

section, and can be put by her in direct communication with the 6,000 subscribers of the same line. Such communication is made by the aid of a flexible cord, one of whose extremities communicates with the subscriber calling upon the board, while the other terminates in a jack that is introduced into the hole corresponding to the subscriber called up on the section of the person wanting him. But after the communication has once been established, it is necessary that it shall be interrupted after the conversation has come to an end.

In the multiple switchboard it is the telephonist of the caller who alone is informed as to the end of the conversation, thanks to a special annunciator interposed in the circuit of the flexible cord that she has used for putting the two subscribers in communication. When the two subscribers hang up their telephones and send the current of the battery into the line, the annunciator falls. The telephonist then pulls out the jacks of the flexible cord connected with the annunciator, and thus renders the two lines free, and replaces them in the position of rest.

The putting of any two subscribers in communication therefore sets at work only the telephonist of the caller, and never that of the person called, whose line may be occupied without her being aware of it.

It is necessary, however, to give each telephonist a means of knowing at every instant whether or not the line of one of the six thousand subscribers is in communication with another subscriber, that is to say, whether or not such line is disposable or occupied, since otherwise one would run the risk, according to the arrangement of the system, either of cutting off a communication already established or of putting in communication three subscribers whose relations—telephonic—are sometimes strained.

The indispensable information as to the occupation or non-occupation of a line is obtained very simply by the aid of the "trial key," the principle of which is as follows: When a line is unoccupied, it is electrically insulated from the ground and forms a complete metallic circuit without a contact of any sort with the earth or any source of electromotive force whatever. Under such circumstances, if any point whatever of such line be touched with a key connected with the earth with the interposition of a magnetic telephone, the latter will remain silent, since this contact with the insulated line will not cause any current to pass into it. The line is free, and the telephone gives an indication thereof through its silence. But if the line is occupied through the interposition of a jack, the latter is so combined as to put the point of the line in which the jack is situated in communication with the earth, but in interposing between the latter and the line a battery of a few elements. The entire insulated line is thus raised to the potential of the battery. If now a circuit be established between any point of this line and the earth through the interposition of the trial key and the telephone, the latter will cause a characteristic "click" to be heard that indicates that the line is occupied.

The telephonist of the calling subscriber obtains the information thus demanded as to the occupation or non-occupation of the line without discommoding the telephonist of the subscriber called and without her knowledge.

As may be surmised, it is the same telephone that serves the telephonist for hearing the subscriber and for verifying the state of occupation or non-occupation of the line of the subscriber whom it is desired to call. To this effect, the cores of the telephone are provided with two windings, one of which serves to indicate the occupation of the line, through the characteristic "click," while the other serves for the ordinary conversation with the calling or called subscriber.

Telephone Apparatus of the Office.—For the easy and rapid manipulation of the keys and jacks, the telephonist must have her hands free while listening to the subscribers, both in calling them and in answering them. To this effect, the microphone transmitter is suspended by two flexible cords that pass over pulleys fixed to arms mounted upon the upper moulding of the switchboard (Fig. 1). These microphones are balanced by counterpoises and remain at the level at which they have been placed on raising or lowering them by hand, so that the telephonist can perform her duty while seated or standing, just as she wishes, and adapt the position of the mouth piece to her stature. The microphone itself, which is of the Hunnings system, does not differ in principle from the granular carbon apparatus of which one of the first types was devised and brought out by Mr. D'Argy. Its sensitiveness is such as to allow the telephonist to speak in a low voice, and nothing is more curious to one who has visited the stations of the old system than to compare the true silence that reigns in a modern office during the hours of telephonic activity with the insupportable chatter that characterized the old offices. The receiving telephone, which presents no special feature, is held against the telephonist's ear (right or left, at her choice) by a light flat steel spring curved to fit the top of the head. The weight of the entire apparatus does not exceed four and a half ounces.

