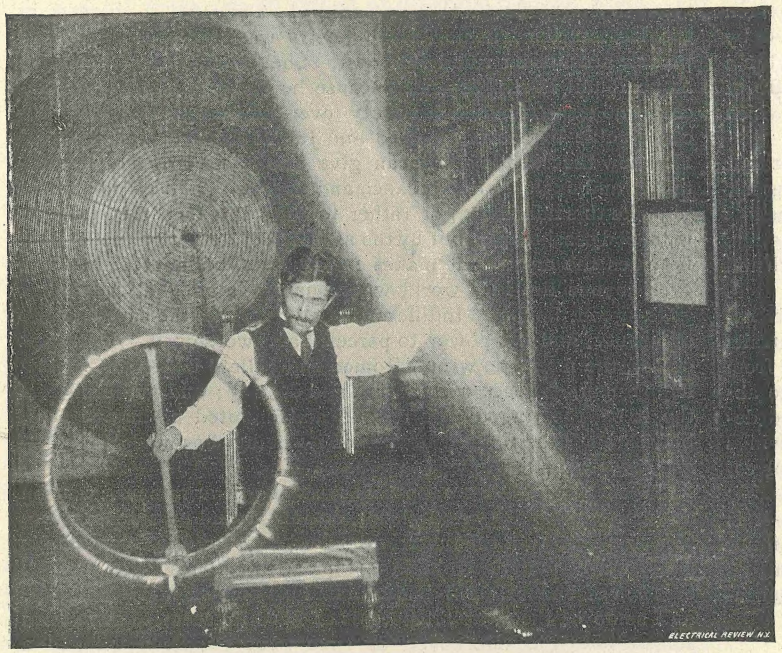
SCIENCE AND INVENTION.

RECENT EXPERIMENTS BY TESLA.

NIKOLA TESLA contributes to *The Electrical Review* (March 29) an illustrated account of some of his latest experiments in the building of improved induction-coils for the development of great electrical pressure. Mr. Tesla says that it is



SOME EXPERIMENTS IN TESLA'S LABORATORY WITH CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY.

The operator's body, in this experiment, is charged to a high potential by means of a coil responsive to the waves transmitted to it from a distant oscillator, and a long glass tube waved in the hand is lighted to great brilliancy by the electrical charges conveyed to it through the body.

Courtesy of *The Electrical Review*.

easier for him to invent than it is to perfect and to record his inventions. He puts it thus:

"Ideas come through a happy inspiration, apparently without much exertion; but it is the working out of the many harassing details and putting into a presentable form which consumes time and energy. It was impossible to abandon research in new directions, in which I have felt myself irresistibly drawn, and it was equally impossible to do full justice to the work partially completed, and I can only hope gradually to retrieve my losses by the only expedient available, which is to redouble the zeal."

The author pays his respects to the sensation-loving public, which at intervals attributes to his genius some new miracle, to the disgust of sober and slow-going, native-born scientists. "Some people," he says,

"have found a singular satisfaction in dwelling extensively in their columns on my proposed glass-house on Long Island, which was to cover acres of ground, and which was to be built for the purpose of catching the sun's rays; on my claims of the discoveries of Roentgen; on my invention enabling me to move and explode torpedo-boats by will power, and on my efforts to annihilate the entire British navy. It is to be hoped that the limits of patience of the readers have been finally reached."

The inventor next describes the process of thought that led him to devote special attention to the improvement of induction-coils. He says:

