that they have demonstrated in service on land. A well-designed producer-gas engine will develop a horse-power on one-half of the fuel that is necessary in a good steam plant. But up to the present time, these installations have been of small capacity, and they have been subject to the serious limitation that they are successful only when a good grade of anthracite coal is used in the producer; and, of course, no large ocean steamship could be regarded as a profitable venture, unless she were prepared, in common with the steam-driven vessels, to take the ordinary coal of commerce into her bunkers. At present there is no gas-producer which is capable of handling successfully bituminous coal, the problem of the by-products from such fuel remaining yet to be solved. The proposed gas-driven destroyer, however, is to make use of crude petroleum, and we understand that the experimental work that has been done with this fuel has given most promising results. If it should prove to be possible by the use of petroleum to produce plants in the larger sizes, which will provide the necessary volumes of gas to supply engines of the size requisite to drive a transatlantic liner, a most important step will have been made in the direction of the large four-day boat.

There will yet remain, however, for solution the difficult problem of building successful gas engines of the necessarily large size required for the development of 30,000 to 40,000 horse-power. For it may as well be set down, once and for all, that the units must necessarily be of large size, and this for the reason that for the propulsion of large vessels at high speed, a certain minimum diameter of propeller and maximum speed of rotation is imposed. Let no one imagine that the problem can be solved by the use of multiple gas engines, driving a plurality of small propellers at high speeds of rotation. The same propeller restrictions which necessitated the 20,000-horse-power turbines of the "Carmania" being designed for such a low speed of revolution, and, therefore, of such great size, that they practically equaled in weight the reciprocating engines of the sister ship "Caronia," will apply in the case of the gas-driven ocean liner. For a 30,000 or 40,000-horse-power producer-gas plant, then, the cylinders will have to be of unprecedented size and weight, and this will bring the designer up against some very serious problems in cooling. Not only must the huge superficial area of the cylinders be cooled, but so also must the piston rods and pistons. Equality of expansion and the prevention of eccentricity of expansion would be an absolute necessity. However, in view of the ingenious design and marvelous accuracy of workmanship displayed in the development of the large-powered turbine, we have little doubt that ultimately the problem of the large-powered gas engine will be solved also, and that the four-day transatlantic liner will take its place as the rival, if not the successor, of the turbine-driven vessels. The advantages secured will be many and gratifying both to the shareholders and the traveling public. If petroleum fuel should be used, the present large bunker space would be available for passenger and freight accommodations, the fuel being carried in the double bottom of the ship. The dirt, dust, and odor incidental to the coal, smoke, and ashes of coal fuel would disappear, as would also the enormous smokestacks, which not only disfigure steamships, but in view of the enormous and little appreciated wind resistance, consume a not inconsiderable proportion of the horse-power.

THREE MONTHS OF DENATURED ALCOHOL.

Although barely three months have elapsed since the Tax-Free Alcohol Act went into effect, the time has been sufficient to demonstrate certain possibilities of the industries favored by the bill, and to indicate some phases of the law which are either inadequate or fail to meet the conditions called forth by the use of the tax-free spirit for specific purposes. It can fairly be said that, in general, the operation of the law promises to be satisfactory, and with a few amendments, it will doubtless successfully fulfill its purpose in all particulars. As was to be expected, the law became operative without the revolutionizing of American industrial and agricultural conditions prophesied by numerous too-ardent advocates of the measure. The Standard Oil Company, which controls our gasoline supply, is still apparently in as flourishing a condition as it was prior to the first of January, and the farmers, with few exceptions, are still utilizing their waste products for purposes other than the distillation of alcohol. Many manufacturing industries, it is true, have enjoyed the immediate beneficial effect of the new law, and have received a healthy stimulus, which has not been without its effect on the general financial and industrial condition of the country. Even the wood-alcohol interests, which opposed the passage of the bill so strenuously, have not suffered as severely as they declared they would; for wood alcohol, which is one of the standard denaturants required by the regulations, will be increasingly in demand with the wider utilization of denatured spirit.

