that June follows May, longer to go back and find a subject for a verb than to go forward and find an object for it, longer when given a quality to find an object possessing that quality than to recall a quality for an object, and so on.

We may here also conveniently consider the overlapping of mental processes, which we have found takes place whenever a series of simple processes, or a complex process involving many simple ones, is performed. The general truth that the time of a complex mental operation is less than the sum of the times needed for the performance of the separate factors into which the former may be resolved, will be again illustrated. Thus Münsterberg finds that it takes 103σ to name a specific instance of a class (e.g., to name a German river), 992σ to make a comparison, (e.g., Which is more important, — this river or that?) but only 1049σ to decide both questions together (e.g., Which is the most important German river?) In this case we clearly recognize that the last processes are not the sum of the preceding two, but that the category "most important German river" is already formed in the mind. The following comparisons are more illustrative. Instead of asking first, "Which is the most important German river?" (1049σ,) and then, "Which lies more westerly, — Berlin, or the most important German river?" (992σ,) we ask at once, "Which lies more westerly,— Berlin, or the most important German river?" and find the time 1855σ, or 176σ less than the sum of the two foregoing processes. Similarly, if instead of asking first, "On what river is Cologne situated?" (848σ,) and then, "Which is more westerly, — the Rhine or Berlin?" (992σ,) we ask at once, "Which is more westerly, — Berlin, or the river on which Cologne is situated?" we find a more remarkable saving of time (1314σ, or 526σ less than the sum of the two questions). This time was still further reduced to 1149σ when the question was preceded by a list of a dozen cities.

(3) *Unlimited Associations.* When we pass to the re-action of naming as rapidly as possible any word whatever, that is suggested by a given word, we are drawing entirely upon the natural associative habits of the individual, and accordingly this method has been most useful in studying psychological habits and tendencies. Our present purpose, however, is only with the time-relations of this unrestricted association. This has been the type of association first and most frequently investigated, and it is customary to speak of the pure association time as the total time minus the time needed to repeat a word. Thus Münsterberg repeats a word in 382σ, and calls out a word in association with the given word in 896σ. Trautscholdt, however, who experimented upon Wundt, Stanley Hall, and two other subjects, finds an average time of 1024σ, 727σ of which is regarded as the pure association time. Galton and others have made estimates, by rougher methods, of the rapidity with which trains of ideas pass through the mind, and the result is a rate not differing much in either direction from one association per second. It will be recognized at once that this process will be very different in different individuals and with different words. Münsterberg's shortest association was "gold–silver" (390σ); the longest, "sing–dance," "mountain–level" (1100σ–1400σ). Trautscholdt also found "gold–silver" a very quick re-action (402σ), "storm–wind" (368σ), "duty–right" (415σ). Long re-actions were "God–fearing" (1132σ), "throne–king" (1437σ), "Karl–August" (1662σ). Some interesting inferences result from the consideration of the times of different types of these unrestricted associations. Trautscholdt divides these into "word associations," or those suggested by the word rather than by the thing; "outer associations," or those relating to the sense-qualities of the object; and "inner" or logical associations. The results were 1033σ, 1028σ, 989σ, though this order may be liable to individual differences. Cattell and Berger have also compared the re-action times to concrete nouns (374σ, pure association time), to less concrete nouns (462σ), to abstract nouns (570σ), and to verbs (501σ), clearly showing that concrete terms are more readily suggestive than abstractions, and concrete objects more so than actions. Trautscholdt finds for associations to concrete nouns, 710σ; to actions, 837σ; to abstractions, 871σ.

Many of the influences to which we found simpler forms of re-action times open, are doubtless true of association times, but the great variability of the latter makes these difficult to establish. The effect of practice is noticed by Trautscholdt; and Cattell has shown that in students from thirteen to eighteen years of age a distinct shortening of the association time accompanies growth and education, while the students ranking higher in class have a somewhat shorter time than those standing low in class. Fatigue very readily enters, the accessible associations are easily exhausted, and the mind repeats itself very markedly. Changes under the action of drugs and in morbid mental states have been incidentally noticed, but still await systematic investigation.

