with a probable error from nine measurements of 0·0074 or an error of one part in 14,630. The angular velocity ω can with proper instruments be obtained with great accuracy.

The principal ballistic result obtained from the experiments may be said to be the locating of a maximum point in the velocity curve outside of the gun. This maximum point is, in the present experiment, at 6 or 7 feet from the muzzle of the gun—certainly more than 5 feet and less than 10—or about 25 calibers in front of the muzzle. The increase in velocity from the muzzle to the maximum point is large, more than 40 foot seconds. The muzzle velocity being about 1,600 feet, this increase is about 2·5 per cent of the whole.

The decrease in velocity beyond the maximum point is comparatively gradual, obeying the true law of the resistance of the air, so that the projectile must travel about a hundred feet before the velocity is reduced to that which it actually had at the muzzle.

This maximum point introduces an error in the present method of obtaining muzzle velocities, in which the velocity is measured at a distance of 100 to 200 feet and reduced back to the muzzle by formulas. The Franklin Institute has awarded the John Scott Legacy medal and premium to Lieut. Squier and Prof. Crehore for this apparatus.*

*This apparatus is described at greater length and with additional illustrations in SUPPLEMENT, No. 1054.

THE ROYAL OBSERVATORY AND HOW THEY TELL THE TIME AT GREENWICH.

BY DR. D. DUNBAR.

Greenwich, situate on the winding Thames, five miles east-southeast from London, in the County of Kent, possesses a large amount of historical interest. It is the birthplace of many ilustrious persons, among them Henry the Eighth, Edward the Sixth, Queen Mary, Queen Elizabeth, and several children of James the First. But it is not of departed kings and queens we propose now to speak, nor of the social attractions of Greenwich. It is a place of great resort, specially on a bright bank holiday.

The observatory building is familiar to every inhabitant of the town, and well known to scientific men all over the world. It stands on the spot once occupied by the tower built by Duke Humphrey. At one time the observatory was furnished with a deep well for the observation of stars in the daytime, but the great improvement in telescopes rendered this unnecessary, and it is now arched over. An apparatus has been erected on the eastern turret of the observatory for the purpose of enabling the captains of vessels leaving the river to ascertain by it the rate of their chronometers, thus obviating the necessity of applying at the observatory. It consists of a large ball of wood lined with leather, which, in order to give preliminary notice, is raised at five minutes before one P. M., half way up a pole, by which it is surmounted, at two minutes before one is raised to the top, and at one o'clock precisely the ball drops. By means of an electric current from the observatory accurate time signals are distributed every hour by the post office telegraphs to a large number of towns, and clocks in the metropolis and country are synchonized. There is in the wall of the observatory a large twenty-four hour clock face, that is, with hours marked from one to twenty-four, to include a day and night; where the time is exhibited at any hour when the park is open for any one who chooses to climb the pleasant hill and look at it.

THE ROYAL OBSERVATORY AT GREENWICH.

The observatory is an oblong edifice, divided into four apartments. It is a quiet, retired spot well walled around, some 150 feet above the average height of the river. The roar of London sounds muffled and distant, and only seems to emphasize the sense of calmness and silence in this abode of science. Here, above the trees of the old park, and on the rim of the mighty city, the astronomers keep the time for half the world. Greenwich time is the standard for the British nation, for British ships at sea, and for the ships of most other countries as well.

We were received by Mr. W. H. M. Christie, Astronomer Royal, and placed in charge of the senior computor, Mr. H. Furnel, to be escorted over the apartments. We soon find that his acquaintance with the interesting and delicate instruments that are explained in turn is much greater than our limited powers of comprehension. But Mr. Furnel, who has become a student of the stars, is a patient gentleman who goes to much trouble in his endeavors to initiate a layman in the mysteries of the heavens.

The main question of this paper is how they tell the time at Greenwich, and we shall endeavor to explain this in popular rather than in scientific language.

The fixing of the standard of time depends on astronomical observations. When the sun is exactly south—on the meridian, as it is called—the hour is twelve o'clock noon. As the movement of the sun apparently fluctuates, astronomers call this apparent noon. At Greenwich Observatory to the study of the sun is added that of the stars for accurately recording the time.

The way of it is this. There are two finely made clocks—the solar clock, keeping the solar time, and the sidereal clock, regulated by observations of the stars.