It is possible to-day to obtain denatured, high-proof spirit for 35 to 40 cents a gallon, depending upon the locality in which the purchase takes place and upon the quantity bought. In New York city, for instance, denatured spirit can be purchased for 36 cents a gallon in five-barrel lots.

These figures are not discouraging, though they hardly permit the present general use of alcohol for fuel for motor purposes in competition with petroleum and gasoline at, roundly, 15 and 20 cents a gallon respectively. They indicate that the future of fuel alcohol is quite as promising as its more conservative advocates claimed prior to the legislative action. There can be no doubt that the price of the denatured spirit will decrease with the development of its industrial utilization, with the wider application of wastes to distillation, and with the growing familiarity of the farmer and the manufacturer with the subject.

Shortly after the alcohol bill became a law, the Department of Agriculture appointed a commission to conduct a series of investigations upon alcohol engines and the use of alcohol in ordinary internal-combustion motors. An interesting preliminary report, to be followed, before long, by a more elaborate account of the investigations, has recently been published. It presents much interesting data and substantiates, in general, the results obtained in Europe and the deductions to be drawn from them. The conclusion, previously arrived at by other investigators, that practically any explosive engine is adapted to the use of alcohol, but that the motor designed specially for alcohol will give superior results, is substantiated. One interesting fact is brought out which, perhaps, has not received a great deal of attention hitherto. This is that the possible margin of inefficiency is much higher in the alcohol engine than in other internal-combustion engines. With good management the consumption of alcohol in an engine not especially designed for the purpose can be brought as low as 1.23 pounds per brake horse-power, though the fuel consumption in the same motor may increase to nearly twice this minimum amount without apparent defect in the operation of the engine. This fact serves excellently to emphasize the necessity for using the specially-designed alcohol motor in order to obtain the best results with this fuel.

The prospect of producing denatured alcohol on the farm economically has been greatly brightened by the recent passage of a bill amending the Free Alcohol Act. Under the latter there was no adequate provision whereby denatured alcohol could be produced on a modest scale, as it was required that the pure spirit be removed from the still in barrels to denaturing warehouses. The amendment makes it permissible to transfer the pure spirit to denaturing warehouses by means of pipe lines or tank cars. Furthermore, it is provided that at distilleries producing alcohol for denaturation only, and with a capacity of not more than 100 proof gallons per day, bonded distillery warehouses may be dispensed with, and the alcohol may be stored in cisterns or tanks and denatured without removal to a denaturing warehouse. Both of the amendatory provisions will be of service in reducing the cost of manufacturing tax-free spirit, and the second will render its production practicable on a far smaller scale than was possible under the original law.

A great deal of independent experimentation has been carried out in all parts of the country for the purpose of discovering or demonstrating the possible use of various waste materials for alcohol production, and valuable data have been obtained in this way. Contrary to expert opinion, it is held by government officials and others familiar with the conditions, that under the law as it now stands, the farmer can successfully distill and denature alcohol from his produce or wastes on a small scale. Speaking recently on this topic, Internal Revenue Commissioner Yerkes declared that there were absolutely no limitations as to the size of a distillery which may be operated under the law. He declared, furthermore, that there are in existence at the present time over a thousand distilleries, of which the daily spirit-producing capacity is less than 30 gallons each, and that many of these plants were installed at an outlay of less than $200. We believe, however, that the successful solution of the problem of farm distillation on a small scale lies not in the use of a low-capacity still by the individual farmer, for the utilization of the produce or wastes from his own land, but is to be found in the communal still, operated jointly by a number of individuals or conducted by a distiller and operated on shares, the distiller being paid for his work in the resulting spirit itself, somewhat as the old-time miller received payment for grinding the grain, in flour. Even if small distilleries can be installed at a comparatively low cost, alcohol can be distilled economically and profitably only when the production is continuous and on a larger scale than is possible on the average farm.