The various processes, the times of which we have been studying, by no means exhaust the possibilities in this field. As our knowledge of mental operations becomes more perfect and more capable of experimental study, and as our power of analysis makes similar progress, the study of the time-relations of mental phenomena, already fertile in suggestions and results, will increase in interest and importance.

JOSEPH JASTROW.

MODERN EXPLOSIVES AND FLUID FUELS.[1]

SIR FREDERICK ABEL commenced with a reference to the great names in art and science which Leeds could claim as its own. He next proceeded to refer to the advances made in electrical science and its application to industrial purposes; dealing with the history of the subject since the association last met in Leeds, in 1858, and bringing it to the present day by a reference to the scheme now on foot for utilizing the power of the Falls of Niagara, electric welding, and electric smelting, the latter in connection with the production of aluminium alloys. The influence of manganese, chromium, aluminium, nickel, etc., in the manufacture of steel, was also touched upon in the address.

It was, however, when the president reached that part of his speech in which he dealt with the appliances of war, that his audience felt they had reached the most important part of his address. He traced the history of the application of gunpowder from early days, and showed how great had been the advance since the last meeting in Leeds, but more especially in quite recent times. When Sir Frederick first actively turned his attention to the subject, Doremus, in America, had proposed the employment in heavy guns, of charges consisting of large pellets of prismatic form. This powder was first used in Russia. The subject was followed up in England, Germany, and Italy. The researches of the Government Committee on Explosives, in which, as is well known, Sir Frederick and Capt. Noble took the leading part, were

[1] Abstract of an address delivered at the annual meeting of the British Association for the Advancement of Science at Leeds, Eng., by the president, Sir Frederick Abel.

also referred to at some length. The "cocoa" powder was produced, which is a prismatic powder containing a very slightly burned charcoal of reddish-brown color, the action of which is comparatively gradual and long sustained. The smoke from this differs but little in volume from that of black powder, but disperses much more rapidly. Even more gradual action yet was required in the case of guns of large caliber, and the brown powder has been modified to meet the case. The desirability of producing a smokeless powder has led many to attempt the use of ammonium nitrate, in which the products of decomposition are, in addition to water-vapor, entirely gaseous. Its deliquescent character has, however, been a formidable obstacle to its application as a component of a useful explosive agent. An ammonium-nitrate powder has, however, been manufactured in Germany which possesses remarkable ballistic properties, and produces comparatively little smoke, which speedily disperses. No great tendency is exhibited by it to absorb moisture from an ordinarily dry, or even somewhat moist, atmosphere; but it readily absorbs water when the hygroscopic condition of the air approaches saturation, and this greatly restricts its use. Sir Frederick next referred to the introduction in France of melinite; but this has now been succeeded by more than one smokeless powder, and the material now in use with the Lebel rifle belongs to a class of nitro-cellulose, or nitro-cotton preparation.

A comparison between the chemical changes attending the burning or explosion of gunpowder, and of the class of nitro-compounds represented by gun-cotton, at once explains the cause of the production of smoke by the former, and of the smokelessness of the latter. While the products of explosion of the nitro-compounds consist exclusively of gases and of water-vapor, gunpowder, being composed of a large proportion of saltpetre or other metallic nitrate, mixed with charred vegetable matter and variable quantities of sulphur, furnishes products of which over 50 per cent are not gaseous, even at high temperatures, and which are in part deposited as a fused solid (which constitutes the fouling in a fire-arm), and in part distributed in an extremely fine state of division through the gases and vapors developed by the explosion, thus giving to these the appearance of smoke as they escape into the air.

