the process of continual disintegration. Their atoms are continually shooting off from themselves, with stupendous velocities, minute particles of matter, some of which are the cathode-ray particles themselves, and others of which are particles 4000 or 5000 times as large as these—that is, about twice as large as the atom of hydrogen.

If you look into a so-called "spintharisco pe"—an instrument invented by Sir William Crookes in 1903, and consisting of a tiny speck of radium placed just above a zinc sulphide screen and viewed with a common magnifying glass—you can almost see the particles projected. You do actually see the continual flashes of light to which they give rise when they impinge upon the zinc sulphide screen. Here, then, we are in the very presence of a disintegrating element. Have we yet found the products which are formed through this disintegration? Yes, in part, at least. In 1903, Sir William Ramsay, and Frederick Soddy, of London, found with the spectroscope that helium was one of the products of the disintegration of radium. Prof. Rutherford's investigations have made it probable that there are quite a series of such products. He thinks that ordinary lead is formed in this way. Again, only last year, it was shown by Prof Boltwood, of Yale, and by Frederick Soddy, that radium itself is only a disintegration product of uranium Hence, in the phenomenon of radio-activity we are actually in the presence of the transmutation of some of the elements into other elements. The three elements which thus far have been shown to exhibit this property—namely, radium, uranium, and thorium—possess the heaviest atoms of any of the elements. And these heavy atoms are spontaneously disintegrated into simpler forms.

I have given the answer of modern science to the first of the questions which we set out to answer. Chemistry has proved that the eighty elements are not independent, ultimate things. Astronomy and chemistry together have rendered it probable that all the elements are simply stages in the evolution of matter from simple into complex forms, the organic life which exists on the earth being simply the later end of this process of evolution from the simple toward the complex. Physics has found a way of producing out of ordinary atoms minute cathode-ray particles which are much smaller than atoms, and has also found that certain of our heaviest elements are in the very act of spontaneously transmuting themselves into simpler forms. To our first question, then, as to whether the elements are transmutable in the laboratories of nature, we may return the answer that certain of them, at least, are transmutable; and it is probable that in nature's laboratories all of them are being produced from some simple, primordial stuff.

Let us turn, now, to the second question—Can man effect the transmutation? Thus far he has indeed learned how to obtain cathode-ray particles from any of the different forms of matter; but he has not learned how to produce by any of the agencies at his command, any of the eighty recognised elements from any other He has caught nature in the very act of doing it herself; but none of the agencies now known to the chemist or to the physicist appear to be able either to accelerate or to retard the process, that is, to change in any way the rate at which radio-active substances are spontaneously transmuting themselves into other substances

It seems probable from the results already given, that the "Universal Solvent" which will produce this transmutation, and which is perhaps producing it now in the stars, is temperature, that the old Greek philosophers were right in assuming that a proper admixture of their old element, fire, would produce any desired transformation. But, unfortunately, the temperatures required to produce these changes, are probably for ever beyond man's reach The relatively little changes which we are able to produce on earth have no measurable effect at all upon the transmutations which uranium, radium, and thorium are undergoing. Although, then, our modern science has opened out before us a view which the ancient alchemist never had, of the wonderful operations going on in nature's laboratories, we are at the present day just as impotent as they in the face of the problem of the transmutation of any element into any other element If the secret of this transformation should ever be found we should be able to unlock almost infinite stores of energy which we now know to be wrapped up in the atoms of the elements The lamented Curie, whose untimely death has robbed science of one of her most gifted sons, proved in 1903 that the disintegration of a gramme of radium liberates at least 300,000 times as much heat energy as is evolved in the combustion of one gramme of coal. Furthermore, it is extremely probable that similar enormous quantities of energy are locked up in the atoms of all substances existing there in the form of the kinetic energy of rotation of the cathode-ray particles, now commonly called *electrons*. J. J. Thomson estimates that enough energy is stored up in one gramme of hydrogen to raise a million tons through a hundred yards It is not improbable that it is the transformation of this sub-atomic energy into heat which maintains the temperature of the sun. Should man ever be able to unlock this energy, he would doubtless look back upon the day in which his progenitors burned coal to warm their houses and to drive their engines, with the same curiosity and pity with which we look back upon the day when our naked ancestors ploughed their fields with a crooked stick, and lit their fires with the spark from a flint.—*Technical World.*

SPONTANEOUS COMBUSTION.

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OF the large number of fires which occur annually it is probably correct to say that the majority may be classed under one of three heads, fires due to incendiarism, fires due to ordinary carelessness, and fires due to spontaneous combustion. It is of course easy to imagine cases, for instance, fires following earthquakes which fall outside of the above classification; or again cases may occur in which the fire belongs partly to one and partly to another of the above three classes The classification suggested will, however, be found to cover the majority of cases

Of these three types it is the spontaneous fires to which the greatest interest attaches They are, to say the least, uncanny, and they are generally regarded as entirely beyond control. Let us see whether we can learn something of this class of phenomena.

