adoption of such measures would be. As soon as a sanitary measure has been approved anywhere, as soon as some hygienic discovery has been made in the workshops of medical science, it should be the duty of the State to try it, to estimate its practical value, and to make it generally known.

It is only by such means that hygiene will become a science, that this science will become the most important part of statesmanship, and that the State will become, as it ought to, a healthy State.

ACROSS CENTRAL ASIA.

AT the meeting of the Royal Geographical Society, on April 9, Mr. St. George Littledale read a paper on his recent journey across Central Asia. Mr. and Mrs. Littledale left England in January 1893, with the intention of crossing Asia from west to east, filling up some blanks in the map, and procuring specimens of the wild camel. After purchasing nearly two pony-loads of silver Yamboos, known on the Chinese coast as Sycee Silver, they travelled in carts to Kurla, where they organized a caravan of twenty ponies and forty donkeys, and followed the river Tarim to Lob Nor. They camped by the Lob Nor swamp, but found the water too salt near the edge to drink; by wading out some distance they were able to get some less brackish, which was just drinkable. Along the Altyn Tag range, as far as the Galechan Bulak, there was a certain amount of water and grazing. This was the point where the great Russian traveller, Prjevalsky, turned back; but beyond, the desert was of an appalling nature—hardly any grass was to be found, and water was very scarce; all the men suffered greatly from thirst, the animals lost flesh rapidly, and many died. Water as a rule was only found every second day. Mr. Littledale in this district shot four wild camels, one of which he has presented to the British Museum. Prjevalsky's wild horse was not seen. The guides were thorough scoundrels, and tried to wreck the expedition in every way; on one occasion they denied the existence of a spring from which they were discovered getting water secretly during the night.

Mr. Littledale was unable to see any trace of a large range of mountains marked on the maps as running north-east from the Altyn Tag. When a few days' journey from Sai-ju they met the first inhabitants, and in vain tried by bribes to get a guide to show a pass over the mountains. They afterwards discovered that their interpreter was playing false; he was scheming to get to some town where he could desert.

They passed an embankment several miles in length, which it was difficult to account for unless it was a continuation of the Great Wall of China from Suchan, two hundred miles to the east. At Sai-ju the Chinese officials were civil, but tried to prevent the travellers returning to the mountains, and their men, exhausted with their journey, were now in addition terrified at the tales they heard of the Tonguts, a Tibetan robber tribe, and refused at first to go on.

Colonel Yule questioned the accuracy of Marco Polo's statement that it was a month's journey from Lob Nor to Sai-ju; but, curiously enough, it took Mr. Littledale exactly thirty days to traverse the distance. As they travelled further east, and crossed the Humboldt range, they found the map which had been constructed from native evidence entirely wrong, and a considerable readjustment is necessary in order to secure an approach to accuracy. They passed large herds of yaks and thousands of antelopes and wild asses. Guides were a great difficulty, and the party were soon left to find their own way. At one place upwards of a hundred mounted Tonguts, carrying lances at least fourteen feet long, match-lock guns, and swords, came past their camp. Their followers predicted an immediate attack. Two Ladakis were sent to parley with them; one expounded a repeating rifle with such marked effect that when the other man proposed to explain the beauties of a revolver they begged him to put it aside, and any idea, if it ever existed, of attacking the camp died a natural death.

Mr. Littledale found his own way over the mountains by a pass, and reached the head waters of the Buhain Gol. They travelled for six days through a luxuriant grass country, and camped on the shores of Koko Nor. Thirteen days more found them at Lanchan, where they disbanded their caravan; their interpreter, who was an arrant coward, absolutely refusing to go to Pekin. Here some China inland missionaries kindly helped them to arrange a raft, on which they drifted down the

Hoang-ho, a journey of exceptional interest through country which is largely un-mapped. Soon after leaving Lanchan the river dashes through a narrow gorge, and the raft had several narrow escapes of being broken up; it was knocked out of shape, and some of the logs smashed. The boatmen had each an inflated sheepskin to act as a life-buoy in case of accident, but none were provided for the passengers. Lower down the river became broader and shallower, and they changed their raft for a flat-bottomed scow, and reached Bonto in twenty-five days. From Bonto to the Great Wall they passed through a country abounding in ruined towns and villages, the result of the disastrous Mahommedan rebellion in 1861. On September 27 they passed through the Great Wall, and reached Pekin three days later.

ELECTRIC TRACTION.

