tion of canals, forebays, tailraces, and other concomitants of a hydraulic-electric installation. The first cost per horse power varies from $17, at Vallorbes, to $320, at Lyons, France. The charge to consumers is determined very largely by the cost of the distribution. Thus, in Norway, the price per electric horse power, per year of 8,760 hours, is $5, while at Niagara the average price is $21, the charge depending considerably upon the amount that is required by the consumer.

From the estimates of the lowest practicable cost of steam power we gather that in America the lowest practicable cost for steam per horse power per year is under the most favorable conditions $17.50, and in the United Kingdom $18. In Switzerland the lowest cost of steam power is placed at $45 per year. Under normal conditions, for steam power to compete successfully with water power, the former must be generated in bulk. If this be done, it is estimated that a 50,000-horsepower plant using coal at $1.75 per ton could produce power at a cost of $18 per horse power per year.

With reference to gas power, the author is of the opinion that the cost depends greatly upon the source and character of the gas, while to realize higher economy for gas engines over steam engines, it is not necessary to use the largest sizes, the economy being particularly marked in motors of moderate size. It is estimated by Meyer that if blast furnace gas be used the cost of an electric horse power per year will be $20, and that with the use of Mond producer gas the cost will be $25 per year.

Summing up, a comparative estimate based upon the lowest actually recorded cost for water power and steam power shows that hydraulic power in Canada is being produced at a cost of $6.25 per annum, that in England the lowest actual cost of steam per horse power is $20 per annum, while in Germany, with gas engines using furnace gas, the lowest estimated cost per horse power per year is $20, and in England, with the use of producer gas, the lowest estimated cost per annum per horse power is $25. While this comparison verifies the general opinion that if the first cost is not excessive, the water turbine is by far the cheapest of all prime movers, when the first cost of the hydraulic plant is heavy, or the transmission line exceeds a certain length, the difference between the relative cost of water, steam, and gas power gradually disappears.

EFFICIENCY IN ACTION.

Is it not to be inferred from remarks in the December 1* issue of the SCIENTIFIC AMERICAN on "The Comparative Efficiency of the Krupp, Armstrong and Schneider-Canet Guns" that the naval ordnance expert secures efficiency of fire rather more through the medium of high projectile velocities than that of projectile weights? There appears, however, to be an exception to this rule, in the case further on recited, as relates to the German navy. It is well known that projectiles disproportionately reduced in the matter of weight for the caliber are so conditioned as to have imparted to them extremely high muzzle velocities without at the time exceeding the prescribed pressure limits, and the error of this practice cannot be better appreciated than in the case of cork or wood projected from a rifle and made to penetrate resisting media, like that of wood, plank or glass, and without change of form, when the penetration follows the instant of passage of such projectile from the bore of the gun.

If we consider this matter of projectile weights and velocities from the small arm standpoint, it will be found that there is a special ratio of weight to the area of cross-section for small arm projectiles, which serves as a guide in the ballistic problem, this ratio being 3,000 grains per inch area of cross-section.

It would therefore be unwise, before a ratio has been settled upon in the construction of any projectile, to determine beforehand upon any arbitrary velocity. It would be better in the first place to properly proportion the projectile and after that ascertain by experiment the velocity which shall accord or accommodate itself to the powder pressure restrictions. Proceeding upon any other line is absolutely incorrect and is of the nature of ignorance or pretense. Keeping in mind this idea our argument may be carried to a legitimate conclusion.

The writer of the article before referred to states that the velocities employed in the naval service are much higher than those common to weapons for field guns, and that "regret is expressed by many naval officers to see the 13-inch gun displaced by the 12-inch, the hitting power of the 13-inch shell at long range being considerably greater than that of the older 12-inch shell." Are we to infer from this that the weight of the 12-inch projectile has been reduced in a ratio to its area of cross-section not in accord with ballistic requirements and the purpose of increasing its muzzle velocity to secure a muzzle energy approaching that of the 13-inch rifle, but which ratio of construction results in disproportionate loss of energy at battle ranges?