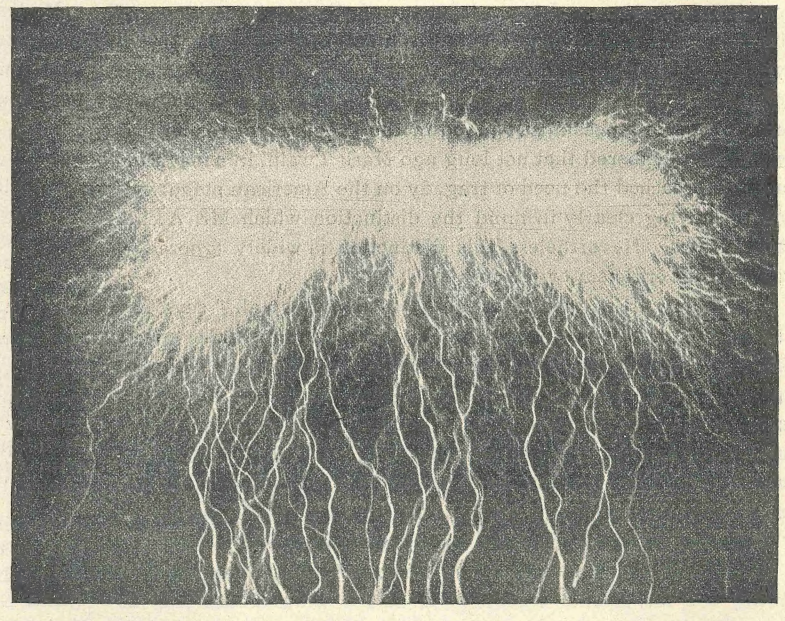
"The importance of the task of providing proper implements for research in these various fields once recognized, it became the question in what line the efforts to this end would be likely to be most profitable. A little thought showed that it was in investigating high electrical pressures, for these were needed in most instances. . . . . .

"Soon it was recognized that . . . generators of steady pressure were entirely impractical, quite apart from their incidental limitations. It was exactly as if one attempted to drive piles into the ground by the application of continuous pressure. This would require cumbersome and powerful machinery, and would be very inconvenient. An incomparably better way of developing high pressure is by delivering violent blows as with a hammer. In such a case the motion of the hammer being suddenly arrested pressure is developed on the point of impact, which is all the greater the smaller the displacement caused; and if there were material absolutely rigid, incompressible, and inelastic, an infinite pressure might thus be developed by a small blow. Hence one is forcibly driven to the use of a transformer or induction-coil as a means for producing great electrical pressures."

We can not follow the inventor in his detailed description of his work. The first difficulty he encountered was that of insulation, but by clever devices and by various alterations of position and arrangement in his primary and secondary coils, he finally attained remarkable results. His final and most radical improvement is thus described:

"During these efforts I fortunately discovered the important part which air played in the breaking down of the insulation, and by adopting proper methods for the exclusion of gaseous matter, I was able to increase the electromotive force to more than ten times the value without breaking down the secondary. I have described this method since, which I am using in the manufacture of coils and condensers, and without which it would be entirely impossible to reach any such results as I have obtained. The industrial world has profited by the recognition of the action of the air, for it has helped to extend power transmission to greater distances than heretofore practicable. . . . . . .

"Further experimentation . . . finally led step by step to the adoption of a coil of large dimensions. . . . With such a coil I found that there was practically no limit to the tension obtain-



PHOTOGRAPH OF AN ACTIVE TERMINAL OF AN IMPROVED OSCILLATOR, USED IN TESLA'S EXPERIMENTS FOR TRANSMITTING ELECTRICAL ENERGY TO GREAT DISTANCES WITHOUT WIRES.

Width of illuminated space is 18 feet—the pressure on the terminal is about eight million volts.

Courtesy of *The Electrical Review*.

liefs and dreams and joys and glories in the spirited adventures of other days. And it is thus that she gets very close to the heart of her people and race.

"There are plenty of warm descriptions—descriptions of the long lake, the rich plain, the steep hills, and the blue mountains of the province of Wermland. 'The Knights of Ekeby,' the book might almost have been named, but Gösta Berling, the dismissed priest, is the central figure and natural leader of the twelve of this new Round Table. Their mad adventures during a year of power fill the book. The volume is a series of pictures of the past arranged in panorama, and the gray old days are portrayed when men were both more brutal and more childish, and women were hardier and more beautiful—and all were controlled by elemental instincts and passions. Every act is exaggerated in a region of legendary lore, where there hovers an atmosphere of ancient sagas and where rule elemental nature forces to which man is bound subject.

