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Science in the War.¹

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These are crucial times in which we are now living. The world has been at war for about three and one-half years. Lord Northcliffe during the last seven months while in this country spent \$127 per second, counting all the seconds day and night, for supplies in the interest of the allies. The U. S. in the short space of three months has built 16 cities of 40,000 population in each, has appropriated over 700 million dollars for the building of aircraft, and made numerous other appropriations on the same scale. Mr. Vanderlip calls our attention to the fact that the total expenditures of our government from its foundation, including that of the Civil War, has been only 26 billion dollars as compared with the 19 billion which we are proposing to spend this year alone.

Germany is pushing on in an effort to realize on a contract in which she has bartered her soul in an expectation of gaining the world.

Twenty-one nations of the world have declared war on Germany and have banded themselves together to defeat this monstrous German propaganda.

In a conflict such as this, every means of production and destruction known to man is being used.

Science in the last fifty years has made some wonderful advances. Its aim has been the amelioration of man. To make the work of men more effective. To take the burden off the backs of men and have it carried by natural agencies. To give men more time to devote to matters of spirit so that his plane of life might be higher. Germany is now forcing the world to divert all these great discoveries and inventions to the art of destruction.

Since the beginning of the war, the effort and application of scientists has been very intense. The subjects "Science in the

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War" or "The Effect of War on Science" would be equally interesting and would lead along the same lines of thought. Many things which scientists have been striving to attain have by intense and cooperative effort been pushed ahead thrice as fast as they would have been in times of peace.

We had gasoline motors before the war, but now we have Liberty Motors. This is the product of patriotic men who have pooled their brains and knowledge of motors in the production of one motor which contains all the good points of all the motors.

We had flying machines before the war, but they were slow. To ascend to a height of a mile or so required considerable time,—30 minutes or more. The requirements now for much of the service is a height of 15,000 feet or more in 10 or 15 minutes. Requirements are constantly changing. If we had made up a lot of flying machines three years ago, few of them would be of any use at the front. We could to great advantage have prepared ourselves to meet the demand for raw material such as iron, coal, copper, etc., also such finished products as cars, locomotives, and ships, but it would not have been wise then to put up a lot of finished machines of the kind which science and invention has rapidly changed to meet changing conditions.

We also had motor trucks before the war. Many different kinds of them. They saved France at the battle of the Marne. At that time they were glad to get any kind of truck but it required about 2,000,000 parts to keep them in repair. The solution of this difficulty has been worked out in America where 12 of the best men from motor truck plants and 62 from parts plants met in Washington a short time ago and dumped their trade secrets on the table. Ordinarily in such a meeting each would have been careful to keep to himself any good point which his company had discovered for his machine, but here all was laid on the altar of patriotism and the result is the Liberty Truck, initial orders for 10,000 of which are now placed with 60 different factories. That is the kind of backing most of our manufacturers are giving to this war.

Of course in a time such as this a great many impractical and foolish schemes are brought forward. It is reported that 40,000 different propositions have been sent in to Washington for combating the submarines and doing many other wonderful stunts. These for the most part are from those who have had neither experience nor scientific training,—those who insist on education

being "practical" to the exclusion of fundamental principles. One scheme that lately attracted considerable attention is the use of so called "free energy," whatever that may mean, by a man named Giragossian. By this it is possible to propel air ships and submarines and locomotives around the earth several times without taking on fuel by the way. It solves the whole problem of gasoline and coal shortage and in fact puts to shame all scientific efforts of the past. The claims for the Keely motor hoax in its day were very modest compared with this. It seems rather ridiculous that a committee of Congress would seriously consider a claim of this kind and make a recommendation to Congress, as has been done, that the matter be investigated. Of course a scientist should have an open mind but it should not have to be open very long in propositions of this kind. Such things admonish all of us who are teachers of science to insist more strongly on the great principles of conservation and correlation of energy.

In contrast with this we may mention, as a real and productive, scientific inquiry, the construction at Washington, by proper scientific authority, of a huge receiver of an air pump. It is made of cement, is air tight, large enough to receive the working parts of a flying machine, provided with a refrigeration outfit, and other apparatus necessary to make the test. The purpose is to try out the operation of the machine at a height, say, of 16,000 feet where the air is rare and the temperature low. Thus it is hoped to find answers to such questions as: What style of carburetor is best for these rapidly changing conditions? Will aluminum and other metals retain their tensile strength and other properties when the temperature changes. Will the varnish with which the linen of the wings are filled retain its earth-surface qualities? Thus the conditions of operation in the upper air can be supplied and the necessary material and means of adjustment can be provided. Painstaking work of this kind is where real progress in science is made.