The relative weights of properly proportioned projectiles for the 13-inch and 12-inch calibers with like "sectional density" requires their ratio to hold at figures of 17 to 14, that is inversely as the square of the diameter of their cross-sections, and not as the cube of this homologous line where a similar proportioned projectile is sought for.

"When the public hears that a gun of a certain caliber is capable of a velocity of 3,000 feet per second, as against velocities of 2,600 feet per second in other guns of the same caliber," it is usually inferred that "the high velocity weapon is incontestably the most effective," whereas should consideration not have been given to the weight of projectile employed, the statement is quite misleading.

What, we ask, is the purpose of the naval ordnance expert in so constructing projectiles as to be ill-proportioned to ballistic requirements? Are his estimates based entirely upon work at close quarters or short ranges, where muzzle energy is the criterion of efficiency; or is the sacrifice due to an effort to provide the greatest total number of rounds that the restrictions of vessels' ton displacement will permit? What is the value of muzzle energy and penetration, if followed by anything assimilating the instability in flight of cork or wood projectiles or where the impact energy at ranges where real work is expected to be accomplished is disproportionately and materially reduced?

"In determining upon the armament of their navy, the Germans have evidently been governed by this consideration (the hitting power of the projectile), for it is a fact that Krupp guns, with which their ships are armed, fire projectiles which are considerably heavier for any given size of gun than those used in any other navy.

"Although the muzzle velocities given in the ballistic tables of these guns are not so high as those of other nations, the muzzle energies are greater, and the '*remaining energies*' are *enormously* so." (The *italics* are ours.)

Here the German at least appears to be working on proper lines, and whatever reason there may be to justify a variety of velocities and projectile weights for the like caliber guns, it is not at all clear that because the 13-inch rifle in our service is disparaged by a comparison of its muzzle energy with that of its rival the 12-inch, our land defense should be expected to discount stable platforms and favorable conditions as to weights and their accessories incident to and necessary for the service of monster rifles. Certain it is this land defense must not be and never will be subordinated to the restrictions imposed upon batteries afloat, nor can it afford to avail itself of all advantages of the kind noted.

The one and half per cent of hits, of all shots fired at Santiago by our fleet in the running fight with the enemy, showed more favorably for the smaller and so-called "rapid-fire guns" than for those of larger caliber; but this engagement is insignificant in comparison with conflicts yet to be anticipated upon the sea. There has been nothing either here or at Manila to suggest the dismounting of the heaviest type of guns on our seaboard, or the removal of disappearing carriages where already they have been placed.

Reverting again to the small arm or miniature phase of the problem, here at least is a sphere of action where the fighting factors on land and sea are bound by common ties and should be governed by common principles. A caliber, 0.23, was at first selected for the navy rifle, and a 135-grain bullet was at first adopted and then discarded in favor of the 112-grain miniature *capsule*.

In this instance had the same prejudice for light weights and high velocities permeated the entire system? How much better it would have been to follow the ratio (3,000 grains per inch area of cross-section) employed in the 0.45 caliber Hotchkiss navy rifle in the army 0.45 caliber Springfield small arm, and one which had been accepted for the army 0.30 caliber magazine arm.

What follows from the 2,700 feet per second muzzle velocity of this 112-grain bullet? A falling off from the extravagant start to 971 feet at one-half mile range, while, on the other hand, a well-proportioned bullet of 135 grains weight for the caliber, with its start of 2,500 feet per second, makes a showing by some 40 feet per second in excess of this "remaining velocity" at this half-mile range.

In other words, the disproportioned bullet has lost 1,729 feet or 66 per cent of its original velocity, while the well-proportioned bullet loses but 1,490 feet or 60 per cent of its original velocity, and both arrive with energies in the ratio of 234 to 305 foot-pounds respectively in favor of the bullet of proper weight. What has the high velocity advocate to say, after this?