"The author's style agrees with the matter. It is almost that of the ancient Norse poems again. There is a story, a legend, a saga to be told, and this begins in the simplest way. It begins and it is—there is no stopping to tell why it is, nor does it matter, it simply is. The simplicity of method is at once the strength and the charm of the book.

"The close kinship with the spirit of the saga goes further. The characters look and are dressed in keeping with their traits and names. Comparisons and figures of speech are taken from observance of nature, direct, strong, concrete, and nowhere abstractions. Everything is alive. Passions and wishes and desires are no longer qualities, they are hoarse ravens with wings of fire and claws of steel. And wolves are more than wolves, and magpies more than magpies.

"The book is not only a distinctly literary production—it is also a spiritual one. It may be symbolic, and if it has an inner meaning this can well be that in the struggle of forces in man's nature the moral must win over merely the esthetic and the sensuous."—*Translation made for* THE LITERARY DIGEST.

PESSIMISTIC AND TRAGIC ART: A DISTINCTION.

MR. WILLIAM ARCHER, one of England's foremost literary and dramatic critics, contends, in a recent review, "that tragedy is not necessarily an expression of personal gloom, any more than comedy is necessarily an ebullition of personal gaiety; and that a work of imagination makes for optimism or pessimism in the reader, not in virtue of the gaiety or gloom of its story, but rather in virtue of its inherent vitality or lack of vitality, the bracing or 'lowering' quality of the spirit which animates it." Thus, according to Mr. Archer, tragedy does not necessarily beget a pessimistic mood in the spectator or reader. It will be remembered that not long ago Mark Twain, in a magazine article, preached the need of tragedy on the American stage, evidently having clearly in mind the distinction which Mr. Archer here draws. Nevertheless, this distinction is widely ignored in the current criticism of the day.

"Ask any artist who is capable of tragedy at all," says Mr. Archer, "and it is ten to one he will tell you that his finest effects have been achieved in the happiest moments of his happiest years." Thus Shakespeare's four great tragedies are not in themselves any evidence of a prolonged mood of despondency and pessimism on the part of the author; nor does Mr. Archer admit them to be pessimistic in themselves. Pessimism, as distinguished from tragedy, he finds in "Troilus and Cressida," in "Timon of Athens," and, to a large extent, in the "Sonnets."

The following passages (*The Fortnightly Review*, March) bring out Mr. Archer's contention that a work of art may be tragic to a degree and yet inspire emotions the very reverse to a fear or a hatred of life. He is speaking, in the beginning, of "Romeo and Juliet":

"There is no ethical or psychological necessity for the tragic issue of the fable. By no strain of sophistry can it be made to 'justify the ways of God to man.' The lovers are 'star-crossed,' that is the last word of their saga. They fell victims partly to man's inhumanity, mainly to brute chance. If it were in the nature of man to quail before the terrors of his lot, who could endure to live in a world where youth and beauty, passion and innocence, may thus be hurled to annihilation by the miscarriage of a letter? But age-old experience assures us that if the artist can make man's lot seem moving, interesting, above all, beautiful, his audience will not shrink from its terrors. Nay, rather, they will be heartened to play their parts bravely and with a will upon so fascinating a stage. It would have been easy to give 'Romeo and Juliet' a 'happy ending.' They did so, indeed, in the Restoration Theater, when poetry was out of fashion, and prosaic sensualism ruled the roost. Shakespeare kept the myth, as he found it—tragic—not because he was a pessimist, but because he was an artist, a beauty-lover, and shrank from the inconceivable bathos of 'Romeo and Juliet Married and Settled.' He knew that death alone can give beauty its crown of immortality, and exalt it above chance and change. If it be pessimism to make this admission, or rather to state this fact, then tragedy is indeed pessimistic; but by the same act of definition, pessimism becomes the creed that makes for resolute, undaunted, healthy, even joyous life in a world where nature, among all her other gifts—good, bad, and indifferent—has given us the supreme gift of beauty, and the power to perceive and worship it. Pessimist or not, the man who wrote 'Romeo and Juliet' impresses us as a happy man, at peace with nature and destiny; and, infinitely sad tho it be, the tragedy has dashed and daunted no human soul, but, through the three centuries of its being, has made for courage, passion, and the will to live. . . . . . .