The sidereal clock is kept as the standard, and every night or day the weather permits, any error is determined by comparison of the clocks. The error of the solar clock is then corrected.

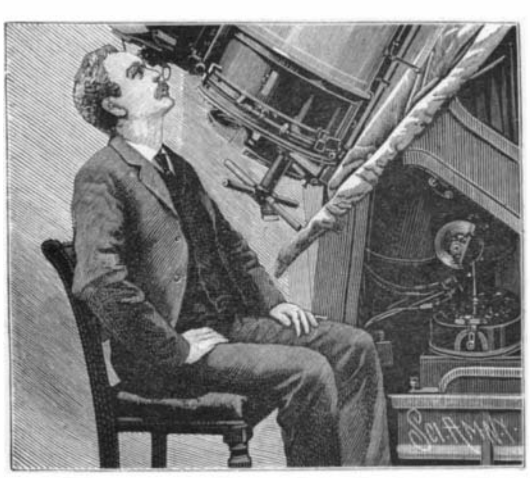
The standard time, therefore, is kept for the nation at Greenwich by constant observation of certain stars, checked by observations of the sun. There are some two hundred and fifty stars calendared at Greenwich, which are known as clock stars. The observations are made with a fine instrument called the transit or meridian circle. Greenwich has the honor of having been the first observatory in the world where a large transit circle was mounted, viz., in 1850. Briefly, it is a large and fine telescope, mounted between two uprights, and pointing exactly to the center line—the meridian—of the heavens, as seen at Greenwich. As the telescope is so hung that it will swing round in a complete circle between the uprights, it can view any point in this center line of the heavens. The roof of the room in which the telescope is placed can be opened by a sliding or trap door above it, and thus can expose any point of the meridian.

This center line is supposed to be drawn across the heavens from pole to pole of the earth, through the Greenwich zenith; and it is when on this center line in their journey from east to west that the sun and stars are said to be on the meridian. When the sun is on this line, the hour is midday at Greenwich.

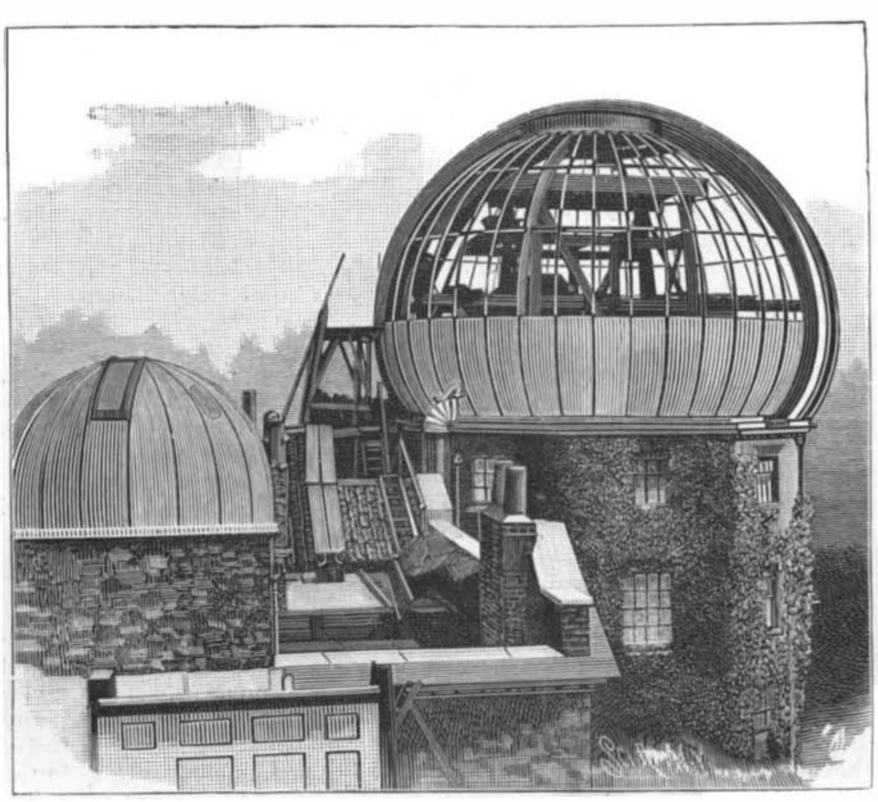
In the eyepiece of the telescope are five wires, one of which is exactly on the middle. When, therefore, the star passes this line, it is at the highest, or crossing the meridian. This, however, is not exactly the same as the actual time, because no transit telescope is probably exactly on the meridian line, and the error is corrected by various calculations.