Most of the operations in this war are applications of physics and chemistry. Some of the wars of the past might be called a blacksmith's war, for they fought with spears and swords which were hammered out in the smithy. A battle now, however, is often a conflict of scientifically constructed machines.

Take, for example, the operation of a flying machine. To begin with, there is action and reaction. The propeller drives air in one

direction and in doing so drives the machine in the opposite direction. Then if the machine is tilted up a little in front, a vertical component of force lifts it from the ground and holds it there as long as the machine is in motion. The aeronaut has with him a barometer by which he can tell how high he is. He carries with him, possibly, a Gatling gun and must know how to operate this. He may want to shoot forward in the direction he is moving but there is his propeller and he must not splinter those wooden blades, so that although the blades are moving so fast that he can see only a hazy circle where the propeller is turning yet the synchronizing device with which his rapid firing gun may be provided will send the bullets between and will not hit the blades.

The flier must also know something about photography for it is by this means that a great deal of information is obtained in regard to enemy positions, trenches, movements, etc. That is what is meant by putting out the enemy's eyes. Our feverish production of air machines at this time has for one of its purposes the mastery of the air so that the enemy may not be able to hover over us, take photographs of our lines, or direct the aim of their artillery.

The dropping of bombs from air planes involves a strict application of Newton's first and second laws of motion, the application of which in this work is an art very difficult to attain. If the plane is moving horizontally at the rate of 100 miles per hour, and at a height of 16,000 feet, then, from $s = \frac{1}{2}gt^2$, a bomb let fall would reach the earth in about 30 seconds. During this time the bomb will continue its horizontal motion of 100 miles per hour. If, then, it is dropped when the plane is directly over a building, it would miss the mark by considerably more than three-quarters of a mile.

Then, too, the flier must be provided with a wireless outfit for both sending and receiving, particularly sending, for he can thus give his army warning of impending movements which they cannot see and the gunners must rely on him to tell them when their missiles go beyond, fall short, or go to either side. Often the roar of machinery drowns out sounds of the message he is to receive and so many machines are provided with delicate string galvanometers and, looking through glasses he can read the dots and dashes by the movement of the string.

Beside all this, the flier must know something about astronomy

and the stars for up there it is easy to be lost and the stars at night may help him on his way.

A young man who prepares himself for such work as this, who is sufficiently sound in heart, eye, ear, lungs and brain, and who can go through the grilling experience of a battle in the clouds, certainly deserves at least our highest admiration. We are told in the press of a young man who recently strolled into a New York hotel and wrote on the register the name W. A. Bishop. He did not have an imposing appearance for he is short and weighs about 100 lbs., but it was soon found out that this was Maj. Wm. Avery Bishop who has had bestowed on him every decoration which the British have provided for this kind of service. He has to his credit 110 combats in the air in which he sent 47 enemy machines hurtling to the earth and put 23 others out of commission. He was just then on his way to Toronto to be married and has since been giving help in the aviation fields of this country.

Of course it must be understood in the description given above that there are a variety of styles of machines and that they are equipped in different ways for the different kinds of service which they are to perform.

Principles of physics are also directly applied in artillery practice. The range finder is a delicate optical instrument. The range of the projectile can be calculated from the angle of elevation and the initial velocity, and the height of ascent is found from the same data, also the time of flight, this last being of especial importance in case of shrapnel shells that the fuse may be properly set.

Of course everybody regrets the enormous destruction that must accompany a war of this kind. Destruction of art, property, and life as well as the cessation of that production which would have taken place during the time the war lasts. But even war is not without its compensations. If a result of this war shall be, as we surely think it will be, that the world will be a better place to live in for all time to come, then the nations will be requited for the sacrifice they are now making.

A nation or an individual can often do more in a single year under the spur of a pressing need or a great motive than they would do during several years under ordinary conditions. This is particularly true if that nation has grown rich and has yielded to the allurements of ease and luxury.

The U. S. since the war began, particularly since last April, has been looking itself over as never before. It has been giving itself a severe cross-examination and taking an inventory of its stock and its ways of doing things. This is very desirable at any time but it is seldom done except in times of great stress. A few examples will illustrate this fact. One large establishment has just discovered that they used no corks in their red-ink bottles and the ink has been evaporating, the waste in this amounting to several hundred dollars per year. Another has discovered that they have been extravagant in the use of rubber bands and are now making the necessary retrenchment. In the scarcity of coal, emphatic attention is being directed to hydro-electric plants. The use of electric locomotives on the C. M. & St. Paul R. R. in crossing the Rocky Mountains is saving thousands of tons of coal and oil each year. The power comes from the Great Falls of Montana. Not only is this great amount of fuel saved but each electric locomotive is equal in hauling power to three ordinary ones. These then are released for other work.