"Shakespeare, to sum up this part of my argument, was an artist to whom gaiety and gloom, optimism and pessimism, were simply qualities of the material he worked in, of the colors on his palette, all equally adaptable to the one end of his endeavor, the creation of beauty. No doubt he had his moods, like other men, and some of them, at all periods of his life, seem to have been somber enough. Moreover, as time went on, he developed a keener eye for the profound spiritual beauties of tragedy, and cared less for the arabesques of comedy, the pageant-frescoes of history. But there is nothing to show that Hamlet, Macbeth, Othello, and Lear, either expressed a personal disgust for life or were intended to beget, or did beget, any such disgust in others. We may rather assert that the mind which gave birth to these plays must have been in its full flush of healthy activity. When bitterness *did* get the upper hand, as in 'Troilus and Cressida,' it ousted the creative energy; and Shakespeare, while still a profound intelligence, ceased for the nonce to be a master artist."

Modern criticism, "not consciously, perhaps, but none the less insistently," says Mr. Archer, "demands the banishment of tragedy from the domain of modern art." His distinction between pessimistic and tragic fiction is stated concisely in the following:

"The only rational definition of a pessimistic novel or play is one which tends to discourage the reader, to put him out of conceit of life, to damp his ardor, to lower his vitality. But this is not necessarily the effect of tragedy, whether ancient or modern. Whatever the precise operation which Aristotle understood by his *katharsis* of the emotions, he evidently conceived it as a beneficial, an invigorating process; and invigoration may be gained from the tragedy of to-day no less than from that of twenty-five centuries ago. The old physiological conception of 'spirits' as a sort of vital essence permeating the frame may conveniently be transferred to imaginative literature. There are books in which the 'spirits' are high and intense, others in which the 'spirits' are low and flagging; and the line of cleavage between books of high 'spirits' and books of low 'spirits' is very far from coinciding with the line of cleavage between 'sad' books and 'happy' books."

Turning to the most recent literature for further illustrations of this distinction, Mr. Archer selects "Gösta Berling's Saga," by Selma Lagerlöf, and "The Open Question," by C. E. Raimond (Miss Elizabeth Robins). Of these two much-discussed books, the one gloomy throughout, the other painful in its conclusion, he says that they are both, to his thinking, "placed far above the reproach of pessimism by the inherent vitality, the love of life, even in its darkest aspects, which animates every page." Yet "The Open Question" has been hailed on every side as an embodiment of modern pessimism.

able, and it is by its means that I discovered the most important of all facts arrived at in the course of my investigation in these fields. One of these was that the atmospheric air, tho ordinarily a perfect insulator, conducted freely the currents of immense electromotive force producible by such coils and suitable accessories. So great is the conductivity of the air that the discharge issuing from a single terminal behaves as if the atmosphere were rarefied. Another fact is that this conductivity increases very rapidly with the rarefaction of the atmosphere and augmentation of the electrical pressure, to such an extent that at barometric pressures which permit of no transit of ordinary currents, those generated by such a coil pass with great freedom through the air as through a copper wire. Following up these promising revelations I demonstrated conclusively by experiments that great amounts of electrical energy can be transmitted to any distance through upper-air strata which are easily accessible, and since this truth has been recognized every fiber has been strained to realize such a transmission on a large scale. These two observations explain clearly the silent discharges noted frequently in dense-air strata, but three or four miles above the earth's surface. One more equally important fact I may mention, which was simultaneously observed. The discharges of such a coil, when of an electromotive force of a few millions of volts, excite powerful affinities in the atmospheric nitrogen, causing it to combine readily with the oxygen and other elements, particularly in the presence of aqueous vapor. So energetic are these actions and so strangely do such powerful discharges behave, that I have often experienced a fear that the atmosphere might be ignited, a terrible possibility, which Sir William Crookes, with his piercing intellect, has already considered. Who knows but such a calamity is possible? And who can tell with certitude that periodical cessations of organic life on the globe might not be caused by ignition of the air and destruction of its life-sustaining qualities, accidentally or as a consequence of some accumulative change? A lump of coal will lie for centuries unaffected in contact with oxygen, but the combustion once started, the process continues as long as there are elements to combine."