Connected by electricity with the transit circle is a "chronograph," which at Greenwich is on the other side of the courtyard.

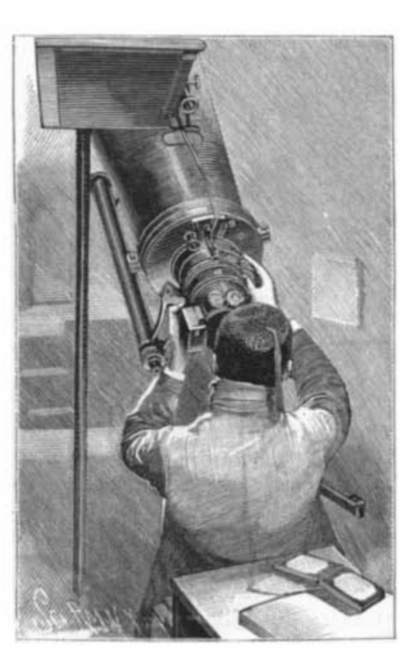
The chronograph is a cylinder on which paper is fixed, and on paper is registered the times of the stars'



THE GUIDER AND PHOTOGRAPHER AT WORK.



ONE OF THE DOMES.



TAKING AN OBSERVATION.

transit across the fine lines of the telescope. It can also register the seconds of a sidereal clock. By this system of registering the transit of stars greater accuracy is gained and also greater time is permitted to the observer to gaze through the telescope.

But it may still be asked, Why are stars selected to tell the time? Because, for one very potent reason, there is but one sun, and there are so many stars; therefore, so many more chances of good observation. There are very few nights on which some of the 250 clock stars used at Greenwich are not observable. Further, the observations on the various stars may be used to check one another and correct errors, while but one observation of the sun on the meridian can be made.

But how can the passing of the star over the meridian tell the time? In this way: The complete turning round of the earth on its own axis causes a day and night, that is, twenty-four hours, which, in astronomical language, form one day. If, then, a certain star be on the meridian at such a time, it should be on the meridian again, after a lapse of twenty-four hours, at precisely the same time; and the clock, to be accurate, should agree. The earth has made one complete turn round, one complete rotation, and one complete day and night have passed. This is termed a sidereal day, and it is regarded by astronomers as always of the same space of time, because the turning of the earth is regarded as exactly uniform.

The solar day or solar time is measured by the passage of the sun day after day across the meridian, and is four minutes more than the sidereal day. Further, the solar day differs somewhat in length, through the movements of sun and earth; thus the earth moves more quickly in winter than in summer; and these differences are allowed for by astronomers in calculating time. The result is what is called "mean" time.

The reason of the difference of four minutes is that one revolution is added to the diurnal revolutions of the earth on its axis, in consequence of its revolution around the sun in its orbit, so that while there are in round numbers 365 days in the solar year, there are 366 sidereal days. The four minutes per day difference, therefore, makes in the year another whole day, that is, 24 hours 20 minutes. Four minutes saved or lost in a day, you see, make up a whole 24 hours at the end of the year.

But the keeping of the time is not the only work that is done at the observatory. There are ten great telescopes, the largest one being nearly 30 feet long, with an object glass of 28 inches. Over this is a beautiful dome, made like the others of papier maché stretched over iron framework. This gives lightness and strength, enabling the dome to be easily worked on wheels. One portion, opened like a sliding shutter, reveals a strip of sky from the zenith to the horizon; so that by turning the dome round, any part of the sky can be easily and speedily brought under observation.

The large telescope is devoted to the stupendous work of photographing the heavens. About a dozen observatories are engaged in this truly gigantic task, each having a certain portion allotted to it.

All is remarkably quiet at the observatory, Greenwich. Day after day and night after night the observations go forward and the calculations are made. About twenty computers are busily engaged in reducing by calculation the various observations that have been made.

For anything I have been able to say, I am indebted to the astronomer royal and his able assistants; also to those who like myself have visited the royal observatory at Greenwich and made notes, and by comparing notes have been assisted in reaching accuracy.