In the first instance we must recognise that chemical changes are taking place around us perpetually, of which we take no heed until they are brought to our notice by some special circumstance Let us take an extreme case A block of granite, exposed to the weather, appears to be undergoing no change, nevertheless, the examination of any piece of granite that has been so exposed for years will show that great changes have taken place, and in particular that the feldspar is breaking down and yielding white china clay There is reason to believe that the weathering of the feldspar is accompanied by heat evolution, but so slow is the change that the heat evolution cannot be measured; for the equalising agencies of radiation and conduction dissipate the liberated heat so quickly that there is no perceptible rise of temperature

Take again the case of the exposure of an iron rail to weather even the most careless observer knows that rusting will take place Now, careful observation has shown that ordinary rusting or atmospheric oxidation of iron requires the presence (*a*) of moisture, (*b*) of carbonic anhydride, (*c*) of oxygen; and that the rate, and this is important, at which rusting will occur is considerably greater in a warm atmosphere than in a cold one Now, if the atmospheric oxidation of the iron take place at a sufficiently high temperature, the rate of chemical change is so great that the metal glows and becomes hotter and hotter up to a definite limit, a fact which is made use of in the ordinary Bessemer steel converter Any circumstance then which hastens the rate of chemical action may be regarded as a possible source of fire risk The circumstances which affect the rate of any particular chemical action are chiefly these (1) The temperature at which the reaction is carried out, (2) the presence of so-called catalytic substances which though apparently unchanged, serve in some way to profoundly modify the course of the action, (3) the state of subdivision, and hence the area and nature of surface of the substances which are undergoing change.

I Temperature In nearly all cases it is found that substances which enter slowly into chemical reaction in the cold will react vigourously at a higher temperature, the rate of action increasing in geometrical progression as the temperature rises in arithmetical progression When once, then, the temperature has risen to such a point that the rate of heat evolution is greater than the rate at which heat can be dissipated, the conditions for an ultimate flare are present Conversely, the cooling of a burning substance to a certain limit will cause the burning to stop, a fact well illustrated by the familiar experiment of extinguishing a burning candle by placing a spiral of cold copper in the flame At the temperature of liquid air very few substances appear capable of chemical action

II The influence of foreign substances in bringing about chemical actions may be illustrated in many ways. (1) A trace of spongy platinum will almost instantly cause a jet of coal gas to ignite in the air, the platinum remaining unchanged. (2) A small quantity of iron oxide may render chlorate of potash explosive, though the oxide appears to be itself unacted on (3) In the absence of a trace of moisture, phosphorus burns with difficulty, even in oxygen.

III. As illustrating the influence of state of subdivision upon the rate of chemical reaction, it may be mentioned that very finely divided iron and lead oxidise so rapidly in atmospheric air that they eventually catch fire—an exceedingly interesting experiment.

If we once firmly grasp the idea that all combustible substances exposed to the air are really undergoing a slow combustion process, and that it is only necessary to hasten the process in order to get an outbreak of fire, we shall, I think, be filled with wonder that the number of such so called spontaneous (Latin *sponte*—of free will) fires is not much greater than we actually find it to be.

Let us now turn to a few specially interesting cases of spontaneous combustion.

I Firing of coal in a ship's bunkers This is perhaps the commonest of the spontaneous firings. Experience shows that such fires occur most readily if the coal be finely divided, if the coal be moist, if the quantity stocked in one bunker be large, and if the ventilation be inefficient. With small quantities and proper ventilation the heat generated by the slow combustion is carried away as rapidly as it is generated, and hence no dangerous rise of temperature can occur Highly sulphurous coals containing finely divided iron pyrites are particularly to be regarded with suspicion.

II Firing of haystacks This phenomenon is almost invariably due to the stacking of hay in an insufficiently dried condition The rise of temperature under such circumstances is often extraordinarily rapid, and in the first instance appears to be undoubtedly due to bacterial action. The temperature being thus raised to a point at which atmospheric oxidation of the vegetable matter can proceed more rapidly than the generated heat can be dissipated from the mass actual incandescence will eventually be brought about In the making of ensilage the original fermentation and rise of temperature occur, but, owing to the fact that the silo is under great pressure, the supply of air is insufficient for rapid oxidation to further increase the temperature of the mass.

III. Firing of greasy rags. Many mills have been destroyed owing to this cause. The initial rise of temperature is due to rapid absorption of oxygen by the large surface of grease exposed to the air in a thin layer Most animal and vegetable oils are liable to cause these accidents, but of all oils linseed oil appears to be the most dangerous on account of its great affinity for oxygen.

IV. The cause of wool fires on ships appears to offer no special points for consideration The evidence appears to be overwhelming, that if wool is shipped in a clean and dry condition the risk is practically nil, but we shall await with interest the report of the Royal Commission which is now investigating the phenomena from the New Zealand standpoint.

V Spontaneous combustion of explosives. This is a peculiarly interesting case. In an explosive we place certain substances which have a great tendency to chemical action in such close proximity that they will not, we hope, act upon one another rapidly at the ordinary temperature When we wish to bring about the explosion we hasten the action to begin either by detonation or rise of temperature Sometimes the reaction begins "spontaneously" if it does there is little evidence for the coroner

Paper Gas Pipes.

PAPER has proved itself a valuable substitute for iron and wood in a variety of ways. It is now used for making pails, tubs, and other domestic articles. Car wheels are also made from it, and are superior to the metal product in toughness, resistance to vibration and durability.

The latest application is in the making of gas pipes For this purpose manila paper is cut in strips of a width equal to the length of the pipes to be made These strips are placed in a reservoir filled with fused asphalt, and are rolled firmly and uniformly around a rod or core of iron, until the desired thickness is obtained Strong pressure is then applied, after which the exterior is covered with sand, and the whole cooled in water. The core is then removed, and the outer surface covered with some water-proof material

These pipes, it is claimed, are perfectly tight, and are more economical than metal pipes.