THE LIFE OF DISEASE GERMS OUTSIDE THE BODY.

WHAT becomes of a disease after it is cured? This is not an Irish bull. Diseases exist often in the soil, the air, or the water. It is well known that certain disease germs grow and thrive outside the human body. If these germs are to be fought successfully we should certainly know all about the conditions of such growth, with a view to making them as unfavorable as possible. When organisms of this kind grow thus in dead, as opposed to living, organic matter, they are called "saprophytes," and the saprophytic state of the microbes of disease certainly merits our close investigation. In the Milroy Lectures, just delivered at the Royal College of Physicians in London by Dr. G. V. Poore, these forms are studied. To quote an abstract of the lectures given in *The Hospital:*

"Dr. Poore describes the action of the earth in relation to the preservation and destruction of contagia, pointing out that the chemical composition of earth is constantly changing, and that its fitness for supporting the life of the various microorganisms that are found in it varies accordingly. Each of these microbes presumably grows best in what one may call its optimum conditions, and the smallest alteration in these conditions may turn the scale and decide which among the competing organisms shall obtain the mastery. In illustration of the curious exactitude of the conditions without which certain fungi will not grow, and of their extraordinary development whenever these conditions are fulfilled, Dr. Poore refers to the growth of mushrooms. 'Some of the larger saprophytes,' he says, 'such, for instance, as the common mushroom, require no little skill for their artificial production, involving far more attention to exact details than is necessary with the ordinary green-leaved garden plants. We know that for a few weeks in the autumn they may appear in great numbers in dry pastures where horses have been fed, provided that the conditions of the air as to temperature, light, and moisture be favorable, and we also know that directly the necessary conditions fail the mushroom harvest is at an end.' And it is clear that 'the optimum conditions for the growth and development of these short-lived and delicate organisms must be marvelously subtle, probably quite beyond the ken of the chemist.' Referring then to certain diseases, such, for example, as anthrax and tetanus, the germs of which are known to grow freely in certain soils, attention is drawn to the rarity with which men are attacked by them even when working on land which has almost certainly been infected. We are thus brought face to face with the importance of the extra-corporeal phases of microbic life in the maintenance of continuity of infection. Unfortunately, we seem to know but little in regard to the exact conditions under which the several pathogenic organisms are best able to maintain their existence in saprophytic form. Something we know about the bacillus of tuberculosis, and something we are beginning to know about that of enteric fever, but much more knowledge in this direction is badly wanted."

In this case the lecturer remarks, "the proper study of mankind" is not man, but what goes on in nature outside his body, for here is where we must look to get to the bottom of the problem of infectious disease, especially when it takes an epidemic form. To quote again:

"No longer must he [the pathologist] be content to study the action of the microbe within man's frame or the methods by which it brews toxins and sets up disease, but he must trace its life history outside, and find out what these infectious particles are doing and how they are living through the long interval that sometimes elapses between the termination of one 'case' and the development of another. One fine morning we look out upon our paddock and find it full of mushrooms; and another, altho we know that the spore is present just the same, there is not a mushroom to be seen. It was the conditions, not the seed alone, that made them grow. And this is a parable."

A GREAT SCIENTIST DEAD.