Bacteria in Milk.*

Bacteria are plants of almost inconceivably minute size. So small are they that in some cases 50,000 might stand side by side and the whole line only reach a length of an inch. They are extremely simple also. Some of them are simple balls, others are short ones and others still are of a spiral shape. But although thus very small and simple in structure, their powers of multiplication are so great as to make them factors of profound significance in the processes of nature. So rapidly can they multiply that in some cases a single individual in the course of twenty-four hours may produce nearly twenty million offspring. This power of multiplication is so enormous we must not be surprised to find them capable of accomplishing by their growth many great changes in nature.

Pure milk, as it is secreted from the udder of the healthy cow, contains no bacteria. If the cow be diseased, this may not be true, but the milk from the healthy cow contains no bacteria when first secreted. Nevertheless, by the time the milk reaches the milk pail it will contain from 30,000 to 5,000,000 bacteria per cubic inch. It is hardly conceivable that the few moments of the milking should be sufficient to contaminate the milk to this extent. We have learned in the last few years, however, the sources of this numerous host.

Part of them, a small part, come from the air; part of them are already in the milk pail. The dairyman never washes his milk pail free from bacteria. Even with the most thorough washing which the pails receive on the ordinary farm the bacteria are not killed, but remain alive, adhering to the cracks in the tin, or in the crevices in the wood. Part of them come from the milker, for he commonly goes to the milking without any special toilet, with his hands not clean, and clothed in the ordinary farm clothes which have become filled with bacteria from numerous sources. But by far the greatest number come from the cow herself. These are not, however, from the interior of the cow, but from her exterior. First, her flanks are always covered with dirt. Frequently they are covered with layers of dried manure, and always the hair of the legs, sides, flanks and tail are covered with a large amount of dust and dirt. All of the dirt and manure is crowded with innumerable hosts of bacteria. Again, the milk ducts of the cow's teats form a prolific breeding place for the bacteria. After each milking some milk is left in the milk ducts, and in this the bacteria which may get to teat from the air or the dirt or hairs of the cow find abundant food. Here they multiply, and by the time of the next milking they are present in countless millions, ready to be washed out with the first milk that is drawn.

From such sources, then, the milk receives its population of bacteria, and these sources are sufficient to inoculate the milk to the great extent mentioned. The great remedy for them is cleanliness. Remembering that the bacteria grow rapidly after getting into the milk and begin to multiply with great rapidity, the value of the immediate application of cold to the milk is plain. The milk when drawn is in just the best possible condition for them to multiply. Immediate and rapid cooling so greatly checks the growth of bacteria as to greatly reduce the number present in the course of twenty-four hours. This is the explanation of the fact that the milk dealer not infrequently has complaints from his patrons that his morning's milk sours, while no such complaints are received of the milk of the night before. The latter was cooled during the night, while the former was taken to delivery at once from the cow or with insufficient cooling. For this reason it actually sours quicker than the milk of the night before, which needs to warm up before the bacteria can grow in it rapidly.

If milk contained no bacteria, it would never undergo any of the common changes which are common in milk, for all of these are produced by the growth of the bacteria. But these bacteria are of many kinds, and even those that commonly get into milk are of many different species. Certainly over 100 different species of bacteria are common in our milk. But these different species do not all produce the same effects on the milk. Some of them sour it by changing the milk sugar to lactic acid. This, as well known, is the most common effect arising in milk upon standing, but others produce other results. Some of them make the milk bitter; some curdle it, but render it alkaline or sweet to taste; others give it an unpleasant, tainted taste; others, again, render it slimy or ropy; some turn it blue or yellow or red.

We are accustomed to think of bacteria as unmitigated nuisances. We think of them as the causes of disease, and if, perchance, we think of them as connected with dairy matters, it is always as the cause of milk souring or some other milk trouble. But the dairyman really benefits from them more than he suffers. Their beneficial effects are shown upon at least two important dairy products, butter and cheese.

Every one knows that cream is seldom churned when fresh. It is allowed to stand in a vessel or vat for a time and undergoes a process which we call ripening, or which is in some parts of the world simply called souring. During this ripening the cream acquires a pleasantly sour taste and a peculiar pleasant odor. This ripening is nothing more than a fermentation due to the growth of the bacteria which are in the cream. During this twenty-four to forty-eight hours the bacteria which were in the cream multiply rapidly, until at the close of the ripening there may be as many as 2,400,000,000 per cubic inch. This growth produces a fermentation, just as the growth of yeast in the brewery malt produces its fermentation.