The Putting in Communication of Subscribers who do not Belong to the Same Office.—In describing the Gutenberg Street office as established for 6,000 subscribers, we have said that the large switchboard comprises but 23 sections, which, in the proportion of 240 subscribers to the section, represents but 5,520 subscribers, while there are 6,000 holes in the complete board. The 480 other holes serve for the auxiliary lines connecting the various offices with each other and for the secondary services, upon which we cannot here dwell. When a subscriber requests communication with another subscriber not belonging to the same office, such communication is established by having recourse to auxiliary lines. To this effect, there have been established auxiliary outgoing lines and auxiliary incoming ones. The former serve each telephonist for calling the other offices, while the latter, on the contrary, are used by the other offices for calling that of Gutenberg Street. The outgoing lines of one office are therefore in reality the incoming ones of the other office at which they end, and reciprocally. The adoption of a single direction of call for each auxiliary line effects an important simplification in the service and in the apparatus.

Suburban and Interurban Communications.—The interurban communications form a less extended sys-

tem as regards the number of subscribers. They are established in a special office in the entresol of the Hotel des Telephones and occupy a switchboard that is not so large as the multiple one of the first story reserved for city communications. The communications between the subscribers of the system and the suburban or interurban lines are established by the aid of a special switchboard which precedes the section boards of the city service and which has the effect of directly switching the line of an office subscriber upon the interurban lines without passing through all the sections of the board, so as not to introduce into the long distance line the prejudicial capacity of all the wires of the multiple board. A subscriber thus switched on to the interurban line becomes isolated from the city one, but the key serving to effect such switching puts all the jacks in communication with the ground and a battery, in order that the telephonist may be notified of the non-disposability of the line voluntarily switched on to the interurban one when the subscriber is called, and that the calling telephonist may test the line, in order to assure herself of its state of occupation.

From what we have just said may be surmised what an enormous number of wires is used for a multiple switchboard for 6,000 subscribers, and the number of connections to which it gives rise. There are more than a hundred to the subscriber, and, in taking into account the auxiliary lines, suburban and interurban, we have more than a million. There suffices but a single bad connection to immobilize a subscriber's line. A bad contact, a break, or a poor insulation of the line wires produces the same result. A subscriber whose battery is exhausted or broken can no longer call up the central station. If he has forgotten to hang up his telephone, the central office can no longer call him up.

Taking into account the great complication introduced into the exploitation through the absence of call by number—the only logical and rapid system—it is now explainable that the telephonic communications undergo delays or interruption for which the telephonist or the administration, which can do nothing in space, is too often held responsible.

We cannot too often repeat the statement that the difficulties are great and that the incessant evolution of telephonic apparatus is not yet going on quickly enough to respond to the continuously increasing exigencies of a perfect service.

As yet we have said nothing of the Hotel des Telephones, in which is installed the entire service, whose broad lines we have just indicated.

This building, constructed back of the Post Office, between Jean-Jacques, Rousseau and Louvre Streets, and fronting on Gutenberg Street, occupies an area of 15,000 square feet. It constitutes a genuine type of modern construction, light and elegant, and forming an edifice largely of glass, into which pour floods of light and air.

The cellars serve for the entrance and distribution of the wires, the ground floor is reserved for the station service wagons, the first story for interurban communications, the second for the city service, and the third and fourth are reserved for future extensions.—E. Hospitalier, in *La Nature*.

[FROM THE OUTLOOK.]

NIKOLA TESLA AND THE ELECTRIC LIGHT OF THE FUTURE.

By WALTER T. STEPHENSON.

EXACTLY ten years ago Nikola Tesla, who, in June, 1894, received high honorary degrees from the colleges of Yale and Columbia, came to this country, poor and unknown, to enter an Edison shop in New York City. For two years previous he had served as engineer in one of the new electric lighting companies in Paris, and, having become an ardent and appreciative admirer of the splendid genius of Thomas A. Edison, whose fame in those days had only recently flashed throughout Europe, he was, naturally, eager to accept an opportunity of meeting the "wizard" face to face.

Tesla had already patented several minor inventions of his own, but, what was of more importance, his brain was then literally teeming with great ideas, as yet, perhaps, chaotic, but which must some day evolve into definite shape for revelation, and of all countries he firmly believed the United States offered the best encouragement to the inventor who could show practical results. Since New York has continued to be Mr. Tesla's home, we may reasonably infer that he has not been disappointed in his early expectations.

The young Servian electrician derived a fresh stimulus and lasting benefit from his association with Thomas A. Edison. Nevertheless, he soon realized that it would be far wiser for him to continue his special investigations alone, unhampered by other work. Therefore, after a few months of delightful intimacy, the two men of genius separated with mutual expressions of good will.