So far as smokelessness is concerned, no material can surpass gun-cotton; but, even if the rate of combustion of the fibrous explosive in a fire-arm could be controlled with certainty and uniformity, its application as a safe propulsive agent is attended by so many difficulties, that the non-success of the numerous early attempts to apply it to that purpose is not surprising. Those attempts consisted entirely in varying the density and mechanical condition of employment of the gun-cotton fibre. No difficulty was experienced in thus exercising complete control over the rapidity of burning in the open air; but when the material was strongly confined, as in the bore of a gun, such methods of regulating its explosive force were quite unreliable, as some slight unforeseen variation in the amount and disposition of the air spaces in the mass would develop very violent action. Much more promising results were subsequently obtained by reducing the fibre to a pulp, as in the ordinary process of making paper, and converting this into highly compressed, homogeneous masses. But although comparatively small charges often gave high velocities of projection, without any indications of injury to the gun, the uniform fulfilment of the conditions essential to safety proved to be beyond absolute control, even in guns of small caliber; and military authorities not being, in those days, alive to the advantages which might accrue from the employment of an entirely smokeless explosive in artillery, experiments in this direction were not persevered in. At the same time, considerable success attended the production of safe and uniform gun-cotton cartridges for sporting-guns and the Martini-Henry rifle.

Sir Frederick next referred to the sporting-powder of Capt. Schultze, the E. C. powder, and the smokeless powder of Mr. Alfred Nobel. He also spoke of the action of camphor and liquid solvents when applied to hardening compressed masses of gun-cotton. The nitro-glycerine powder first produced by Mr. Nobel was, he stated, almost perfectly smokeless, and developed very high energy, accompanied by moderate pressures at the seat of the charge; but it possessed certain practical defects, which led to the development of several modifications of that explosive and various improvements in manufacture. The relative merits of this class of smokeless powder, and of various kinds of nitro-cellulose powder, were under careful investigation in this and other countries, and several more or less formidable difficulties have been met with in their application, in small-arms especially. These arise in part from the comparatively great heat such explosives develop, which increases the erosive effects of the products of explosion, and in part from the more or less complete absence of solid products. The surfaces of the barrel and of the projectile, being left clean after the firing, are in a condition favorable to their close adhesion while the bullet is propelled along the bore, with the consequent establishment of very greatly increased friction. The latter difficulty has been surmounted by more than one expedient at the cost of losing absolute smokelessness.

Our knowledge of the results obtained in France and Germany with the use of smokeless powders in the new rifles and in artillery is somewhat limited. Our own experiments have demonstrated that satisfactory results are attainable. The importance of insuring that the powder shall not be liable to undergo chemical change detrimental to its efficiency or safety, when stored where it may be subject to considerable variations of temperature, necessitates qualities not very easily secured in an explosive agent consisting mainly of the comparatively sensitive nitro-compounds to which the chemist is limited in the production of a smokeless powder. It is possible, therefore, that the extent of use of such a material in our ships, or in our tropical possessions, may have to be limited by the practicability of fulfilling certain special conditions essential to its storage without danger of possible deterioration. If, however, great advantages are likely to attend the employment of a smokeless explosive, it will be well worth while to adopt such special arrangements as may be required for securing these without incurring special dangers. This may prove to be especially necessary in our ships of war, where temperatures so high as to be prejudicial even to ordinary black powder sometimes prevail in the magazines, consequent mainly upon the positions assigned to them in the ships, but which may be guarded against by measures not difficult of application.

The press and other accounts of the wonderful performances of the first smokeless powder adopted by the French engendered a belief that a very great revolution in the conduct of campaigns must result from the introduction of such powders. It was even reported very positively that noiselessness was one of the important attributes of a smokeless powder; and highly colored comparisons have, in consequence, been drawn in service periodicals, and even by some military authorities, between the battles of the past and those of the future. The absence of recoil when a rifle was fired with smokeless powder was another of the marvels reported to attend the use of these new agents of warfare. It need scarcely be said that a closer acquaintance with them has dispelled the credit given to such of the accounts of their supposed qualities as were mythical.