The object of this ripening is at least threefold. First, it makes the cream churn more readily, and, second, it gives a larger amount of butter from a given lot of cream. The third object is to give flavor to the butter. The explanation of the flavor is simple enough. While the bacteria are growing in the cream they are producing, as they are feeding upon it, certain chemical changes in it. As the result of these chemical changes decomposition products are developed, and these products have various flavors and odors. If the ripening is allowed to continue long enough, the whole mass becomes decayed and the flavors and tastes are decidedly unpleasant. But the first products of decomposition, instead of being unpleasant, are decidedly agreeable, and it is these which give flavor to the cream and to the subsequent butter. After they have developed in the cream, the churning simply separates the butter already flavored with these products. Thus the flavor and aroma of a first class butter are the gifts to the butter maker from the bacteria of the ripening period.

To make good butter, the butter maker needs not only the freedom from the species of bacteria which produce unpleasant flavors, but he needs also the presence of the species which produce the desired flavors. Butter made from cream that comes from the cleanly kept dairy may be depended upon not to develop the unpleasant flavors which arise in butter of cream from the filthy dairy and barn.

But to insure the proper number of proper flavor-producing species simple cleanliness is not so much to be depended upon. In many such cases it is true the proper flavor-producing species will be present, but not always. But why is it not possible to directly inoculate the cream with the proper flavor-producing species, just as the brewer inoculates his malt with yeast? This does, indeed, appear not only to be possible but perfectly feasible, and it involves the use of what are now known as starters. The starter is simply a lot of cream or milk containing a large number of bacteria, which is poured into the cream to be ripened to start the proper kind of fermentation. The starters are of two kinds. Natural starters, which are easily made by any butter maker, and artificial starters, which are made upon a different plan. Our bacteriologists, both of this country and Europe, have been searching for proper flavor-producing species, and having found them, they propose to furnish them in quantity to the butter maker for use in his cream ripening. In the use of these starters the species of bacteria furnished by the bacteriologist is allowed to grow in a small lot of cream until its species is very abundant and then the cream is added to the large vat as a starter. The result is that the butter maker can always depend upon having present a quantity of the proper flavor producing species, and can, therefore, depend with more certainty upon the product. This method of using artificial starters is not new. It has been adopted in Denmark and some other countries of Europe to a wide extent. In this country it has been used only for about a year, and is only just coming to be recognized as a proper method of butter making. The bacteria favorable for this purpose are now upon our markets, two or three different ones being now used in this country. They are generally known as pure cultures, a term which simply means a large quantity of one species of bacteria unmixed with others.

The bacteria are even more needed in cheese making than in butter making. A fresh, flat, curdy taste is seen in fresh cheese. The cheese to be marketable must be set aside for a few weeks to ripen, and during the ripening the flavors develop. This ripening again is simply a fermentation. It is a fermentation of a different character from that of cream ripening. It takes place more slowly and the products are of a different nature, but it is none the less due to the growth of bacteria, and the different flavors of different cheeses are due to the growth of different kinds of bacteria in the cheese. But the problem has proved a difficult one to handle, and while the general facts are easily made out and are demonstrated beyond question, very little in the way of practical results has as yet been reached. A future in this line can hardly be questioned.

*By Prof. H. W. Conn (of the Biological Department, Wesleyan University), in the Spatula.

The World's Wine Production.

The Moniteur Vinicole has recently published a statement showing the wine production of the various countries of the world. From this statement it appears the yield in France amounted in the years 1895 and 1894 to 587,127,000 gallons and 859,162,000 gallons respectively; in Algeria to 83,549,000 and 80,124,000 gallons; Tunis, 3,956,000 and 3,936,000; Italy, 469,555,000 and 539,000,000; Spain, 379,500,000 and 528,000,000; Portugal, 43,890,000 and 33,000,000; Azores, Canaries, and Madeira, 4,620,000 and 2,640,000; Austria, 66,000 000 and 88,000,000; Hungary, 63,030,000 and 46,103,000; and Germany, 80,190,000 and 110,000,000 gallons. In Turkey and Cyprus the production last year amounted to 52,800,000 gallons, and this compares with an average yield of 40,000,000 gallons. In Bulgaria the yield was 26,400,000 gallons; Servia, 17,600,000; Greece, 35,200,000; Roumania, 68,640,000; Switzerland, 27,500,000; the United States, 89,700,000; Mexico, 1,980,000; Argentine Republic, 29,700,000; Chile, 33,000,000; Brazil, 7,700,000; Cape of Good Hope, 2,420,000; Persia, 594,000; and Australia, 3,300,000 gallons.