Mr. Tesla now threw himself with redoubled ardor and energy into the study and analysis of alternating or polyphase currents, which had long been his chosen field of electrical investigation. In 1887 he exploited his wonderful invention of the rotating magnetic field for the economic transmission of power. This simple statement means that, after thirteen years of indomitable effort, embittered by sore disappointments and fierce controversies, a substantial success was at last assured, while scientists everywhere began now to await with keenest interest succeeding developments of the potentialities undoubtedly latent in these hitherto neglected alternating currents.

The majority of us probably are aware that the principal electricians of the world have long been struggling vainly toward the solution of a tremendous problem—the improvement of the electric light. When we are told, for one thing, that fully ninety-nine per cent. of energy is wasted every time such artificial illumination is produced under existing conditions, we begin to realize the crying need there is for a radical change in industrial methods. Now, the goal which some electricians declare to be already in sight means nothing less than the recovery of fully one-third of this wasted energy, thereby rendering possible an illumination many times brighter than at present and at a notable reduction of expense. The question is,

Which one of the few leaders in the race will outstrip the others and win an immortal name?

Rumors have reached the public ear with increasing frequency of late that Nikola Tesla was working slowly but surely in his own way toward the accomplishment of some such magnificent end.

We know that in May, 1891, Mr. Tesla emerged from the seclusion of his laboratory to deliver an address before the American Institute of Electrical Engineers, at Columbia College, on polyphase currents as applied to artificial illumination. Having in this lecture created a marked impression by the lucid exposition of his peculiar theories, he was soon urged by some of the prominent scientists of Europe to favor them in like manner. So it was that in February, 1892, he crossed the ocean and lectured before numerous audiences in England and on the Continent. It is not too much to say that the name of Nikola Tesla now commanded universal attention in the world of science, but still the man himself was beginning to chafe sadly already under his prolonged absence from the distant laboratory. In the fall of 1892, therefore, he gladly returned to New York to resume his interrupted labors in behalf of science.

In view of all this, even the hardest of interviewers would be apt to think twice before intruding upon such an individual in his privacy. It will be enough, perhaps, for me to say that the forbearance and kindness of Nikola Tesla are by no means his least distinguishing traits. Not very far from Washington Square, in the heart of that picturesque neighborhood known as the French quarter, teeming with cheap restaurants, wine shops, and weather-beaten tenements, the observant passer-by will notice a huge yellowish brick building of some half-dozen stories apparently devoted to manufacturing purposes.

If such a one should undertake to explore the murky interior of this uninviting looking pile, say to the extent of climbing three or four flights of stairs, and warily threading a signless path through successive mazes of vociferous machinery, his perseverance might be rewarded, as in my own case, by discovering the retreat of a modern wizard. While awaiting my opportunity in an anteroom, I caught glimpses through the adjoining office and library of the mystic laboratory itself, which, as I ascertained later, opened into an immense machine room.

I may candidly state that I was a trifle shocked the first time I saw Nikola Tesla as he suddenly appeared before me in the library and sank into a chair seemingly in a state of utter dejection. Tall, straight, gaunt, and sinewy of frame like a true Slav, with clear blue eyes and small, mobile mouth fringed with a boyish mustache, he looked younger than his thirty-seven years. But what arrested my attention chiefly at the moment was the pallid, drawn and haggard appearance of the face. While scanning it closely I plainly read a tale of overwork and of tremendous mental strain that must soon reach the limits of human endurance.

"I would like to talk with you, my dear sir," he said, "but I feel far from well to-day. I am completely worn out, in fact, and yet I cannot stop my work. These experiments of mine are so important, so beautiful, so fascinating, that I can hardly tear myself away from them to eat, and when I try to sleep I think about them constantly. I expect I shall go on until I break down altogether. So you would really like to see some of my experiments in electric lighting," he added. "I shall endeavor to accommodate you, my friend, if you will come with me into the laboratory. Be prepared, though, for a surprise or two."

Mr. Tesla then ushered me into a room some twenty-five feet square, lighted on one side by two broad windows, partially covered by heavy black curtains. Directly opposite was an open door leading into the machine room, which seemed to be fairly alive with grimy figures flitting to and fro. The whole scene, to my unaccustomed eyes, suggested a veritable magician's den.

