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THE SCIENTIFIC MOBILIZATION IN ITALY FOR THE WAR

THE various manifestations of the present war have had, for the most part, their foundation in applied science and industry. The best minds turned to study methods of offense and defense, based on the application of pure or applied science, and inventive genius has had and still has a wide field in which to find new arms and new devices and to perfect those now existing.

From the beginning of the war, Italy, no less than her Allies, has mobilized her scientific and industrial forces for the one purpose to which all the activities of the country have had to be devoted, and nothing has been spared to help and perfect the great war-machine which *had to* bring victory.

The work began first individually and as demanded by the necessities of the moment; then, a little at a time, for individual work, for the work of individual scientists as officers on the fighting line or in the rear where their technical skill was required, or in the war industries which had to enlarge all their plants rapidly and modify them according to circumstances, there was substituted a single organization, a state institution. This was founded in order to mobilize properly for war purposes all available Italian scientific forces and all the means at the disposal of the numerous laboratories of the schools and state technical establishments.

This institution, which naturally was situated at the Ministry of Arms and Munitions, had the following duties:

(1) To classify and mobilize the various scientific institutions according to their possible utilization and the means at the disposal of each. (2) To study the problems which were eventually proposed by the military technical offices, distribute them to the laboratories and institutions best adapted to the particular

problem, follow the various experimental phases, especially in the case of inventions worthy of attention. The institution was in this way the connection between the military offices and all those who had improvements to propose on the methods of war then existing or new applications or inventions. When the experiments had advanced to such a point of development as to be utilized, it transmitted the results to the military offices for application. (3) To take charge of the shops already mobilized for war work and to adapt others as the need arose. (4) To take care of the completed inventions and researches and the unsuccessful attempts, of the problems overcome and of those yet to be overcome, seeking to improve what already existed and to create new things without repeating long and fatiguing work. (5) To collaborate closely with the analogous institutions of the allies, by means of specially appointed delegates who had to keep informed of the progress made in the various problems, and follow the scientific movement in the allied countries.

The institution thus conceived was definitely established at the beginning of 1916 under the name of Office of Inventions and Research, acting as a department of the Ministry of Arms and Munitions, and under the direction of Senator V. Volterra, who was the authorized proposer and founder. The Minister of Education then authorized the directors of the universities, the heads of the other institutions of higher instruction, and the directors of the scientific and experimental bureaus to put themselves at the disposal of this office, and to correspond directly with it in order that predetermined objectives might be attained most rapidly. In the same way the mobilization was started of the scientific and technical department of our higher institutions of learning, and their relative personnel, with the exception of clinical and other similar institutions engaged in medical work, and they now work assiduously and efficiently.

Some of the institute directors came to Rome to form part of the central office, to coordinate and select the work according to the special aptitude of the personnel of the various local institutions, and the quality of material there available for the researches.

Along with the studies and researches on problems of various kinds and of immediate necessity, the study of inventions was brought under scientific supervision. We should notice that in large part the cases concern proposals made by persons who know little or nothing about the problem which their invention attempts to solve. For a group of those competent, it is easy to exclude, from the enormous number of inventions presented, those that have no foundation; then they may study those for which there is hope of succeeding. On the other hand, these same persons are in a position to engage themselves, each one in the branch of science in which he is most interested, studying the same problems and directing the line along which the same class of inventions must be worked out. More than that, it has been necessary to conduct systematic researches in order to learn the availability in Italy of the raw mineral products needed for certain war-productions; this problem was immediately attacked by our best mineralogists and geologists.

In this way the office promises also to be an institution of permanent utility when the present conflict has ceased and the work of the civilized world is again directed toward more profitable purposes of peace.

For evident reasons the moment for unveiling the results of the work of the Italian scientists for the war has not yet come. But at least we can give the names of the most efficient cooperators of Senator Volterra. Among them these ought to be remembered: Lori Nasini, Miolati, Piola, Fano, Vacca, Millosevich, Corbino, Occhialini, Trabacchi, Ciamician, Angeli, Martelli, Vinassa, Aloisi, Carrara, Dalla Vedova; of our universities and in the military and naval world, Avallone, Valsecchi, Vitali, Buffa and many others.