IN the present state of electrical science and practice, electric traction must be considered as a branch of the electrical transmission of energy. We require, first of all, a natural source of energy, such as coal or other fuel, or water at a high elevation or in motion. In the next place, we require a prime mover to transform energy into work, such as a steam or gas engine, a turbine, or water- or tide-wheel. Then this work has to be transformed into electric current, by means of a dynamo or magneto-electric machine, the so-called primary machine. The electric current has then to be transmitted from the place where it is produced to the place where it has to be used, by means of a conductor or a storage battery. The current has next to be retransformed into work, by means of a motor carried by or attached to the vehicle which has to be moved. This work has then to be mechanically transmitted from the motor to the axle of the wheel of the car which travels along the line.

In each of these transformations and transmissions a loss takes place, reducing the original unit of energy to a less and less fraction of itself. In the case of water, with a turbine as the prime mover, we obtain 60 per cent. of the energy as work or motive power, or an efficiency of '6. With a steam-engine, owing to the coal having to break up water into steam, a proportion only of the heat or expansive energy of which can be applied as pressure to drive the piston, because of the impossibility of obtaining, at least at present, a perfect vacuum, or, stated otherwise, of getting the lower limit of temperature anywhere near the absolute zero; and again, owing to the loss occasioned by transforming the motion of translation of the piston into rotatory motion, we have a much smaller efficiency than in the case of a water-wheel. About one eighth only of the energy of the coal is transformed in a steam engine into work to drive the axle, or we have an efficiency of only 125.

The efficiency of electrical machines is very high, as high as '9 with primary machines or dynamos, and '75 with secondary machines or motors. The conductor, or its substitute a storage battery, offers a resistance to the passage of the current, and when the latter is used its weight is so much extra weight to be carried by the car.

All these considerations seem to lead to the conclusion that before electric traction can be employed on a very large scale, we must possess a means of producing the electricity on the spot and at the time it has to be used, or, in other words, we must possess a battery in which the energy of coal can be transformed directly into electric current, so that we may do without storage batteries in which to carry electric energy about, or heavy copper conductors through which to convey it at moderately low tension from the spot where it is produced to where it is used, or light aerial conductors through which to convey it at high tension.

How long we shall be without this, or how many minds are engaged in the solution of this or some such problem, we know not, but the moment it is solved, and solved doubtless it will be, there will be such a transformation scene in the industrial applications of electricity as one can hardly conceive. It would mean that for almost every purpose except those in which heating is required, electricity would or could be used. An electric light-producing battery in every house, quite independently of any mains in the streets; an electric power-producing battery, to carry us whither we would on rails or on the street; and in every house, to put an end to all the evils attendant on crowded factories and workshops in crowded streets and towns; such

and other advantages would result from turning electricity from a servant into a master, from a mere transformer of energy into a source of energy.

But we have to do with things as they are:—One hundred per cent. of water-power turned into a net motor power of thirty-three and a third per cent. on the average of the best results; and certainly a wonderful result in itself—nothing of the kind could possibly be obtained either with a steam or a gas engine, and it points to the direction in which, at all events in the meantime, we have to look for a cheap supply of energy for electric traction.

Electric traction may be looked upon as the most economically difficult application of the electrical transmission of energy. The problem of the supply of electrical energy to a factory, for driving such industrial machines as lathes and sewing-machines, and for its illumination when need be, from an electrical main; the problem of utilising a single large steam-engine within a works for supplying motive power to all the different shops, so as to get rid of the waste and inconvenience of shafting, gearing and belting, is not without its difficulties; but these problems are, from the nature of the case, economically simple. The work that has to be done is of a uniform steady character within a compact space.

The problem of electric traction is quite otherwise; the load is now on, now off; the electrical resistance of the line is always varying with the distance traversed; here there are gradients, there curves; whilst the demand for cars, and the most economical supply of car-loads, are matters all of which have to be taken into consideration, and have their influence on the economy of the undertaking.

Six systems have been employed for supplying the motor on the car with electricity; these are using the rails on which the cars travel as conductors. This was done in the first undertakings at Lichterfelde, and at Brighton in the first instance; having a special rail as conductor either beside or between the rails on which the car travels, as used at Portrush, now at Brighton, and on the City and South London underground electric railway; using underground conductors with an open conduit or slot in the road, as at Budapest, Blackpool, and elsewhere; having an insulated underground conductor, such as that laid down for a short distance near Hammersmith; overhead conductors, the system which has the largest application at present, and first used between Frankfurt and Offenbach, and mainly in use in the United States of America, where some 3000 miles of electric tramways are said to exist. In the sixth system the conductors are replaced by storage batteries.