The extensive use which has been made in Germany of smokeless or nearly smokeless powder in one or two special military displays, has, however, afforded interesting indications of the actual change which is likely to be wrought by these new explosives in the conditions under which engagements on land will be fought in the future. Although the German powder is not actually smokeless, the almost transparent film of smoke produced by independent rifle-firing is not visible at a distance of about 300 yards, and the most rapid salvo-firing by a large number of men does not have the effect of obscuring them from distant observers. When machine-guns and field artillery are fired with our own almost absolutely smokless powder which we are employing, their position is not readily revealed to distant observers by the momentary vivid flash of flame and slight cloud of dust produced. In the naval service, it is, especially for the quick-firing guns, so important for defensive purposes, that a smokeless powder has been anxiously looked for.

The ready and safe attainment of very high velocities of projection through the agency of these new varieties of explosive agents, employed in guns of suitable construction, would appear at first sight to promise a very important advance in the power of artillery. The practical difficulties attending the utilization of these results are, however, sufficiently formidable to place, at any rate at present, comparatively narrow limits upon our powers of availing ourselves of the advantages in ballistics which they may present. The strength of the gun-carriages, and the character of the arrangements used for absorbing the force of recoil of the gun, need considerable modifications; greater strength and perfection of manufacture are imperative in the case of the shells to be used with charges of a propelling agent, by the firing of which in the gun they may be submitted to comparatively very severe concussions; the increased friction to which portions of the explosive contents of the shell are exposed by the more violent setting back of the mass may increase the possibility of their accidental ignition before the shell has been projected from the gun; the increase of concussion to which the fuze in the shell is exposed may give rise to a similar risk consequent upon an increased liability to a failure of the mechanical devices which are applied to prevent the igniting arrangement from being set into action prematurely by the shock of the discharge; lastly, the circumstance that the rate of burning of the time-fuze which determines the efficiency of a projected shrapnel shell is materially altered by an increase in the velocity of flight of the shell, also presents a source of difficulty.

One of the first uses for purposes of warfare, to which it was attempted to apply gun-cotton, was as a charge for shells.

The author next again refers to the French melinite, and states that, although the secret of its composition was well kept, it soon transpired that the French authorities were purchasing large quantities of picric acid; and this led to the inference that this substance, known to be explosive, was used in the preparation.

The precise nature of melinite, Sir Frederick continued, appears to be still only known to the French authorities. It is asserted to be a mixture of picric acid with some material imparting to it greater power; but accounts of accidents which have occurred, even quite recently, in the handling of shells charged with that material, appear to show, that, in point of safety or stability, it is decidedly inferior to simple picric acid. Reliable as the latter is in this respect, its employment is, however, not unattended with the difficulties and risks which have to be encountered in the use, in shells, of other especially violent explosives. Future experience in actual warfare can alone determine decisively the relative value of violent explosive agents, and of the comparatively slow explosive, gunpowder, for use in shells; it is certain, however, that the latter still presents distinct advantages in some directions, and that there is no present prospect of its being more than partially superseded as an explosive for shells. Referring to submarine mines and locomotive torpedoes, such as the Whitehead and Brennan torpedoes, Sir Frederick stated that progress recently made in the practical development of explosive agents has not resulted in the provision of a material which equals wet compressed gun-cotton in combining with great destructive power the safety to those who have to deal with these weapons.

The president next proceeded to deal with the question of explosions in mines, dwelling at some length on the use of naked lights and safety-lamps,—a subject upon which he is, as is well known, an authority. The petroleum industry next occupied his attention, the following statistics being given of the product of the United States:—

In 1859, 5,000 barrels (of forty-two American gallons) were produced; in the following year the production increased to 500,000 barrels; while in the next year (1861) it exceeded 2,000,000 barrels, at which figure it remained, with slight fluctuations, until 1865. The supply then continued to increase gradually, until, in 1874, it amounted to nearly 11,000,000 barrels. In 1880 it amounted to over 26,000,000 barrels, and in 1882 it reached 31,000,000. Since then the supply furnished by the United States has fallen somewhat, and last year it amounted to 21,500,000 barrels. In addition to the petroleum raised in Pennsylvania, there is now a very large production in the State of Ohio, which is, however, transported by pipe-lines in great quantities to Chicago, for use as liquid fuel in industrial operations.