Although apparently there is no lack of persons and the already available methods are utilized as largely as possible, they are not sufficient. What must be done in Italy on a much larger scale than has been done heretofore is to bring scientific research into direct

relation with industry. The example given us by the United States, which has produced and knows how to produce on such a vast scale without losing sight of scientific research, must be followed to the farthest possible limit. The great industries of Ansaldo, Pirelli, Fiat, the Galileo factories, the Filotecnica, the Rossi Electrochemical factories, and many others which are based on the studies and researches conducted for years by the Italian scientists and engineers, are now having the opportunity to continue their work with the assistance of research laboratories which will perfect, increase and improve their production along lines peculiar to these establishments. But if it were possible for these laboratories to specialize in some branch of pure science without an immediate application, it would all be for the moral and educational gain of the establishment itself and still more of the country.

By means of the special representatives sent to the allied countries, we have been able to compare, step by step, with those made in our country, the conditions and development in the various Allied countries, the improvements made, and the researches which have increased and bettered the methods of offense and defense. Our cooperation with the United States has been and still is of great interest. Though they are geographically very far from the theater of war and have thus lacked the advantage of knowing at each moment what was needed and which ways were the most useful to follow, still their great richness of means and of materials have made it possible that from them and them alone could come that help which has brought us to victory. And close cooperation in scientific and technical matters is of the same importance as that exclusively military. The researches which we could begin with our better knowledge of the necessities and problems which were constantly arising on earth and on sea and in the air, could immediately be developed here where means and materials are not lacking.

When the great struggle is completely at an end, it will be possible to enumerate for the sake of history and as a help in times of peace, the studies and researches made; then we will see what an amount of work has been accomplished and what part has been taken by Italian scientists and engineers in the field of mathematics, and its application in ballistics, in engineering, in electrotechnics, in the natural sciences, in chemistry, in the navy, in artillery, in aeronautics. Notable results have already been attained in utilizing raw materials, which we could dispose of at home or in our colonies, and certain minerals have been discovered which are used in producing steel.

The progress made by Italy in aeronautics is already known. Especially in the construction of aeroplanes have notable results been obtained recently, by employing a *Sva* engine which has been evolved through the cooperation of theory and practise at the Direzione Tecnica dell' Aviazione at Turin. And that this collaboration was necessary and perfect is demonstrated by the aerodynamic qualities of this engine and its exceptional characteristics of flight—especially the small velocity necessary to support it in the air and its great stability.

In the field of dirigibles and of aerial artillery the Central Aeronautical Institute in Rome, which already long before the war had made and published aerodynamic studies under the direction of Crocco, Ricaldoni, Prassone, Bianchi and many others, was ready to do their share in the present war, in which the operations of our dirigibles have been universally noted. These dirigibles, which are certainly among the most perfect engines of their kind, are the results of long years of theoretical and practical study at the Institute of Rome. The aerial artillery, under Volterra and Crocco, has had a beginning which will make it a powerful weapon as soon as we can use it on a large scale on airships of any type.

Aerial navigation was made the object of special study, particularly on the part of astronomers, the necessary instruments were constructed, and for its practical application, courses for aviation pilots were instituted. The tables for the determination of the point, the lessons in aeronautics by Bianchi, and the

route indicator devised by Crocco might be mentioned in passing.

Meteorologists of the Army and of the Weather Bureau organized an Aerologic Service for the immediate use of the fighting armies on earth, on sea, and in the air, and specially interesting are the new methods for forecasting developed by Vercelli of the University of Turin.

In the field of marine engineering, especially in light craft for offense and defense, very notable results have been reached—from the engines to the hulls. In radiotelegraphy, naval and physical engineers have invented new instruments for the detection of submarines, and have sought to improve those already existing, in complete cooperation with the allies.