The laboratory was literally filled with curious mechanical appliances of every description. Wires innumerable, from the smallest size to cables three-quarters of an inch thick, ran along the walls, ceiling, and even the floor. In the center was what appeared to be a large circular table covered with thick strips of black woolen cloth; snakelike cables running up underneath were connected at the other end with an adjacent dynamo, thereby establishing a possible center of electro-dynamic vibration. Between the table and the windows two large brownish globes, eighteen inches in diameter, depended from the ceiling by cords. These balls were composed of brass, coated with two inches of wax to render them non-injurious, and served the purpose of spreading the electrostatic field.

So much for my surroundings, as I glanced about in some bewilderment after hearing Mr. Tesla say that he had a surprise in store for me. Promptly suiting the action to the word, he called in several employes from the workshop and issued a succession of hurried orders which I followed but vaguely. Presently, however, the doors were shut and the curtains closely drawn until every chink or crevice for the admission of light was concealed and the laboratory bathed in absolutely impenetrable gloom. I awaited developments with intense interest.

The next minute exquisitely beautiful luminous signs and devices of mystic origin began to flash about me with startling frequency. Sometimes they seemed iridescent, while again a dazzling white light prevailed.

"Take hold," said a voice, and I felt a sort of handle thrust into my hand. Then I was gently led forward and told to wave it. On complying, I spelled the word "Welcome" flaming before my eyes. Unfortunately, I was totally unable at the time to appreciate the kindly sentiment implied.

A hand approached mine ere I had quite recovered, and I felt the tips of my fingers lightly brushed. Fancy my dire dismay when I immediately experienced an acute tingling sensation, accompanied by a brief pyrotechnic display that was surprising, to say the least. When the daylight, as well as my equanimity, was in a measure restored, I learned something of the meaning of these wondrous experiments, which may be said to foreshadow in a way the electric light of the future. What impressed me most of all, perhaps, was the simple but cheerful fact that I remained unscathed while

electrical bombardments were taking place on every side. Curiously enough, the polyphase currents of high frequency and high potential, of say 200,000 volts, have, as Mr. Tesla has demonstrated repeatedly on the platform, no harmful effect whatever on the human body, although a like energy exerted in indirect currents would prove instantaneously fatal.

Over two and a half years ago Mr. Tesla made this striking observation in one of his lectures: "The ideal way of lighting a hall or room would, however, be to produce such a condition in it that an illuminating device could be moved and put anywhere, and that it should be lighted no matter where it is put, and without being electrically connected to anything."

To return to my own experience in the darkened laboratory, it seems that the entire room was actually filled with electric vibrations through the agency of these same currents, styled alternating (that is, with direction perpetually changing). The strange devices I had seen were nothing more than nearly exhausted glass tubes bent into various shapes and analogous to lamps, excepting that they were devoid of filament or button.

These tubes being carried into the area where the electrical agitation was strongest, the remaining molecules of ether or air within all the while pressing against the crystal confines, a molecular bombardment followed, produced by the collision of two forces, and the bulbs simultaneously became luminous. Those which were made to glow with the colors of the rainbow were coated on the inside with phosphorescent substances.

I have attempted nothing more than a very imperfect outline of Mr. Tesla's novel and interesting scheme, which is to be regarded as still in a state of embryo. It cannot be denied, too, that there are many scientists to-day who shake their heads dubiously at the brilliant Servian's unequivocal attitude toward the electric light.

Meanwhile Mr. Tesla makes no boasts, but is willing to abide his time. Throughout the interview I was constantly impressed with the man's loftiness of purpose, innate modesty and utter indifference to public applause. "I should much prefer not to be written about at all," he remarked; "but if it must be done, I trust you will take due pains to quote me correctly."

Speaking of the scientific status of the United States as compared with that of older nations, he said: "English scientists are the greatest in theory, perhaps, although, as far as practical results go, America may well claim to lead the world. That is why I like to stay here."

Mr. Tesla speaks our language with the idiomatic range and choice diction of a native who is also a scholar and a trained speaker, the guttural accent of the Slav, of course, being slightly noticeable. He told me that he felt equally at home in six languages, not to mention the same number of dialects.

Though simple, self-contained and undemonstrative in manner, when he is especially pleased or absorbed in enthusiastic description of electrical wonders, the intellectual animation of his frank blue eyes, combined with a rarely winning smile, exercises a charm that is irresistible. I have noticed the same unconscious quality of personal magnetism in Mr. Edison, though in almost every other respect these two remarkable individuals are totally dissimilar.

