WHAT SMOKELESS POWDER HAS MADE POSSIBLE.—I.

BY ROBERT G. SKERRETT

Except for saluting purposes, where smoke making is a factor in the ceremony, smokeless powder has supplanted the older propellants.

Our biggest battleships could not be given their present powerful armaments had not smokeless powder made it possible to add to the destructive force of our guns while calling for much less weight per unit of energy than formerly.

Smokeless powder was first generally used in the French navy at the time of the development of rapid-fire guns to repel the swift torpedo boat. The use of smoky gun powder in those weapons would have blanketed the defensive vessel in a cloud and have given a greater chance of success for the torpedo boat. Thus, a military necessity demanded the change. Once developed, however, smokeless powder became the stepping stone to a revolution in ordnance engineering. This was due in the main to the differences between the physical actions of the old and the new propellants.

Black gun powder has a very dignified antiquity. It is a mechanical mixture of saltpeter, charcoal, and sulphur. Smokeless powder, on the other hand, is a chemical combination in which the atoms bear a different and a far more intimate relation to one another. Common gun powder is a violent explosive and generates its gases with great suddenness. Its grains, however, when burned in a confined space, are only imperfectly consumed, and large volumes of smoke are generated. When used in guns, the products of this combustion give about 40 per cent of propelling gases. These propulsive gases have the double burden of moving the shell and this inert mass of smoke and unburned grains.

Prior to our adoption of smokeless powder, the charge was about half the weight of the projectile—double the quantity of smokeless powder required to give the same ballistic results. Black powder exerts a very great and disproportionate stress upon the breech of the gun. Thence toward the muzzle, the pressure drops suddenly—especially if the grains be small and the mass thus easily inflamed. Our diagram shows graphically the quickness with which the highest pressures are developed and the rapid way in

middle of these units so that as the consuming flame reduced the outer surface the burning area of the hole was increased, maintaining thus a relative balance of ignited surface and giving a more regular and gradual

dealing with the briefest fractions of a second of time, but measurable intervals that mean everything to the ordnance engineer.

Higher velocities and better ballistics followed. But

	Armstrong Gun.	U. S. Navy Gun.
Caliber.....	12.5 inches	12.0 inches
Length of bore.....	198 inches	546 inches
Weight.....	38 tons	52.9 tons
Muzzle velocity (per second)....	1,400 feet	2,950 feet
Maximum pressure.....	23.8 tons	15.3 tons

	Armstrong Gun.	U. S. Navy Gun.
Minimum pressure.....	.6 tons	5.79 tons
Average pressure.....	6.37 tons	10.40 tons
Powder charge.....	130 pounds	365 pounds
Weight of projectile.....	820 pounds	870 pounds

Comparison of construction, powder pressures, etc., of the old Armstrong and the latest 12-inch navy gun.

generation of gas. For a time, this answered. But the gun grew, and the exposed surfaces of the greater powder charge required offered too large an initial burning area, and dangerously high and sudden pressures were produced at the breech of the weapon.

there was actually more smoke than before, the bores of the guns were quickly fouled, and there still remained a wasteful percentage of unburned grains. Such was the state of the art in this country when we went to war with Spain.

Weight of gun, 63 tons; Weight of shell, 1,400 pounds; Powder charge, 365 pounds; Muzzle velocity, 2,600 feet per second; Muzzle energy, 65,687 foot-tons.

THE NEW 14-INCH, 45-CALIBER GUN NOW UNDERGOING TEST FOR THE NAVY.

which they fall—the average propulsive force being but a low percentage of the maximum power evolved. It is this average pressure that sends the shot on its destructive errand; and the aim of the ordnance engineer is to have this reasonably high while lowering the crest of the curve of maximum energy.

The first remedy tried was in the form of larger grains, so that, for a given weight of charge, the superficial area at once exposed to the flame should be reduced—the powder instead of going off with a single flash burned more slowly, and the propelling force was better distributed along the bore of the gun. This method led to the making of prismatic grains up to an inch and a half in diameter—regularly and carefully formed. Next, a hole was bored through the

Besides this, a big percentage of the grain was blown out of the gun unconsumed. Advance for a time was blocked until the powder makers evolved a "slow-burning" propellant by changing the proportions of some of the ingredients. The purpose of sulphur is to lower the ignition temperature of the powder, and by lessening this element inflammation was momentarily retarded. By increasing the charcoal a greater percentage of moisture was added, and that served as a slowing-up agent in the general combustion of the mixture. The powder thus developed was called "cocoa" because of its color—the consequence of the under-charred charcoal used. In this country, we later called it "brown prismatic." The terms "quick" or "slow-burning" are merely relative. In either case we are

Smokeless powder has quite reversed the task of the ordnance engineer. His aim now is to provide an explosive which can be made to suit the gun rather than to fashion the weapon to meet the violent vagaries of the older propellants. Our present smokeless powder generates a relatively low, regular, and progressive pressure from the instant of ignition up to the time the shot leaves the muzzle of the gun with its maximum velocity. The curve of our big 12-inch rifles shows how much nearer the powder makers have come to solving the problem; but much patient experimenting has yet to be done before the ideal is measurably approached.

