In ordinary running the arms are also moved, each in reverse direction from the homonymous leg. This movement is impossible or at least very limited in the ricksha-coolie, because he puts the forearms on the shafts; but as the ancient Greeks practiced running in an ambling pace, *i.e.*, right arm and right leg forward at the same time, it appears that the movement of running is not hindered by fixing the arms.

In estimating the work done in drawing the ricksha it must be remembered that the ricksha is so constructed that during motion the center of gravity is over the axle. Consequently the coolie need exert no force upwards, but can apply all his power for pulling. This traction on level ground need only overcome the resistance of friction. I have found this resistance to be from 2 to 5 kg for the occupied ricksha, according to the nature of the ground. These figures harmonize with other data for the frictional resistance.

The work done by the ricksha-coolie is consequently the same as if he were drawing a cord over a pulley at the end of which is fastened a weight of from 2 to 5 kg. In effect while traversing one kilometer he lifts a weight of from 2 to 5 kg to a height of a thousand meters and does a quantity of work of from 2,000 to 5,000 kgm. The work done in one minute is from 260 to 650 kgm.

Thus during fast locomotion about one tenth of a horse-power is used for drawing the ricksha. This is the expenditure of energy over and above that which would occur during running at the same pace without drawing the loaded ricksha. The period during which this high velocity can be maintained is only a few minutes at a time. Both the amount of external work per minute and the duration for which it can be maintained are therefore less than that of the Egyptians who lift water from the Nile,[1] while themselves standing still, or that of French navies[2] ascending a ladder. It is much less than that of the oarsmen in a university crew during a boat race.[3] The energy which the coolie can apply to drawing the ricksha is limited by the considerable exertion involved in transporting his own body by running.

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[1] J. S. Haldane and Y. Henderson, "The Rate of Work Done with an Egyptian Shadouf." *Nature*, August 28, 1926.

[2] Jervis Smith, "Dynamometers." (Quoted by Haldane and Henderson (1).)

[3] Y. Henderson and H. W. Haggard, "The Maximum of Human Power." *Am. Jour. of Physiology*, 72: 264, 1925.

CHEMICAL "TESTS"

Every profession, trade or branch of knowledge has its use of words and phrases which convey specific meaning which can be accurately and briefly conveyed in no other way. In chemistry the word "test" carries a very specific meaning. When a chemist "tests" a certain material for phosphorus, he wishes to determine if there is any of this element present and expects to obtain only a very general idea of the relative amount of the phosphorus present. He may not be able to say whether there is nearly 5 per cent. or nearly 20 per cent. present in the material "tested." He may "test" a substance to determine the presence or absence of potassium by a simple flame test requiring less than a minute of time. This "test" is *qualitative* and gives only a vague idea of the per cent. of potassium present. If a chemist wishes to determine the per cent. of potassium in a sample he uses an entirely different procedure requiring several hours of time. This latter procedure is not a "test" but is a *quantitative* determination of the amount of potassium present. The material is *analyzed* for potassium.

In research and other publications, in conversations with scientific men and in correspondence one often notices the word "test" used when reference is actually made to a method of analysis to determine quantitatively the amount of a certain element or compound present in a substance. One may incorrectly mention a protein "test" when he actually has reference to a procedure (Kjeldahl method) which will determine the quantity or per cent. of protein (N) present. A test for the presence or absence of protein may be made by simpler methods (Biuret, etc.). Most requests which come to a chemist are actually for an *analysis* of a sample (for protein, for instance) and not for a "test" (for protein). He *analyzes* the sample and makes a determination of the *per cent.* of protein. He does not "test" the sample for protein or run a protein "test."

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ATMOSPHERIC ELECTRICITY DURING SAND STORMS

The Jornada Range Reserve—near Las Cruces, New Mexico—is an experiment station maintained by the U. S. Forest Service for the purpose of the study of range problems. Since grazing studies are paramount, the station laboratory is not equipped with the instruments used in the measurement of electrical energy. However, the article entitled "Electricity from the Air" which appeared in the News Supplement of Science of March 30, 1928, brings to mind some very interesting observations which were made recently at the Jornada headquarters.