In wireless especially, the institutes of the Ministry of Posts and Telegraphs in Rome and that of the Royal Navy at Livorno have contributed to the study and to the improvement of the communication between the different belligerent units on earth, sea and air, and of transoceanic communication. Vallauri, of the Electrotechnical Institute of the Royal Navy, has published in the *Nuovo Cimento* a study on the functioning of vacuum tubes with three electrodes called *audion,* which can be considered as a first attempt at the theory of these tubes, which have many applications today in wireless.

In optics, precision laboratories were established under the direction of scientific men and the construction of optical instruments for war uses was improved in a notable manner. It may be sufficient to call to mind the work of the Galileo factory at Florence, especially in searchlights, periscopes and sighting instruments in general, the Filotecnica of Salmoiraghi in Milan, and the precision laboratory for the artillery in Rome.

For the sound ranging problem—that is, the determination of the position of the enemy artillery by sound—Garbasso, after the beginning of the war, founded the phonotelemetric service for use of our artillery, and in it several of our young physicists have found a field for technical and practical work.

In the field of photography there existed before the war a photographic section of the army, well known, especially for the works of Tardivo in telephotography and aerial phototopography. These immediately found application in war, and no matter whether from the air or the ground or the sea the photographic explorers, using the good apparatus designed and constructed by the section itself, contributed genuinely to knowledge of the enemy positions. Telephotography, especially in the regions of the Alps, was much used, and, when the censorship permitted, the results were in small part published, as for example in the panoramas of the war prepared under the direction of the Supreme Command of the Army.

Corbino and Trabacchi improved the working conditions of X-ray tubes, together with the application of devices for producing currents of high tension and of constant direction especially adapted to control them.

It was clear that Italian chemistry was ready when called upon. The already existing factories for explosives were enlarged and other large ones established, and our best chemists showed they knew how to push ahead and direct them, introducing new methods and courageously starting new ways of working. The numerous chemists who were selected for these war industries have given excellent account of themselves, as well as those who have been directing other industries also now engaged in war service.

Through the initiative of Prince Piero Ginori Conti, interesting studies have been made by Nasini and his students of the boraciferous "soffioni" of Larderello and of all the problems concerning boric acid, its by-products and the gaseous emanations of the soffioni already used in various ways. The volcanic energies of our soffioni, unconquered and yet conquered by the will of man, donate to national industry with generous and singular abundance, boric acid, ammonia, carbonic acid, radioactive emanations, heat, vapor and pressure. Illuminated minds and generous hearts knew how to transform desolate and frightful regions into busy and prosper-

ous industrial centers, where every day the vapors let out into the atmosphere are steadily diminished, but the amount conveyed in pipes, conquered and utilized in every way, increases.

On account of the growing difficulty in importing nitrates from Chile, much has been done in Italy in regard to the problem of nitrogen, but its solution, important in time of war for explosives, in time of peace for agriculture, has been by no means easy, although we may mention the Rossi Factory of Legnano, gratified to-day by merited success along this line. The air has no political boundaries, and its nitrogen has no owners; it is this nitrogen which has to serve to fertilize our ground, which has to give us nitric acid for our industries. Our abundant waters, which are our natural wealth, must some day, when systematized and rendered obedient, supply the electricity necessary to feed uninterruptedly the cycle of nitrogen, to return the precious element from the inexhaustible atmospheric reservoir to the ground to intensify the agriculture and the life of our country, without limitations of commerce, of treaties, of transports, of possible mineral exhaustion.

Among the electrochemical industries, we have firmly established in Italy that of calcium carbide, and in electrosiderurgy, the Stassano electric furnaces, by means of which we have attained success in preparing many special steels and ferro-silicon. By means of the electrolysis of fused salts we produce aluminium in a certain quantity.

The dye industry has resorted to the preparation of certain simple colors; it has revived the manufacture of vegetable dyes and obtained brilliant results.