The rails on which the cars run are now seldom used for the transmission of the current, as being an uneconomical application, but the use of the third rail is a simple and convenient method, where, as in this country, a pressure or tension above 500 volts is not permitted, and where a third rail on the surface, as in rural districts, or in special tunnels, is not an inconvenience; in urban districts, on the other hand, underground conductors are more suitable. There are two ways of arranging the circuit in underground conductors; either connecting the positive and negative poles of the generator, to two insulated underground conductors respectively, or connecting one pole to the insulated underground conductors, and the other to the rails, which in the latter case are in continuous conductive connection, besides having cross connections at different points.

The use of thin aerial conducting wires is interesting in connection with the practical appreciation of the fact, which took place some years ago, that electric energy consists of two factors, viz. the electromotive force or tension and the current strength. As it is to the latter only that a metallic conductor offers resistance, a certain amount of energy may be transmitted through a very thin wire, if care is taken that the electromotive force of the current is high enough. This is the system which it is proposed to use on the St. Louis and Chicago Electric Railway. The distance between these two towns is 250 miles, and it is proposed to run the cars at the rate of 100 miles an hour; the line is to be divided into twenty-five sections of ten miles each, and in the centre of each section there will be a transformer station. The current is to be generated at a tension of 500 volts, transformed to a tension of 25,000 volts, at which it will be transmitted to the several transformer stations, and will be there reduced to 3000 volts, transmitted to the wire, and thence to alternating current motors attached to the cars, each driving axle being supplied with a separate motor.

Secondary or storage batteries, which is the sixth system, to which we have referred, are specially suitable for use on existing tramways, on account of their simplicity and immediate applicability. The objections to them are their weight and the necessity of renewing them from time to time. As regards the former, they weigh from $1\frac{1}{2}$ to 2 tons, and increase the weight to be propelled from 20 to 25 per cent., and there seems to be a real difficulty in making these batteries at the same time light and durable. The batteries which are oxidised by the direct action of the current are found to be too heavy for electric traction, and those in which the oxide is mechanically applied have been more generally used, the positive plate having a paste of red lead, Pb_2O_3 , and the negative a paste of litharge, PbO . The life of a storage battery depends upon its being discharged at a low rate, whilst in traction high rates of discharge are required. It is the positive plate which becomes disintegrated, and cannot again be brought into the condition of metallic lead; the negative plate lasts for a very long time, and can then be re-cast.

This system has been employed on the Birmingham Electric Tramway. On this line a method of controlling the circuit is in use, obviating the necessity of inserting resistances in the circuit, which is always a wasteful way of employing the current. By this means the driver is able with a switch handle to apply from a fourth to the whole of the power which the batteries can produce; the whole would be available when required to start the tram, or when going up-hill with a heavy load, whilst a fourth would be used when travelling on the level with a light load. There are two other positions in which a half or three-quarters can be used as required.

A consideration of importance in connection with electric traction is the style of motor to be used; it should be able to do its work equally well when starting, when after having started it is under the influence of the full current, or where at the further end of the line the current is reduced by the resistance of the conductor; it must be able to be stopped in a moment, and work efficiently with all variations of speed and load. For these purposes shunt motors are not so suitable as series motors, in which the field-magnet coils are connected up in series with the armature, and hence the latter and compound wound motors are those most frequently used. Its special design depends upon the space at disposal in which to fix it, and upon the gearing—whether spur, chain, or worm gearing—used to transmit its motion to the driving axle of the car. In some instances it is advantageous to drive each pair of wheels by a separate motor.

In conclusion, it may be stated that the present conditions under which electric traction is carried on are altogether in its favour, namely, light tramway cars following one another in frequent succession, and travelling at a moderate speed. What is proposed to be done on the St. Louis and Chicago Railway is something quite different. It will probably be difficult to find passengers enough to fill cars to follow one another at a sufficiently quick rate to make the undertaking pay. And then as regards the very high speeds proposed to be used there and elsewhere, one hundred up to two hundred miles an hour, the cars will have to be made of special forms to resist the enormous pressure of the air at these high velocities, and specially ventilated; whilst the effective horse-power required to be supplied by the motor will greatly increase the weight of the car.

E. F. BAMBER.

EDUCATIONAL AGRICULTURAL EXPERIMENTS.

THE Agricultural Research Association of Scotland was founded for the purpose of obtaining trustworthy and useful information on agricultural subjects, by means of scientific investigation and practical experiments. The report of the committee for 1893 shows that the work of the association continues to proceed satisfactorily. Research work is always difficult to maintain, and a committee fostering it must regard it as an unavoidable, though unpleasant, duty to press its claims. "It is a matter of much regret to the committee," we read, "that we should have so constantly to press for adequate means to carry out the work, and that progress should so constantly be checked for want of means. But the reason is obvious, for an association confining itself to investigation holds a peculiar position. It is different, on the one hand, from organisations that are enabled to return interest for the money spent; and, on