The World's Fair Awards.

Many of our readers will be glad to know that the long expected distribution of Columbian World's Fair diplomas and medals has begun. On April 20 a considerable number of diplomas and medals were given to Baron Thielmann, the German ambassador, for distribution in Germany. Those awarded to American exhibitors will be ready for delivery in a short time. The excessively long delay is to be deeply regretted.

Largest and Smallest Books.

Prof. Max Muller, of Oxford, in a recent lecture, has called attention to the largest book in the world, the wonderful "Kuth Daw." It consists of 729 parts in the shape of white marble plates, covered with inscriptions, each plate built over with a temple of brick. It is found near the old priest city of Mandalay, in Burma, and this temple city of more than seven hundred pagodas virtually makes up this monster book, the religious codex of the Buddhists. In accordance with the three parts of which it is composed, generally called in a figurative sense "baskets" (pitaka), the whole is often termed "the three baskets" (tripitaka), and constitutes a library larger than the Bible and the Koran together. As the Jews figured out that the Old Testament contained 59,493 words and 2,728,100 letters, so the Buddhist priests have computed that the "Tripitaka" contains 275,250 stanzas and 8,808,000 syllables. This monster book is written in Pali. Rather strange to say, it is not an ancient production, but its preparation was prompted by the Buddhistic piety of this century. It was erected in 1857 by the command of Mindomin, the second of the last kings of Burma. As the influence of the tropical climate has already marred the inscriptions, a British official, Mr. Ferrars, proposes to have these 729 plates carefully photographed, and asked that the government, or some friend of science able to do so, make provisions for this. Prof. Muller urges that this be done in order to preserve at least the pictures of this unique temple-city book.

A noteworthy contrast is furnished by a recent German literary journal describing what is probably the smallest book in the world. This is a "Konversations-lexikon," published in Berlin, and prepared by Daniel Sanders. The volume occupies the space of only six cubic centimeters (0·366 cubic inch), although it is claimed to contain 175,000 words. The book must be read through a microscope especially prepared for it.—Mining and Scientific Press.

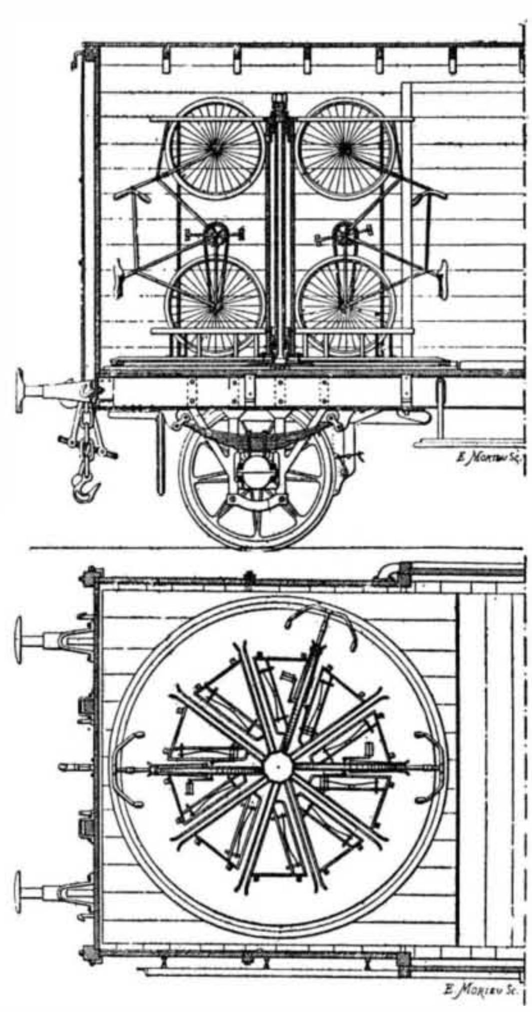
ENGLAND AND THE SOUDAN.