Prior to the passage of the present law the American literature of industrial alcohol was, naturally, extremely limited, and strange to say, this is true to-day of England, despite the fact that the latter country has had tax-free alcohol for many years. Recently a number of books have appeared, dealing with different phases of the subject, and providing in many instances excellent means for the education of the layman and proving of value even to the expert. Among these we call attention to "Industrial Alcohol, Its Manufacture and Uses," a practical treatise, recently issued by the publishers of the SCIENTIFIC AMERICAN, and described at greater length elsewhere in this number.

THE EVAPORATION OF SOLID METALS AND THEIR COMPOUNDS.

The evaporation of metals at ordinary temperatures, which has long been conjectured from their characteristic odors, has recently been clearly demonstrated by several methods.

Zenghelis's method is as follows: The metal is placed in a saucer in an air-tight glass vessel which also contains a piece of chemically pure silver foil, suspended horizontally above the metal under investigation at a distance from 1-25 to 4-10 inch. Silver was selected as the material of the foil because it does not oxidize rapidly and exhibits considerable affinity to non-metals. Its effect is to increase the evaporation from the other metal by absorbing the vapor as it is formed, so that the volume of the containing vessel never becomes saturated.

Many experiments were made, with copper, lead, iron, zinc, the non-metals sulphur, selenium, tellurium, and phosphorus, the metalloids arsenic and antimony, and various oxides, hydrates, sulphides, and haloid and oxygen salts. In nearly every case the silver foil was more or less affected. Usually a golden tint, resembling that of an alloy, gradually extended inward from the edge until it covered the entire surface, but every color of the rainbow appeared in the course of the experiments. The metals were employed in the form of plugs, most of the compounds were powders obtained by precipitation, and some of the oxides were formed by roasting.

Weeks or months were required to produce a distinct effect with most substances, though a few days or even hours sufficed in some cases. The metalloids and non-metals, having a greater affinity for silver, acted more energetically than the metals. Phosphorus made the foil brittle throughout.

Among oxides the most rapid evaporation was shown by those of zinc, iron, chromium, uranium, and bismuth. Analysis of the foil that had been exposed to the vapor of zinc revealed the presence of 2 per cent of that metal. In most other cases the fact of evaporation was confirmed by simply determining the increase in weight of the silver foil.

No evaporation from quicklime or carbonate of lime was detected, while the sulphides of arsenic, antimony, tin, and barium evaporated very rapidly, comparatively speaking. Both sulphur and zinc were detected in the silver foil that had been exposed over zinc sulphide. In many cases the colors which occur on polished silver exposed to traces of sulphureted hydrogen were observed.

The haloid salts of lead, mercury, zinc, iron, and the alkali metals also acted very energetically, the iodides evaporating more rapidly and the chlorides more slowly than the bromides. With the haloids of silver, however, the order was reversed. The silver foil was completely corroded by long exposure over lead iodide.

The metals of the alkalies and alkaline earths were easily detected in the foil by the color of the blowpipe flame. In some cases in which the balance gave no result the presence of foreign metals in the foil was detected by the production of characteristic colors with appropriate reagents—potassium ferrocyanide for copper, iron, and uranium, sodium molybdenate for tin.

When copper, nickel, or aluminium was substituted for the silver foil no effect was observed. Gold was affected by the vapors of the oxides of zinc and mercury, but by no other substance.

The presence of moisture in the air of the vessel increased the rapidity of evaporation, and the water of crystallization of certain salts, including cobalt sulphate and chrome alum, had a similar effect. Rarefaction of the air also quickened the evaporation and the silver foil was attacked sooner in small than in large vessels. Evaporation was also favored by reducing agents such as hydrogen and alcohol vapor, but was not affected by covering the vessel with yellow glass to exclude the chemically active rays of light.