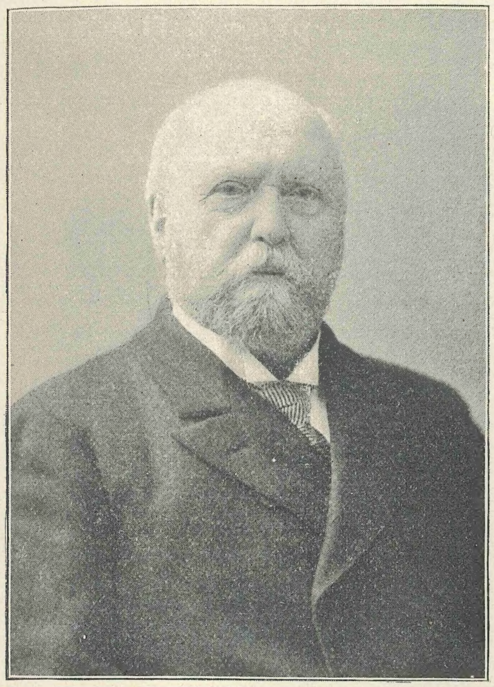
PROF. OTHNIEL CHARLES MARSH, of Yale University, who has just died, occupied a unique position among American scientific men, in that he was not only a skilled scientific worker, but a most generous giver to the cause in which he worked. The man who gives and the man who works are usually distinct, but Professor Marsh gave freely of his wealth to advance the cause for which he himself constantly toiled. We quote the following brief notice of his life from *The Engineering and Mining Journal* (March 25):

"Othniel Charles Marsh, who died at New Haven, Conn., March 18, was one of the best-known geologists in the world, his fame having long been fully established by his original researches. In his especial branch he was for years the highest authority, and his name is honored by geologists everywhere.

"He was born at Lockport, N. Y., October 29, 1831. In 1860 he was graduated at Yale University, and passed two years at the Yale Scientific School, fitting himself for higher studies in natural history. At first he became most interested in the study of mineralogy, but soon devoted himself to the problems of paleontology. He was fortunate in the discovery of a fossil reptile in the coal formation of Nova Scotia, the 'Eosaurus Acadianus,' which he reconstructed and fully described. This gave him at once positive rank and recognition among scientists.

"From 1862 to 1865 he studied zoology, mineralogy, and geology in Germany under Professor Ehrenberg and other eminent authorities in the universities of Berlin, Heidelberg, and Breslau. During his vacations he devoted himself to original investigations in the Alps and in the less known parts of Germany. By the time he had completed his studies abroad his fame had become firmly established in this country, as well as in Europe. A chair of paleontology was created especially for him at Yale; he accepted it in 1866 and held it until his death. During these thirty-three years he strove earnestly and in the most highly scientific method to increase the stock of facts about the fossil history of this continent, as well as to multiply the means for the careful study and classification of the specimens collected. In the latter field his greatest benefaction is the establishment of the Peabody

Museum at Yale. He was the nephew of George Peabody, and induced his uncle to give to Yale a fund that should be used for the erection and founding of a great museum of natural history. Much work had been done on the building and in the collection of specimens, but Professor Marsh died before the whole work was completed, as the fund had not accumulated sufficiently to warrant the building of the central structure and one of the wings. This will not be possible for several years yet, altho the fund is growing rapidly and the success of the museum is assured. Until it shall be completed it will not be possible to exhibit and use for study the great mass of specimens which he had collected.



PROF. OTHNIEL CHARLES MARSH.

"Professor Marsh selected as his special field of study the remains of extinct vertebrate animals, particularly those found in the region of the Rocky Mountains. His first expeditions led him to places so remote from the army posts, then the vanguard of civilization, that they had never been visited before by white men. In some of his excursions he had very narrow escapes from death at the hands of savages or from the exposure to the weather. He used to delight his classes at Yale, as well as scientific students and others who were fortunate enough to listen to his lectures or to his addresses, by narrating many of his adventures among the Indians.

"It was on these expeditions that Professor Marsh learned much about the outrages inflicted upon the Indians. He made representations to the Government that finally, after a long controversy with Secretary Delano, led to the retirement of the Secretary and the redress of some grievances of the red men. This was in 1875.