Edison may be more truly the man of genius. He works out his intricate problems by intuition. He peers into the future like a seer of old, and receives, as it were, lightning flashes of inspiration to guide him to the goal. In a word, the illiterate train boy of thirty-odd years ago has come to be regarded as little less than a wizard; and yet, assuredly, he is neither a thinker nor a student in the true sense.

Now, how is it with the Servian, who has acquired fame much less rapidly? What was his life before he came among us? Let me say, at the outset, that eighteen years of exhaustive, patient study were accomplished before Nikola Tesla deemed himself adequately prepared to embark upon the career which he had planned from childhood.

Born in 1857 at Smiljan Lika, a remote village in Austro-Hungary, he is the descendant of a sturdy line of Servian patriots, who for centuries had taken a prominent part in the protracted struggle against the domineering Turk.

The young Nikola commenced his studies in the public school of Gospich when five years of age. Not long afterward the marvels of electricity and magnetism began to dawn upon the boy's receptive soul. Fascinated and stirred until he scarcely thought of anything else, he resolved thenceforth to devote his life to research and investigation in this noble field of knowledge. In 1873, against the wishes of his father, who, being a clergyman in the Greek Church, had hoped that his son would discover a theological bent, Nikola entered the Polytechnic School at Gratz. It was at this institution, while puzzling over the complexities of a direct current Gramme machine, that his alert mind was led to conceive of a rotating magnetic field, which discovery was destined to deal the death-blow to those troublous contrivances the commutator and brushes. After completing the technical course at Gratz, Mr. Tesla removed to Vienna, where for several years he attended philosophical lectures, read omnivorously on many subjects, continued his special studies, and incidentally found time to master five or six languages. Verily, an intellectual training of this sort, in the face, too, of untold trials and difficulties, would have far exceeded the scope of any ordinary student.

Before I bade a regretful farewell to this kindly wizard of Washington Square he confided to me that he was engaged on several secret experiments of most abundant promise, but their nature cannot be hinted at here. However, I have Mr. Tesla's permission to say that some day he proposes to transmit electric vibrations through the earth; in other words, that it will be possible to send a message from an ocean steamer to a city, however distant, without the use of any wire.

To those who would gain a complete technical knowledge of the Servian's manifold labors since he came to the United States I would recommend a careful study of the volume recently issued by Mr. T. C. Martin, of the Electrical Engineer, entitled "The Inventions, Researches and Writings of Nikola Tesla." How strange it is, indeed, that, though electricity has so

long been partially controlled by mankind, yet we are utterly unable to define it! As Mr. Tesla has said: "The day when we know what electricity is will chronicle an event probably greater than any other recorded in the history of the human race."

[FROM THE ASCLEPIAD.]

HEALTH AND ATHLETICS.*

By Sir BENJAMIN WARD RICHARDSON, M.D., F.R.S.

EFFECTS OF SPECIAL EXERCISES.

I AM led now to refer to certain special exercises and sports in their effects upon the health of the body, and in this direction I shall follow a division instituted by a recent most able writer, Professor Kolb, who, in his book on the "Physiology of Sport," has made a larger number of correct observations than any other writer with whose work I am acquainted. Kolb, himself a sportsman, mixing largely with sportsmen, gaining their confidence, observing their modes of life, and bringing to bear in his researches the finest instruments of precision, has brought the physiology of sport almost to mathematical demonstration. He divides the effects of sports into a series of classes. (1) In the first class he refers to physical acts, during which particular groups of muscles are actively moved until they become affected, but without interference of a serious kind with the functions of the other organs of the body. (2) Exercises in which the breathing or respiratory system is exceptionally affected. (3) Exercises in which the motion of the heart and the circulation is primarily and most distinctly concerned. (4) Exercises in which the nervous system becomes particularly influenced, and in which that system is reduced in power or worn out by efforts of too severe a kind.