Elevation of temperature had no visible effect, probably because it promoted to the same degree the formation of vapor and the decomposition of the silver compound.

The golden metallic hue which was the first effect in nearly all cases, even when the substance under investigation was a compound, suggests an alloy of the silver with the other metal; and as the sulphides of arsenic, antimony, and tin produced colors indicating combination of sulphur with the silver, it seems probable that the vapors of compounds were dissociated as a result of their extreme rarefaction. This view is supported by the fact that the less stable of two related compounds attacks the silver more than the other. For example, the bicarbonate and the thiosulphate of sodium acted more quickly than the carbonate and sulphite respectively. Compounds that dissociate at low temperatures, such as hydriodic acid and oxide of mercury, also acted very quickly.

There is probably some connection between the evaporation of solid bodies and their long-known action on photographic plates. Many substances exert such action not only immediately after exposure to sunlight, but after they have long been shielded from light of every kind, and some of them affect the plate both when in contact with it and when separated from it by a layer of air. Zinc affects the plate at a distance of 1-3 inch, but magnesium and aluminium act more rapidly. Other substances possessing this property are wood, paper, leather, silk, cotton, shellac, and various metals.

The results of numerous experiments make it appear very probable that these effects are caused by invisible metallic radiations. These radiations are apparently subject to the law of gravitation, for when a metal plate is placed horizontally between two photographic plates the effect is confined almost wholly to the lower one of the latter. If the three plates are placed vertically in a centrifugal apparatus the photographic plate which is farther from the axis than the metal plate is more strongly affected than the other.

Streintz attributes this radiation to the agency of the so-called electrolytic pressure (which has been measured in the case of certain metals) and finds it proportional thereto. In the series platinum, gold, lead, iron, cadmium, zinc, aluminium, magnesium, the metals are arranged in the order of increasing electrolytic pressure and increasing effect on the photographic plate. According to Streintz, the effect of the electrolytic pressure is to expel positive ions which affect the plate, ionize the air, and leave the residual metal negatively electrified.

It appears probable, therefore, that evaporation, autophotography, and radioactivity are nearly related and are common to a great many metals and their compounds.

THE CURRENT SUPPLEMENT.

The current SUPPLEMENT, No. 1631, opens with an excellent article by Mr. Robert H. Chapman, of the United States Geological Survey, on the Deserts of Nevada and the Death Valley. In the management of wireless telegraph stations where open and closed oscillation circuits are compounded to form coupled systems for the efficient radiation of electric waves from an aerial wire, it is often necessary to determine with precision the frequency of the surging oscillations and the length of the emitted waves. This can be done by means of the ondameter or electric wave meter. Mr. A. Frederick Collins, in the current SUPPLEMENT, explains very clearly the principle of the ondameter's operation and its application in wireless telegraphy. Mr. Charles P. Steinmetz's excellent paper on light and illumination is concluded. Richard Lee writes on coal mine gases. The inundation of Salton Sink, and the formation of the great new lake in the Imperial Valley of California as the result of the diversion of the Colorado River, is very interestingly discussed by Mr. Arthur P. Davis, with the help of many excellent illustrations. Baron Suyematsu concludes his eloquent summary of the ethics of Japan. That the Romans were very good mechanical engineers has been proven by more than one striking discovery. How true this is may be gathered from an instructive article in the current SUPPLEMENT on an ancient Roman pump, which shows that long ago the Romans were very familiar with natural laws. On July 13 next the earth and Mars will be in opposition. At that time the much-discussed surface-markings of the planet will be observed. For that reason the very excellent article by the Abbé Moreux, director of the observatory at Bourges, on "The Planet Mars as Revealed by Recent Observations" may be considered a good preparatory discussion of a subject which will soon be dilated upon in the daily press. The abbé writes not only on observations of his predecessors, but on his own work. Sharp and clear illustrations accompany his offering. Interesting, too, is a report on the testing of railway spikes prepared for the New York Central and Hudson River Railroad.