The operative cycle of a shot moving along the bore of a gun is exactly opposite to that of a train of cars gaining full speed from a standstill. In the latter case, the engineer knows that he would endanger his couplings—even if he did no other damage—if he opened wide the throttle at the instant of starting. So he begins by just acquiring headway, and then gradually increases the motive energy until the train has reached full speed—a matter of quite several minutes for a fast train and during a distance of a mile or two. The ordnance engineer, on the other hand, can give to his projectile only a flying start by suddenly applying a great and violent pressure; and enough of this propulsive force must follow the shell to the muzzle in order to give the desired maximum velocity. This must be accomplished within a period of not more than one-hundredth of a second of time, and, in our biggest guns, while the shot travels a distance of not more than fifty feet. A few figures will enable us to realize better the task set the ordnance engineer and

PARTLY CONSUMED GRAINS OF 12-INCH GUN SMOKELESS POWDER.

SMOKELESS POWDER OF VARIOUS FORMS AND SIZES TO SUIT DIFFERENT CALIBERS OF NAVAL GUNS.

the part that smokeless powder plays in the result when measured by the power to strike an appalling blow. The shell leaves the muzzle of one of our latest 12-inch, 45-caliber rifles, with a velocity of 2,950 feet a second—33.52 miles a minute—and has a striking force at that instant equal to a blow of 52,632 foot-tons! A fast express of 350 tons, thundering along at the rapid rate of 98.34 miles an hour, in collision with a standing object, would be able to deal a blow of exactly corresponding magnitude. The gun's missile weighs but 870 pounds, and the charge of powder 335 pounds—such is the power concentrated in our smokeless propellant; and yet so wonderfully regulated is the development of this stupendous energy that the weapon is actually less taxed than the older 12.5-inch rifle dealt with in the diagram, while the present-day gun has far more military value.

Referring to our diagram we see how far smokeless powder has made it possible to improve upon the performance of the Armstrong gun of the "eighties." That gun fired a shell of 820 pounds, used a charge of 130 pounds of black powder, and gave to its shot a muzzle velocity of 1,400 feet a second. At the instant the shot left the gun it had a striking energy of 10,980 foot-tons. To-day, our big 12-inch rifles weighing but forty-odd per cent more than the older weapon, can send their 870-pound armor-piercing shell on an errand of destruction with an initial speed of nearly 3,000 feet a second—delivering at the muzzle a blow nearly five times as great as that of the Armstrong gun. The 38-ton gun, with a powder charge scarcely more than a third of that now used, developed the dangerous maximum pressure of 24 tons to the square inch in the powder chamber. Our big "twelves"—using 365 pounds of smokeless powder—have a maximum chamber pressure in service of not more than 16 tons. This means a reduction of stress upon the breech of the weapon of quite 33 per cent, and yet yielding an average propulsive pressure of something more than 60 per cent greater; all because the present powder burns slower and exerts its driving power for a longer period during the passage of the shell along the bore of the rifle. It is the difference between the shock of a single, sudden, violent impulse and the better-sustained push by which an object may be set in motion and accelerated.

Surely these are truly astonishing strides; and yet so unobtrusively have they been made from year to year that but few of us have realized their extent and their significance in strengthening our powers of defense and of retaliation. Such are the achievements of to-day! What may we not expect to-morrow?

(To be continued.)

A NEW UNITED STATES NAVAL GUN OF GREAT POWER.

Our illustration of the new naval 14-inch gun cannot fail to excite widespread interest among those who are following the trend of development in the United States navy. The piece was constructed at the Midvale Works from plans of the Bureau of Ordnance, and received its finishing touches in the naval gun shops at Washington. It is now undergoing tests at the Indian Head Proving Ground which are giving much satisfaction to the officers of the Bureau.

There seems to be a growing conviction among some of the leading naval powers that, in view of the fact that future engagements will be fought at long ranges at which the remaining energy increases greatly with an increase in the size of the gun, future dreadnoughts will be armed with a piece of larger caliber than twelve inches. Great Britain is building, if she has not already completed, a 13½-inch gun, and our 14-inch piece has been designed and is now being tested, with a view to putting our navy in a position to arm future dreadnoughts entirely with the 14-inch if it should be deemed desirable to do so.