Further than this, the lesser weight of bullet at the greater mile range by computation indicates but 90 foot-pounds "remaining energy," against 130 foot-pounds for the greater weight projectile of the same caliber, and this notwithstanding the fact that the muzzle velocity of the more weighty bullet was but 93 per cent of that of its lighter competitor.

In the foregoing comparison of ballistic properties the writer has erred on the right side of the argument by assuming values for velocities in the computations so great as 2,700 and 2,500 feet per second, whereas such velocities cannot be and never have been realized in practice. Computation somewhat nearer the mark will be found in estimates of 2,500 and 2,300 foot-seconds respectively, and such ratio will be useful and comparable with that of the 0.30 caliber rifle projectile, which is the present adopted caliber for both services. The muzzle velocity for the 0.30 caliber arm does not exceed 2,000 feet per second, but its weight of bullet (220 grains) more than compensates for this.

The efficiency of this 0.30 caliber weight of projectile with but 2,000 feet per second muzzle velocity is quite marked at the half-mile range, and even allowing a start of 2,700 feet per second for its little (112-grain) competitor the ratio of velocities for these bullets for this range is as 901 to 971 respectively, and their "remaining energies" for the range as 234 to 397 in favor of the 0.30 caliber bullet, a ratio falling off to 175 and 90 foot-pounds respectively at a range of one mile. If anything were wanting to stimulate the practical man in his effort to secure the greatest efficiency with arms of all calibers it would be to look a little closely into this matter of weights. X.

*See also SUPPLEMENT December 1.

SCIENCE NOTES.

A fire in the pathological museum of the University of Berlin on January 16 damaged Prof. Virchow's collection of skeletons and other objects.

The new mint at Philadelphia, Pa., is being sumptuously decorated with glass mosaic. The mosaics with figures are eleven in number, and have been designed by Mr. William B. Van Ingen.

The patrol wagons of Allegheny, Pa., have been equipped with medical outfits, and the sergeants of the police have been instructed how to render aid to the sufferings of victims of accidents. The equipment includes antidotes for poisoning, dressings for burns and almost everything that is used in emergency cases.

A large pottery firm in Staffordshire (England) has been carrying out a series of experiments with a view to manufacturing glazed china without white lead. The mortality among the workers, due to white lead poisoning, is heavy, and efforts have been made for some time past by legislative and other methods to reduce the misery of the employes engaged in this trade. The firm in question has produced numerous articles by an improved process, which are equal in every respect to those produced by the white lead process. Attempts are also to be made to apply the system to the manufacture of earthenware.

The Comte da Schio is busily engaged in the construction of his airship. The first vessel will be a small one, measuring only about 100 feet in length. It will have accommodation for two passengers. The power for propelling the vessel will be placed in the fore part of the car. Should the preliminary trials prove successful the Comte proposes to construct a larger machine. The Duke of the Abruzzi is displaying a keen interest in the invention, and has expressed a desire to accompany the inventor upon his maiden voyage. Should the machine prove successful it is quite possible that the Duke of the Abruzzi may take it with him upon his next Arctic expedition. The Comte does not claim to be able to sail against the wind. His intention is rather to take further advantage of the winds blowing in the direction in which he is traveling, to aid him in the steering of his machine.

The strike among the lace workers of Calais will have the effect of considerably injuring this important French industry. No less than 14,000 employés are standing idle. For some years past the competition between the Calais and Nottingham lace manufacturers has been very acute, and now that cessation of work has ensued at the French center, the lace makers of Nottingham will reap inestimable benefit. The specialty of the Calais trade industry, however, is the manufacture of the silk lace for mantle makers, but, owing to the demand for the article being very limited, it is not anticipated that the Nottingham makers will compete very energetically in this field. It is in the manufacture of the Valenciennes, fancy cotton laces, and cotton fancy nets that the French trade will suffer. The French article has never been equal in quality or finish to the English product, and consequently it has been somewhat cheaper, but once the trade returns to Nottingham it is doubtful whether Calais will ever regain it, owing to the tendency among the English manufacturers to lower their prices.