"Professor Marsh's studies and investigations have brought to light more than one thousand new species of extinct vertebrates that were not before known to have existed in this country. He published descriptions of more than three hundred of these, principally in papers in *The American Journal of Science*. Among them are a new sub-class of birds with teeth, odontornithes, and the first known American pterodactyles; two new orders of large mammals from the eocene-tertiary of the Rocky Mountains, the tillodontia, which seems to be related to the carnivores, ungulates, the rodents of elephantine bulk, bearing on their heads two or more horn-cores; also from the same formation, the epihippus, or the early ancestor of the modern horse, and the first monkeys, bats, and marsupials ever found in this country. He also discovered several new families of the dinosaurs, probably the largest land animals yet discovered. . . . . . .

"Professor Marsh was elected president of the American Association for the Advancement of Science in 1878, and in 1883 president of the National Academy of Sciences. He received many honors and degrees from scientific societies and universities. In addition to the degrees conferred upon him by Yale, he received the degree of Ph.D. from the University of Heidelberg in 1886, and in the same year Harvard conferred upon him the degree of LL.D. He was a member of the geological societies of London and Germany; of the Royal Irish Academy, the Royal Bavarian Academy of Science, and the royal academies of Denmark and Belgium. In 1898 he was awarded the prize of the French Académie des Sciences."

EXPLOSIONS FROM COMMON SUBSTANCES.

MANY serious explosions have been caused by common substances not generally known to be explosive or by substances that are explosive only under special or rarely occurring conditions. Cases of this kind are described in a recent address by Prof. Charles E. Munroe, printed in *Science*, March 10. We quote portions of this address below. Professor Munroe first speaks of the explosive power of finely powdered substances, of which he says:

"It is well understood that the speed of the combustion is greatly accelerated by comminuting the combustible and mixing it intimately with the supporter of combustion, and it is also well recognized that many explosions are due solely to very rapid combustion; yet it is only within comparatively recent times, and since manufacturing operations have come to be carried on upon a very considerable scale, that we have had it strongly demonstrated that ordinarily combustible solids might, when finely divided and mixed with air, give rise, on ignition, to most violent and disastrous explosions; and it seems especially notable that the first well-demonstrated cases of this kind should have arisen from the apparently harmless operations attending the grinding of grain, and the more particularly as flour is not looked upon as a very readily combustible substance when compared with other commonly used solids."

Professor Munroe describes some of the classical flour-mill explosions, including those at Glasgow, Scotland, in 1872 and that at Minneapolis in 1878. In the latter two millstones "striking fire" produced an explosion that destroyed large buildings, blowing fragments to a distance of two miles, and projected a column of flame to a height of six hundred feet. Of course to produce such an effect the flour must be very fine, must be thickly mingled with air, and must be confined in a closed space such as the "exhaust-box" of the mill. To quote further:

"Knowing the chemical composition of flour, we may calculate approximately the mechanical work which a given mass of flour can perform, and find that the contents of an ordinary sack, when mixed with 4,000 cubic feet of air, will generate force enough to throw 2,500 tons mass to a height of 100 feet. If we now consider the many tons of flour there must have been in a mill such as the Washburn 'A,' where as much as 1,000 pounds of dust per day was collected from a single pipe, we can readily comprehend how such great destruction could be wrought."

Of course flour is not the only powdered substance that will explode thus, and the author chronicles similar explosions of dust from oatmeal, candy, rice, malt, spice, sawdust, and even soap and metallic zinc. A curious kind of explosion is that which results from the unwitting production of an explosive in the compounding of drugs or in laboratory work. The volatile hydrocarbons are especially dangerous, and many disastrous explosions of benzene or other petroleum products have taken place both on land and by sea. Some of these are historical. Says Professor Munroe:

"Even where great precautions are taken to prevent accidents they not infrequently occur from inflammable substances being met with in unexpected places, or being introduced surreptitiously in admixture with harmless bodies. Nowhere, perhaps, is more care taken in this respect than on passenger steamships and in the naval service, yet eighteen years ago a series of accidents occurred on board English ships, the cause of which was for a time veiled in mystery and which, in the then existing state of