Before the war there were only five factories engaged in making dyestuff in this country and their output was small. Now we have 100 such companies which produce not only all the dyes needed here but export more than we formerly imported. Germany has had a monopoly in the dye industry because she managed to make us believe it was her secret, and she is able under her political system to exploit her labor at home and undersell anything we might produce. It is hoped that after the war Germany may be put on the same producing basis as ourselves or that our congress will see the wisdom of keeping this industry at home. Our chemists are eminently able to produce the dyes.

Again, we are finding ourselves short of potash. A German authority said that our going into the war was like a man putting a noose about his neck and allowing them, the Germans, to hold the other end of the rope, for they, he said, had a monopoly of potash and so could dictate what nations should starve and which might have food. So we have been looking about and find that we have various sources of this important ingredient of the soil. The dust from our cement mills and the kelp, sea weeds, growing beneath the water on the Pacific coast will furnish a considerable quantity and chemists tell us that Searles lake in California contains in solution

20,000,000 tons of potash. Our importation from Germany before the war was about one-half million tons per year, and so the potash in this lake would at this rate keep us supplied for about 40 years.

The nitrates also are indispensable in the manufacture of munitions and in fertilizers. The nitrate beds in Chili are nearing exhaustion and the war is forcing the U. S. to look about for new sources of this chemical. Years ago when the great hydro-electric plant at Niagara was started, an attempt was made to form a company for the fixation of atmospheric nitrogen. Capital could not be interested however, and so nothing was done in this country. The Norwegians and Germans copied the proposed process with success. In 1916 the du Pont powder company offered to make a contract with our government and furnish all the capital needed to establish a large plant for the fixation of atmospheric nitrogen, the government to permit the use of water power. This was not done. If it had been done we would now be well on our way in the production of all the nitric acid and nitrates we need. We are slow in giving the proper encouragement or subsidies to science in its early stages and to far-seeing men and corporations who make a close study of conditions. Eriesson received no help from our government until after the Monitor had defeated the Merrimac. It is hoped that one effect of this war will be that all of us will have a more liberal attitude in this respect. Congress has lately appropriated under the pressure of war necessity, 20,000,000 dollars for the fixation of atmospheric nitrogen either by the electric arc process or by some other method which a committee of scientific men will recommend.

Any stimulation of the production of potash or the nitrates will assist not only in winning the war but will be very useful afterward in increasing the productivity of the land.

Science makes this war different from all other wars not only in the machines and chemicals used but also in the care of the man. Reports show that about 90% of those who are wounded recover and 40% of them return to the lines. Immediate antiseptic applications and irrigation of deep wounds are in no small degree the cause of this gratifying result.

Deaths from sickness in the army, also, are less than in peace times. This is brought about in two ways. First, sanitary conditions are enforced by men who know what real sanitation is and

thus germs of disease are for the most part avoided. Second, the bodies of soldiers are fortified against disease before they go into service. A soldier is not asked whether or not he wishes to be vaccinated, he is simply vaccinated. Likewise he is fortified against typhoid. There is also an anti-gangrene serum which will further improve matters in this regard.

This is in marked contrast with conditions during the Civil War where more men died from sickness in the camp than were killed in battle.

Of course in a conflict such as this, many must die. It is difficult to find a satisfactory compensation for this, but while the most cherished principles of America and other free nations are at stake, we must be willing to make the sacrifice or go down in history as a nation of cowards. As Secretary Lane has lately said, "It is more precious that America should live than that we Americans should live".

The enthusiastic response of our people to all the appeals of President Wilson gives full assurance that the United States will do her duty.

Science in Modern Warfare.¹

BY L. L. EDGAR.

The Great War has been called a "grand physical phenomenon" and a "battle of the sciences." To the layman this does not mean very much, but it is nevertheless a fact. It could just as well be called a "chemist's war" or an "engineer's war" or a "surgeon's war," so much have the various sciences contributed toward carrying on the war. Most of us do not think of the part science has played in this great struggle. All we see and read of is the terrible fighting and wastage of human lives. It is very interesting to go into the subject deeper and see what has made possible all this fighting, and just where science and its application has to do with modern trench warfare.

Every known science has played an important role, including chemistry, physics, hygiene, mathematics, engineering, geography, geology, metallurgy, geodesy, bacteriology, meteorology, astronomy,

¹From November, "Edison Life."