A problem for which Italy has found no solution is that of fuel, although we have tried all possible means to improve and increase to the utmost the few resources of our miserly soil. How insoluble the problem is can be understood by comparing the 800 thousand tons of poor combustible which our soil produces with the 11 million tons of fossil which we have to import in normal times, for the greatest part from England. To improve, to the greatest degree possible, this state of affairs, studies have recently been made of the hydraulic problems and the necessary legislation in regard to the waters, for the purpose of utilizing in the best possible way, our resources of white coal, which, in part at least, free us from the necessity of importing black coal from abroad.

An interesting study on the subject of black and white coal in Italy has been published by Novarese of the University of Rome in the *Atti della Società Italiana per il Progresso delle Scienze* in 1916. The extraction and the use of our fossil coals known by the name of *picee* or *black* and *xiloid* or *brown* lignites, have received during these years of war a very decided impetus, the unjustifiable objection to them, which the consumer has always had, having been overcome. The study of the various fields and their coordinate utilization has been of great advantage for war purposes in times of difficulty, and has demonstrated that our lignites, save for the manufacture of coke, to which they are not adapted, could be substituted, as far as there was an available quantity, for the imported fossil coals in all the uses to which they are applied in our country, and in not a few cases with noticeable advantages. Along this line, especially important are the recent studies made in the United States on the use of pulverized coal and on combustibles in general, on the subject of which a vast and interesting amount of material has been published in the *General Electric Review*.

According to Novarese our very modest reserve will acquire considerable value if, in the coordination of services which must come in the production of hydroelectric energy, it is employed as an auxiliary source to supply the deficiencies which are experienced in all hydroelectric plants more or less every year in periods of ordinary or extraordinary scarcity of water. Our coal, therefore, ought to represent a reserve for extraordinary needs, whether due to meteoric changes, or to other causes.

In order to make use of our hydraulic energy, the various sources available are being studied, and both the surface and the under-

ground hydrography of our country. The Institute of the "Regio Magistrate alle Acque" of Venice, similar to the one which existed at the time of the glorious Republic, and that of the commission for the study of hydraulic regulation of the Po river are examples of activity in this problem, activity which has already led to noteworthy results in several regions of Italy. An important study of the evolution of dikes for artificial lakes in high mountains has been made by Dr. L. Luiggi, with interesting comparisons between the dikes constructed in the various countries of the world, especially in the United States, and conclusions on the mountain dikes in the high valleys of the Alps and Apennines. In these valleys it may be possible to make numerous artificial lakes, in order to utilize better our hydraulic resources, whether to create electric energy, destined especially for the electro-metallurgical and electrochemical industries, or to fertilize arid ground which, if irrigated properly, would produce more and better, or merely to drain unproductive or malarious regions, which with mechanical drainage could rapidly be put under cultivation.

The steel industry, which can not be attempted by us on the vast scale it is in other nations rich in iron and coal, has increased noticeably. During the war the siderurgical production of Italy was almost doubled in comparison with preceding years. We did not need to make changes in technical processes, but we completed plants for producing metallurgical coke and furnaces with apparatus for the extraction of by-products, increased the number of electric furnaces for steel, and constructed new hydroelectric plants or made use of energy from other societies already established.

In the medical sciences, the mobilization of the whole personnel and all the scientific resources in the country has met admirably the needs of the war; in our organized medical service, which is considered one of the best in existence, we have also found the time and means to make interesting researches and publish reports on them. The physiologists occupied themselves essentially with the problem of alimentation, and a scientific committee which applied itself to the various questions connected with the subject was appointed. During the war the studies and experiments of the physiologist Lo Monaco of the University of Rome were made on the action of sugar on the bronchial secretions. According to these studies, sugar in solution inoculated under the skin of those suffering from respiratory diseases, determines a rapid decrease in the quantity of bronchial secretion, which is gradually reduced until finally it ends completely.