The new weapon, which will be 45 calibers in length (that is to say its length will be 45 times the bore), measures over all 53 feet 6½ inches, and it weighs 63 tons. It fires a projectile of 1,400 pounds weight with a charge of 365 pounds of smokeless powder, and the shell leaves the muzzle of the gun with a velocity of 2,600 feet per second and an energy of 65,687 foot-tons. It will be noticed that the velocity is 350 feet a second less than that of our latest 12-inch gun, but that because of the heavier shell the muzzle energy is greater. The lower velocity has the great advantage that the pressures and temperatures in the bore of the gun will be less, and therefore the erosion will be reduced and the life of the gun before the rifling is so badly worn away as to destroy the accuracy will be considerably longer. The method of construction is generally similar to that shown in the accompanying article entitled "What Smokeless Powder Has Made Possible"; and, except that the powder pressures are lower, the curve of pressure from the powder chamber to the muzzle is approximately the same for the two pieces.

The telescope which is being installed in the Transvaal Observatory will be the second largest in the British Empire. It will be 35 feet long and have an aperture 26 inches in diameter.

The Rockefeller Institute's Work on Infantile Paralysis.

BY JOHN B. HUBER, A.M., M.D.

The psychic machinery in our body is made up of two systems—the cerebro-spinal and the sympathetic; the latter does not here concern us. The cerebro-spinal system is made up of the brain, the spinal cord, and the nerves, which are derived from the cord and extend thence to the muscles, the skin, and the uttermost tissues. The basis of this nervous system is the neurone, composed of a cell-body (gray matter), and its dendrites or fibers (white matter) which emanate from the cell like the roots of a tree. The neurones are sensory and motor; and infantile paralysis is an affection of the motor neurone. The whole is like a telegraph system: The fibers (which make up the nerves) are the telegraph wires; the cell bodies (as grouped in ganglia) are the telegraph stations, communicating by their fibers with the extremities, with one another, and with the main office in the brain cortex.

The sensory ganglia in the spinal cord, to which sensations are telegraphed from the surface of the body, are in the posterior "horns"; thence the sensations are transmitted to the brain cortex, from which in return commands are sent down through the motor ganglia, in the anterior horns of the spinal cord to the muscles working the affected area.

Infantile paralysis is known also to physicians as anterior poliomyelitis (*polios*, gray; *myelitis*, marrow—a term applied, no doubt, when the gray matter was erroneously supposed to be marrow; and *itis*, inflammation). So this disease is an inflammation of the anterior horns in the spinal cord—those parts of the cord which are concerned in muscular movements and development; and such a lesion means paralysis, atrophy or degeneration in the particular muscles innervated from the part of the cord involved.

Infantile paralysis is generally an acute disease; and by far the greatest sufferers from it are little children from one to five years of age. Apart from the pathos in this circumstance, we would infer (though not, of course, conclusively) the infectious nature of this form of paralysis. For almost all the acute infections—measles, scarlet fever, whooping cough, and the like—are generally diseases of childhood; adults and the aged seldom contract them, if they have once contracted them in childhood, because the attack in infancy has conferred, in most cases, lifelong immunity upon the individual. Another reason for inferring infectivity in poliomyelitis is its frequently epidemic character; as in the summer of 1907, when nearly the whole Atlantic seaboard was swept, and again in the summer of 1909, when the disease appeared in New York and spread widely throughout the United States and Europe.

In perhaps two-thirds of the cases that have been studied physicians have concluded them to be infectious, though they could not prove this; in the remaining one-third the disease has been attributed to falls, to antecedent maturing fevers, and to hemorrhages into the spinal blood vessels. In the light of our present knowledge, however, it is safe to consider that such falls, fevers and hemorrhages have not been causative of the poliomyelitis, but rather predisposing factors, making the tissues concerned vulnerable to the essential or specific virus.

The motor neurones in this paralysis become smaller; then they degenerate, liquefy, and finally shrivel up; the fibers emanating from them degenerate and atrophy. This process may go on to complete destruction of these precious elements; or it may be arrested at any stage. If arrested early, repair may ensue and the cells and their fibers regain fairly well their normal condition and function. If, unfortunately, the inflammation goes on, the size and shape of the spinal cord at the points involved are contracted and changed; and in consequence of this the muscles concerned become paralyzed, atrophic, and incapable of their proper function. When recovery does take place these muscles are apt to remain small, perhaps throughout lifetime. These little patients suffer also retarded bone growth, deformity of the joints involved, sometimes lateral curvature of the spine, sluggish circulation, and impaired nutrition.