The exercises which influence the muscles purely, and which may be classified under the first head named above, are such as cause the muscles to move without serious change in regard to the position of the body on the surface of the earth: lifting weights, working dumb bells, and bell ringing are examples of this sort. The body moves but does not progress. Kolb puts this well in the following way: "Let a strong man take a pair of dumb bells weighing about fifty pounds each, and move them from his chest upward by stretching his arms. A man of common strength cannot do that at all; our experimental man may be able to do it ten, twenty, or thirty times; at last, however, the muscles refuse, that is to say, he can no longer move up the weight against the force of gravity. If we examine the man's pulse and respiration soon after, we observe the rate of his heart beats to be certainly fast, being about 100 to 120 per minute; his respiration, too, is strong and deep, about 25 times a minute; but neither his heart nor his lungs are strained at all. The muscular pains, however, that remain for days, and the feeling of lassitude, prove distinctly that the muscles have failed." All games of this nature produce the same effect. In young gymnasts who are practicing climbing movements, in men who are beginning to learn what is called the art of self-defense, in men who are learning sword exercise, this same condition of wearied muscle occurs, and in all such cases it is bad practice to keep up the exercise until actual muscular fatigue is developed. Nothing, in fact, is gained by overwork in this direction, for muscle is apt to get overstrained, and to lose that flexibility as well as strength which is essential for its perfect action. The golden rule here is that so soon as a muscle or group of muscles begins to be weary it is time to leave off action, for muscles should never feel pain in action, pain in movement of muscle being the most certain index that rest is immediately called for. Exercises of another kind belong to the second class named above, and affect primarily and indeed chiefly the muscles of respiration, the breathing muscles. Rowing, of which university men are so fond, is of all exercises the one which affects respiration. You will see a crew that has not yet been trained go out for active exercise, and as they get into the full swing of the work you will notice, if you are careful, how powerfully the breathing is affected. The breathing, you will see, is rapid; there is a sort of bluish pallor in the lips and face, and even when the act of rowing is stopped there is an out-of-breath condition which is felt, more or less, by all who have been doing the same work. Of course there are always differences in different rowers according to the build of the body. The man with a good large chest, and the tall man, the man who by a spirometer can show from 250 to 300 cubic inches without fatigue, will be infinitely less breathless than the man with a small chest and short body, and who can blow only 200 to 250 cubic inches; but, more or less, all will suffer, and the great danger of rowing lies in injury done to the respiration in the first instance. If I were to select from a body of young men, promiscuously brought together, those who were best for a rowing match, I could, by proper measurement of the breathing power, of the height of the body, of the size of the chest, pick out almost without question those men who would make, in the end, the best crews, although at the time not one of them had become trained to rowing practice; and this, I think, what ought to be done in the selection of crews for great competitions, since it is very bad for a young man even to train into a practice which by excessive exercise shall impair the function of the lungs. I do not say this from any prejudice, and I do not wish to exaggerate in the least degree. The disease emphysema—that is, rupture of the air vesicles of the lungs—which some think they have noticed as consequent upon rowing, I cannot say I have ever seen, and it is but honest to add that I have known an improved development of the breathing organs and of the capacity of the chest induced by moderate rowing. What I have seen, and what I would warn against, is an effect of rowing which shows itself in a persistent difficulty of breathing during the exercise, and which is followed by some shortness of breath in other efforts, such as walking and riding, playing at tennis or cricket, and such like exertions. Rowing, moreover, when it affects the breathing, is liable, secondarily, to cause disturbance of the circulation. The position of the rower in the boat is peculiar. His lower limbs are to a considerable extent fixed; his body is bent forward, and then strongly backward,

the chest being kept in full tension. During these acts there is a considerable strain thrown upon the valves of the heart. The blood which has to course over the arteries from the heart must ascend, before it makes its way anywhere over the body; ascends over what the anatomists call the aortic arch, and be prevented from going back into the heart on the left side by three valves, which allow the blood to come forth from the center, but which, falling down, check it from being returned. But in the motion of rowing with the lungs charged with air, the blood rising through the arch is, in a sharp degree, thrown back upon the valves, much as occurs in water falling back on a tap, to which we give the name of the water hammer. So I have observed that in a man who has been briskly rowing, the second sound of his heart, which is produced by closure of the three valves, is often accentuated, owing to the sudden pressure exerted by the column of blood. Now this is a very considerable strain. By the influx of blood the heart is made to work more laboriously; it has an extra pressure put upon it; it is quickened in its action, and the great elastic blood vessel, or aorta itself, is unduly distended. So in rowing men, there occasionally follows disturbance of the heart as well as of the breathing. The heart becomes unduly large and over-active, a state for which, in order to obtain recovery, the injured person may have to lie in a recumbent position for several months, and from which possibly he never entirely returns to health, but has an excitable state of the circulation when he is subjected to any particular strain or mental worry. Rowing, therefore, although a fine exercise, requires to be carried on with some prudence, and while I have not a word to say against it, but indeed very much enjoy the sight of it in a good contest, it is, I should like to intimate, an exertion which should never be persevered in if the signs of embarrassment, first of the respiration, and secondly of the circulation, are clearly felt and detected by those who practice it, for I doubt if there is any going back to health in the strict sense of that term, when such signs are definitely pronounced and for a long time maintained.