Numerous stories regarding the electrical phenomena which occur during sand storms are in circulation throughout this region. These accounts vary with the personal characteristics of the story-teller. Some versions are no more than drab, conservative statements. Others are displayed in a glamorous setting of colorful phrases and artistic profanity. All of them deal with a near electrocution of some luckless cowboy while placing the coffee pot on the camp stove during a sand storm, or with automobiles becalmed by static under similar climatic conditions.

The first tangible indications of proof observed by the writer that these accounts were not without foundation were obtained during a severe storm on April 4, 1928. On the afternoon of this day the sand storm reached its peak of violence between three and four o'clock in the afternoon. During this time the sky was cloudless. The first evidence of an electrical disturbance was observed in the vacuum tube lightning arrester on the office telephone. Between the carbons of this device, a strong electric arc would form and continue uninterrupted for a period of about thirty seconds. When the arc was broken it was immediately followed by another arc of the same general character.

The radio receiving set was the second object of concern. This instrument is equipped with a 75-foot multi-strand copper aerial which is elevated about twenty feet above the ground. Both the aerial and the telephone wires extend in a north and south direction, which places them at right angles to the strong west wind.

The receiving set was disconnected from the ground and aerial. The tip of the lead-in wire from the radio antenna was placed near the tip of the ground wire. An electric arc resulted immediately. By varying the distance between the wires it was found that three and one half centimeters was the maximum width of the gap over which an arc would form. With this arrangement of the wires, the arc was consistent and would continue for a period of thirty seconds without a visible break. The breaks were of short duration when they did occur. The path of the arc varied in its course, between the ground and antenna tips, much after the manner of chain lightning.

Subsequent observations made during the night revealed a much longer arc of about four and one half centimeters in length. This longer arc was of a filmy nature which made a glow rather than a light, as did the arc when the wires were closer together.

When the storm was strongest a spark would span the gap at about seven centimeters. Sparks jumped this gap at the rate of about one per second. As the storm lessened in violence the rate of spark formation slowed down and became erratic. The width of the gap which the spark would jump decreased rapidly as the storm abated.

The presence of so great an amount of electricity in the air may be the reason for the conspicuous unrest of men and live stock during sand storms. This condition is usually attributed to the discomfort caused by the wind and sand. However, the wind and sand do not account for the fact that the same feeling of unrest is, in a lesser degree, experienced by a person who is sheltered within a thick-walled, adobe house.

R. H. CANFIELD

JORNADA RANGE RESERVE

SCIENTIFIC BOOKS

Life and Work of Sir Norman Lockyer. By T. MARY LOCKYER and WINIFRED L. LOCKYER, with the assistance of PROFESSOR H. DINGLE. Macmillan and Company, London. 1928. xii + 474 pages.

As the title indicates, this book is divided into two parts, of which the first contains the general biography of Sir Norman Lockyer. These chapters are filled with many details about the events in the long life of this great pioneer in the field of astrophysics. Such a story can not fail to be entertaining reading for all who are interested in the development of modern science, because Lockyer's own scientific interests were wide, and he gave much attention throughout his life to all sorts of things connected with the advance of science in general.

He wrote no end of articles, and gave innumerable lectures before all kinds of audiences for the purpose of bringing scientific knowledge and facts to the attention of the whole English nation. With this end in view, in 1869 Lockyer started the general scientific magazine *Nature,* and was its editor for fifty years. During these years it achieved great success, due to his untiring efforts and the willingness of the publishers, Macmillan and Co., to wait patiently for the magazine to become a financial asset.

The activity of Lockyer during his entire career is amazing. As a young man, he did his astronomical work in his spare hours, and earned his living as a clerk in the War Office. It was while he was thus employed that he developed and put to the test of observation the method of using the spectroscope to view the solar prominences, which up to that time had been seen only during total eclipses. This discovery alone would have established his fame as an astronomer for all time. Toward the end of his life, he was greatly