Such an illness begins suddenly with a high temperature and all the symptoms accompanying a fever; there is a pain in the back and limbs; suddenly there supervenes paralysis, generally in the leg muscles. A child may be put to bed seemingly quite healthy; and may in the early morning manifest these sufferings. The outlook is generally good as to life itself, yet the severity and fatality of the disease, as in all infections, fluctuate widely; and taking it all in all, poliomyelitis is sufficiently disastrous to give medical men much anxiety, as it should give the community in general grave concern.

As intimated, the infectious nature of poliomyelitis has been rather assumed than proved; it would now seem that complete demonstration of infectivity will presently be forthcoming. We may then entertain the confident hope of a preventive and immunizing agent

against infantile paralysis akin to that which has practically eliminated smallpox from human experience. Early in 1909 two German experimenters, Landsteiner and Popper, successfully inoculated two monkeys with the spinal cords taken from two fatal human cases of poliomyelitis. In both the monkeys lesions of the spinal cord were on autopsy found similar to those in man.

In September of 1909 Dr. Simon Flexner and his colleague, Dr. Paul A. Lewis, of the Rockefeller Institute, in New York city, obtained the cords of two children that had unfortunately died of poliomyelitis, in which cords the anterior horns exhibited the characteristic grass and microscopic appearances. Transmission was then made to monkeys. After ether anesthesia inoculation was made in the brain of these simians through a small trephine opening. The injected material consisted first of emulsions in salt solution of the two human cords; and later of emulsions of the spinal cords of the monkeys that had developed paralysis after injection of the first emulsion, that from the human cords. The spinal cords in six series of monkeys thus inoculated showed without exception lesions similar to those of human poliomyelitis.

Now, a single successful inoculation with human virus resulting in experimental poliomyelitis could not establish the scientific case here set forth, because the result might have been due to a transferred toxic body; but in the experiments of Flexner and Lewis the transfer of the active agency of epidemic infantile paralysis was regularly successful. In one series of seven monkeys the first inoculation was of human virus; the other monkeys were successively inoculated each with the virus from the cord or the cortex of its predecessor, the disease regularly resulting. Hence, by these and other equally conclusive experiments, one cannot doubt the infectious nature of poliomyelitis.

Again, later injections were made, not only in the brain of monkeys but also into the abdominal cavity, the blood vessels, into nerve substance (as in the sciatic) of these animals. Nor "can it yet be affirmed that still other avenues of infection (as the skin, the organs of respiration or the digestive tract) do not exist, for the entrance of the virus into the central nervous system."

But now as to the nature of this virus which is responsible for infantile paralysis. It is at present invisible under the microscope. Flexner and Lewis, after most exhaustive search, have found that it is neither a bacterium nor a protozoon, which parasites have been isolated as pathogenic of most of the infectious diseases. The virus of infantile paralysis—its infecting agent—is of the same nature as that of smallpox; it belongs to the class of the minute and filterable viruses that have thus far not been demonstrated with certainty. Nevertheless, although the smallpox virus still remains invisible to us, for a century past a vaccine has been evolved from it by which we have practically banished this dreadful disease from the face of the earth; there should then be no reason in science why a vaccine or an immunizing agent against poliomyelitis should not now in good time be forthcoming.

By the way, did the reader note in this paper the phrase "after ether anesthesia?" It means that the monkeys suffered no torture during these experiments, so beneficent in their trend for humankind. Let us congratulate ourselves that infantile paralysis is another added to the long list of dreadful diseases for which a remedy is being found through animal experimentation, which could otherwise never have been evolved.

An Electro-pneumatic Conveyer System for Libraries.

An electro-pneumatic system is used in the Berlin royal library for carrying out the distribution of books to the readers. Upon this system the reader fills out a blank containing the name of the desired book, and upon this blank an employee writes an exact indication of the place where such volume is to be found. The bulletin is then sent by pneumatic tube to the central office. This office is directly connected by elevators with the different stories of the building. These elevators are of small size and are operated electrically on a push-button system. Besides, there is a large elevator running through all the floors for transporting persons and books. A set of pneumatic tubes also run from the central office to the different floors which contain the books. The employee of the central office who receives the reader's bulletin sends the same by pneumatic tube to the proper floor, and on this floor the attendants read the sheet and bring the desired books to the elevator which takes them to the central office. This latter office then sends the books to the point from which the bulletin was sent in the first place, either in the main reading room or any other of the rooms of the library.

The production of mercury at the Almaden mines, Spain, was 1,017,023 kilos, or 29,472 flasks, in 1908. At Micares it was 50,685 kilos.