The exercises or games which affect the circulation, and which come under the third head, include running, cycling, dancing, and football. The first of these sports—running—I cannot say much for from a health point of view; indeed, I am obliged to speak adversely in respect to it. Man was not constituted to be a running animal, and the irritability of the circulation induced by sharp running exceeds everything that would be expected of it. You are all aware that a runner on first setting forth has got to get what is called his wind. He seems to be stopped by the fact that he cannot breathe fast enough; he pants for breath, and it is some time before he gets over this difficulty. The fault is not in the breathing organs, however; it is in the circulation. In order that a healthy feeling may be maintained, in order that there be no oppression, the balance of the circulation and the respiration must be properly set; the heart must send forth the proper quantity of blood that the breathing can supply with oxygen, or else the heart, sending over blood too rapidly, the breathing must be increased so as to adapt the one function to the other. If, therefore, the heart be set going at an unusual rate, and beyond the relationship of the breathing power, the balance is broken and "the wind," as the common saying goes, is imperfect or deficient. In running the balance is disturbed, owing to the sudden rapidity of the heart induced by the exercise. Supposing the natural beat of the heart to be about 75 in the person commencing to run, if he run briskly one minute, the circulation will go up to as much as 200, and at two minutes it may reach the incredible rapidity of 250 or even 260 beats per minute. But the breathing, which in a natural state would be about one to four of the pulse, ought under these circumstances to increase proportionately, that is to say, the breathing should rise to 50 or even 60 per minute; but this it cannot do immediately. It cannot rise with proportionate rapidity to the heart, and some time has to elapse before it reaches that maximum; so the runner has to wait to gain his wind, and then he can go on for a considerable time. When he comes to a stop, a new order of things prevails. The heart has become fatigued with the effort, and, instead of falling down leisurely to its natural stroke it intermits—that is to say, there are four or five rapid beats of the heart and then a stoppage, followed by another series of quick beats, and again a stoppage, until equilibrium is obtained. Under this condition the breathing comes down to natural action more steadily than the pulse, and most, if not all, runners are obliged to hold their breath at intervals, in order that the breathing may not be too rapid for the heart. It is fortunate that the breathing is, to some extent, under the power of the will, so that the accommodation can be met by a voluntary effort; if it were not so, fatal accidents after running would be exceedingly frequent. On the whole, running carried to competition is, as you must see, a dangerous exercise. I have known very bad effects indeed from it, telling always on the circulation. The heart becomes enlarged, and, more than that, it becomes irregular, which is a very bad state for those who suffer from it. I have, in fact, never met with a man who practiced running for a long time who had not an irregular circulation or an intermittent one, and in whom the heart was not very irritable or very feeble; nor do I think that perfect recovery from this injury to the circulation is ever actually witnessed. I should, had I my way, exclude running from all athletic exercises.

Cycling has something of the same effect as running—that is to say, it tells upon the circulation. In a very short time, during rapid cycling, the heart is brought into extreme action, the beats of it rising under great pressure to 200 or even 250 per minute; and when the active career of the over-enthusiastic cyclist is shortened, with the occasional collapse of a man in full exercise, the fact is due generally to the overwork of the heart. I have for many years past been cautioning cyclists on this matter. I have been criticised for my pains, and have even been charged with doing injury to the exercise by the advice I have given; but I have never had any reason to change the line I have pursued in this matter, my very love for the pursuit having an impetus to the emphatic way in which I have dealt with it. It has been a hard fight for me to offer opposition on this subject; it has been a clear task to predict consequences; and I regret that far too

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