In the field of the economic and political sciences, our studies and discussions on the principle of nationality are especially interesting at this moment. Senator Francesco Ruffini brought to light and discussed in one of his lectures another lecture given January 22, 1851, by Pasquale Stanislao Mancini, while exiled by the Bourbons, with which he inaugurated the first course in international law given in Italy. The title of Mancini's lecture is "On Nationality as Foundation for the Law of the People," and it has remained famous in the history of International Law, constituting probably the most modern and original page of the science of public law which has been written by an Italian hand in the past century. The economists and the men of letters of "Italia irredenta" have contributed in an efficient manner to the study and knowledge of all the problems which should find their natural solution in these times.

In the geological and geographical sciences, publications for actual and immediate use have been edited, such as the Report of the Commission for the study of Albania, and the studies on Dalmatia and Alto Adige. The Royal Italian Geographic Society has published the studies and conferences of Baratta, Taramelli, Martelli, Dainelli, Vinassa, Sillani and Tamaro, showing the Italian characteristics of those regions and presenting the justice of our aspirations.

Although this review is necessarily incomplete, yet it may be an incentive to look into the future and foresee what must be done to

continue the collaboration between the scientific and industrial elements of the country and the exchange of proposals and the united action for scientific and moral progress between the allied countries, specially what concerns the United States and Italy, who, during this war, have had opportunity to know and appreciate each other more thoroughly than before.

The institution, which, in the United States, is parallel to our Ufficio Invenzioni e Ricerche and the analogous institutions in France and England, is the National Research Council founded by Dr. G. E. Hale, which works as a scientific and research office acting as a department of the Council of National Defense.

In regard to the cooperation of the United States with the Allied countries we remember that on the entrance of the United States into the present struggle the following telegram was sent by Dr. Hale, foreign secretary of the American National Academy of the Sciences to the Royal Society of London, the Académie des Sciences, to the Accademia dei Lincei of Rome, and to the Russian Academy of Sciences, namely, to all the important scientific units with which the American Academy has cooperated for many years in the International Association of Academies:

> The entrance of the United States into war unites our men of science with yours in a common cause. The National Academy of Sciences acting through the National Research Council, which has been designated by President Wilson and the Council of National Defense to mobilize the research facilities of the country, would gladly cooperate in any scientific research still underlying the solution of military or industrial problems.

As a result of this invitation missions composed of men of science were exchanged by the various allied nations and a research information committee was established in the National Research Council, represented at Rome, Paris and London by scientific attachés at those embassies. Exchange of ideas and progress in their common work have been and are still continuous and constant. and, speaking especially of Italy, they have brought their results, although greater progress is expected with the increase in exchange of persons, ideas and facts.

The extended program of Dr. Hale for an interallied research council also plans for after the war an interallied institution that provides the means of reaching a common agreement as to what researches are most vital and ought to be begun because of the pressure of economic necessity or in light of recent progress, and has the privilege of selecting the countries or institutions best adapted to undertake certain researches and of finding the best methods to coordinate the work of the investigators of the different countries. This project was presented by Dr. Hale with complete success at the meeting of the academies in London. Thus were laid the foundations for a cooperation which will surely be fruitful of results, especially in the long work of readjustment and reconstruction which is going to begin with the desired conclusion of peace in the world.

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THE PERSONAL RELATION OF THE INVESTIGATOR TO HIS PROBLEM[1]

As president of the local chapter it is my privilege to welcome you to membership in Sigma Xi and to say a few words concerning the main purpose of the society, the furthering of original investigation in science. I shall confine myself to the question of the personal relation of the investigator to his problem.

As a preliminary consideration it is well to emphasize the unlimited possibilities of scientific investigation. I have been asked by a member of our faculty, not in scientific branches, what scientists will do when they have discovered everything that is to be known about natural phenomena. The obvious answer is of course that instead of approaching such a consummation we are rapidly moving away from it. The number of things to be

[1] An address to newly initiated members of Sigma Xi at the University of Illinois, May 21, 1919.