The production of crude petroleum in Russia was next referred to in the address. In 1863 the supplies from the Baku district amounted to 5,018 tons. They increased to somewhat more than double during the succeeding five years. In 1869 and following three years the production reached about 27,000 tons annually, and in 1873 it was about 64,000 tons; three years later, 153,000 tons were produced; and in the following five years there was a steady annual increase, until, in 1882, the production amounted to 677,269 tons; in 1884 it considerably exceeded 1,000,000 tons; and last year it was about 3,300,000 tons. The consumption of crude petroleum as fuel for locomotive purposes has, moreover, now assumed very large proportions in Russia, and many millions of gallons are annually consumed in working the vast system of railways on both sides of the Caspian Sea.

The imported refined petroleum used in this country in lamps for lighting, heating, and cooking, was exclusively American until within the last few years, but a very large proportion of present supplies comes from Russia. The imports of kerosene into London and the chief ports of the United Kingdom during 1889 amounted to 1,116,205 barrels of United States oil, and 771,227 barrels of Russian oil. During the same period the out-turn of mineral oil for use in lamps by the Scottish Shale Oil Companies probably amounted to about 500,000 barrels.

The prospects of less-known or less-worked sources of supply in other parts of the world were next touched upon. The subject led up to some remarks on the discovery and application of natural gas, which, in turn, brought water-gas before the meeting. No address delivered to a scientific body is now complete without some reference to technical education, and Sir Frederick naturally devoted a few paragraphs to that subject. The Imperial Institute also could not with decency have been excluded from an important delivery by its organizing secretary. Sir Frederick, however, with great moderation, confined himself to a few paragraphs on the subject. The address was of great interest, and was listened to by a large audience. It could, of course, have been made doubly instructive had its author dealt with Cordite, among the other explosives upon which he spoke; but this naturally would have been a breach of the conventionalities, for which, no doubt, Sir Frederick was sufficiently thankful.

HEALTH MATTERS.

Danger in Exercise.

THE *Providence Journal* quotes Dr. Patton, chief surgeon of the National Soldiers' Home at Dayton, O., as saying, in an interview he had in Pittsburgh, that, of the five thousand soldiers in the Dayton home, "fully 80 per cent are suffering from heart-disease in one form or another, due to the forced physical exertion of the campaigns;" and he made the prediction, according to the *Medical and Surgical Reporter*, that as large a percentage of the athletes of to-day will be found twenty-five years from now to be victims of heart-disease, resulting from the muscular strains that they force themselves to undergo. As for the likelihood of exercise to prolong life, it may be said, that, according to the statistics of M. de Solaiville, there are more people living in France to-day who have passed the age of sixty than there are in England, the home of athletic sports; and there is probably no nation in Europe more adverse to muscular cultivation for its own sake than the French. Great athletes die young; and a mortality list of Oxford rowing-men, published a few years ago, showed that a comparatively small percentage of them lived out the allotted lifetime. Dr. Jastrow has demonstrated in some very elaborate statistics that men of thought live, on an average, three years and a half longer than men in the ordinary vocations of life.

Decrease of Tuberculosis in England.

There is an instructive lesson in the English mortality returns from tuberculosis for the last forty years, says the *Medical and Surgical Reporter*. In the ten years from 1851 to 1860 the number of deaths from tuberculosis in persons from 15 to 45 years of age amounted to 3,943 in every million; from 1861 to 1870 it had fallen to 3,711; from 1871 to 1880 it was 3,194; and from 1881 to 1887 it did not exceed 2,666. The decreased rate is more marked in the female than in the male sex.