For the accompanying pictures of Soudanese women and warriors, reproduced from photographs by Dr. Jousseaume, we are indebted to Le Monde Illustré. The Soudan includes, in a general way, all the territory south of Nubia and the present British possessions in Egypt to the equatorial lakes, and from the Red Sea on the east to the desert on the west. It is estimated to have a population of from five to seven millions, and is ruled over by the Mahdi, whose seat of government is at Omdurman, and whose lieutenant, Osman Digna, has made frequent raids into the English territories in upper Egypt. To strengthen and possibly advance their frontier, a British expedition of some 9,000 native Egyptian troops, and a contingent of British soldiers, is now advancing up the Nile, although it is not expected that the most serious part of the campaign will begin until September or October, when the rise of the Nile will permit the carrying of supplies for the troops up the river in boats. It is said the dervishes all the time have some fifty thousand men under arms—a force which they could vastly increase without trouble, did mere numbers seem desirable. Famine, disease, the slave trade, and war among the tribes of the Soudan are reported to be thinning out the population.

H. MOISSAN describes two new metallic borides, says the Comptes Rendus, obtained at a temperature of 1,200° C., nickel boride, NiBo, and cobalt boride, CoBo. Both occur in brilliant prisms several millimeters in length and are magnetic. Their densities at 18° are about the same—nickel boride, 7·39; cobalt boride, 7·25. The properties of the borides are analogous to those of iron boride, and the compounds serve for the introduction of boron into a metal such as iron when at a high temperature. It has been demonstrated that both boron and silicon can displace the carbon in molten iron when added in suitable form.

THE CARRIAGE OF BICYCLES BY RAILWAY.

Among the numerous systems of carrying bicycles by railway, now proposed or put into practice, one of the most ingenious is certainly that devised by Mr. J. Oller, and which is at present on exhibition at the third Salon du Cycle at the Palace of Industry, Paris. The apparatus, which is represented herewith, consists essentially of a turn table capable of receiving ten bicycles arranged vertically around a central pivot from which they radiate and are held in place by two series of forks, which embrace, respectively, the fore wheel above and the hind wheel below. One of the branches of the fork is stationary, while the other, mounted upon springs, is capable of receding from the first through the pressure of the pneumatic tire, which the springs hold in place in such a way as to prevent any tossing about. As a further measure of precaution, the bicycle is held by a strap that passes through the frame near the handle bar. The turn table that supports the apparatus is mounted upon rollers and revolves around the pivot, so as to present to the employe in charge either an empty receptacle or the bicycle that is to be removed from the support.



APPARATUS FOR THE CARRIAGE OF BICYCLES ON RAILWAYS—ELEVATION AND PLAN.

The bicycles thus stowed away are perfectly independent, and well arranged for easy approach when the time comes for putting them off the car. An ordinary baggage car is capable of receiving two of these movable apparatus, say twenty bicycles, and yet leave a free space between them for two bicycles or two tandems. These apparatus may also be placed upon trucks or open cars during fine weather, when a crowd of bicyclists is anticipated upon a line on a holiday.

The same arrangement, mounted upon an ordinary truck, will furnish the ideal vehicle for a system of bicycle transportation analogous to that used in large cities for the carriage of pianos. A special truckman with this apparatus will be able to deliver unpacked bicycles either to private parties, on the account of railway companies or of cycle manufacturers, or to railway stations.

We do not dare to assert that the apparatus under consideration affords a complete solution of the problem of stowing away bicycles upon cars, says La Nature, but, with the present form of machines and their handle bars, we know of none more simple and practical.

Intoxicated Wasps.

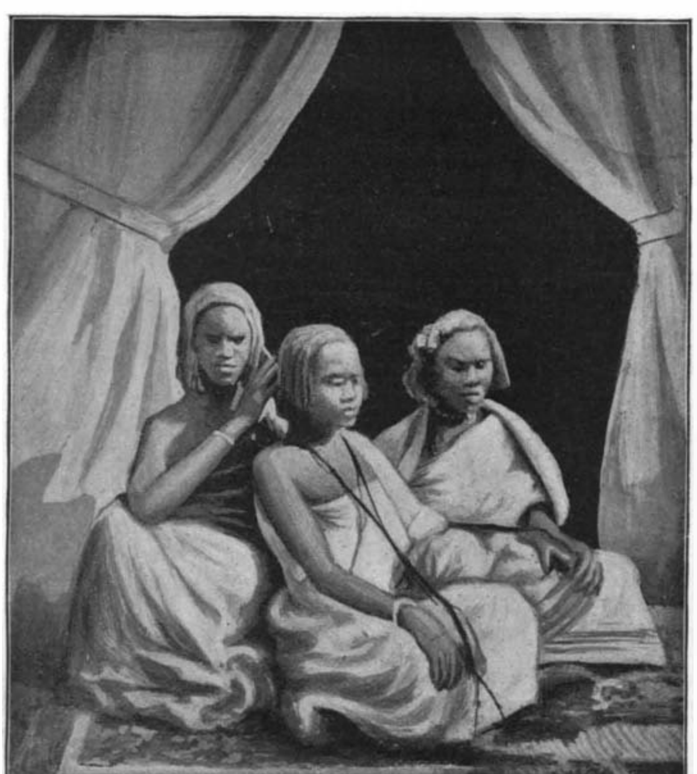
Concerning his observations of wasps which are addicted to the use of intoxicating liquors, Lawson Tait relates the following:

"I have been watching the wasps with great interest and have noticed the avidity with which they attack certain fruit when fully ripe, rotting in fact, and I have also noticed some of the peculiar results of their doing so. The sugar in some fruits which are most attacked by wasps has a tendency to pass into a kind or kinds of alcohol in the ordinary process of rotting, a fact which is easily ascertained by the use of a still not large enough to attract the attention of the excise authorities. On such fruits, particularly grapes and certain plums, you will see wasps pushing and fighting in numbers much larger than can be accommodated, and you will see them get very drunk, crawl away in a semi-somnolent condition, and repose in the grass for some time, till they get over the 'bout,' and then they will go at it again. It is while they are thus affected that they do their worst stinging, both in the virulent nature of the stroke and the utterly unprovoked assaults of which they are guilty. I was stung last year by a drunken wasp, and suffered severely from symptoms of nerve poison for several days. In such drunken peculiarities they resemble their human contemporaries."—Registered Pharmacist.

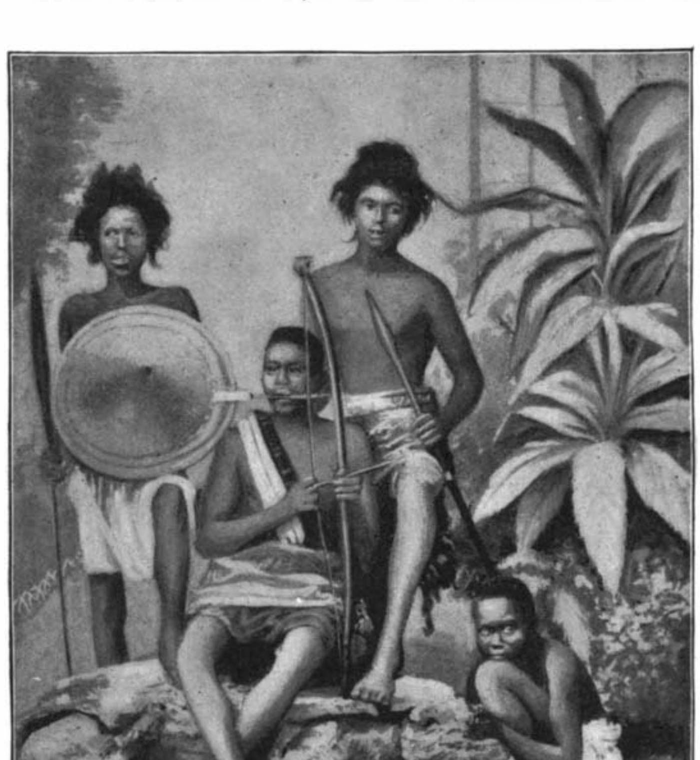
Niagara's Power Transmitted to New York.

A model of Niagara River, the power house, the town and the discharge tunnel will be exhibited at the National Electrical Exposition to be held in New York in May. The model is 12 feet by 4. The turbines will be run for a time each evening with electricity generated at Niagara Falls and transmitted to New York by two copper wires of the Western Union Telegraph Company. Telephones will be connected with instruments at Niagara, so that the roar of the falls may be heard. It is also said that some steps are being taken to deliver some of the current to condensers connected with an Atlantic cable, so that the power of Niagara may be transmitted to Europe.

DR. HOLDEN, of the Lick Observatory, has received the decoration of the Order of Bolivar (of Venezuela) for his disservices to science. He has previously received the decoration of commander of the Ernestine Order of Saxony.



TYPES OF WOMEN AT KHARTOUM.



SOUDANESE WARRIORS.