rediscovery, which have been prepared by Herr Mahn on his suggestion. They appear in the *Vierteljahrsschrift der astronomischen Gesellschaft*, 12 Jahrgang, 2 Heft. Encke's period, 70·7 years, would bring the comet to perihelion again in 1883, but Mr. W. E. Plummer, now of the University Observatory at Oxford, some years since stated that a period of 69·2 years would better agree with normal places which he had very carefully prepared. The comet may therefore visit us in 1881, or possibly much earlier with the unknown effect of perturbation. The sweeping-ephemerides are arranged upon a plan conveniently indicating the line in which the comet should be sought at a particular date. It is a case where the "orbit-sweeper," suggested by Sir George Airy, and advocated by Prof. Winnecke, would, if provided with an object-glass of sufficient optical capacity, render much assistance.

THE COMPANION OF SIRIUS.—In the *Comptes Rendus* of the French Academy of Sciences, August 13, M. Flammarion has a graphical representation of the orbit assigned by Dr. Auwers, to the perturbing companion of Sirius and of the observed course of the small star discovered by Mr. Alvan Clark, with the view to illustrate the increasing differences between theory and observation. Allusion was made to this subject in NATURE (vol. xiii. p. 428), where the differences of Dr. Auwer's ephemeris, 1872-75, were given. The latest measures of the Clark-companion at Washington, show for 1877·21, position $(c - o)$, $+ 6°·9$, distance $- 0''·88$.

Prof. Asaph Hall found no other star in the vicinity of Sirius nearer than one of the thirteenth magnitude, which was measured on February 28, 1877; position 114°·9, distance 72″·09; probably the star seen by Mr. Marth at Malta in January, 1865. An examination of the vicinity with the great refractor was made at the request of M. Tempel, of Florence, who had suspected the existence of several small stars near Sirius.

SATELLITE OF MARS.—One of the newly-discovered satellites of Mars was observed by M. M. Henry at the Observatory of Paris, on August 27.

At 12h. 9m. mean time, position 249° 56′, distance 85″·2, the satellite was very faint, and only observable when the planet was screened from view.

BIOLOGICAL NOTES

THE DEVELOPMENT OF THE NERVES IN VERTEBRATES.—Mr. Balfour's discovery that the spinal nerves of sharks and rays are developed as outgrowths from the central nervous system has been followed by a similar revelation with regard to birds. Mr. (now Dr.) A. M. Marshall (of Cambridge) has given an account of investigations respecting the origin of nerves in the fowl (*Journ. Anat.*, April, 1877), describing a longitudinal ridge arising on the summit of the neural canal, and giving off paired processes, the rudiments of the posterior roots of the spinal nerves. Hensen has made analogous observations on the spinal nerves of the rabbit. The anterior roots arise later, distinct from one another, as processes from the spinal cord. Mr. Balfour has endeavoured to solve the difficult question of the relations of the cranial to spinal nerves. He finds as yet no traces in the brain of anything comparable to anterior roots of nerves; all the nerves are posterior roots. The fifth, or trigeminal, arises from the dorsal summit of the hind-brain very early, just like a dorsal root of a spinal nerve. This nerve also, instead of being a compound one, is at any rate in its origin perfectly simple. The auditory nerve and the facial arise by one common root. The glossopharyngeal and vagus have a series of distinct roots. In an adult Scyllium twelve separate strands have been counted in the vagus nerve. This number, and their origin like so many separate spinal nerves, opens up interesting questions in regard to the primitive segmentation of the head and the loss or condensation of segments in the evolution of the vertebrates. Dr. Marshall's observations on the cranial nerves of the chick, so far as they go, correspond to Mr. Balfour's. It appears that there is no definite indication of a limit between head and trunk afforded by the central nervous cord, by the outgrowths from it, or by the mode of development of the nerves. It is open for consideration whether the absence of anterior roots to the cranial nerves may not furnish such a limit; this would be very convenient for morphology.

INSECT AID IN FERTILISATION OF FLOWERS.—Mr. Thomas Meehan, of Philadelphia, continues to bring forward cases to show that many flowers are not so dependent on insect fertilisation as has been imagined. Recently (*Proc.* Acad. Nat. Sciences, Philadelphia, 1877, p. 128) he has instanced the common mignonette, which usually does not seed when forced in greenhouses in winter. It has been asserted that this is due to the absence of suitable insects to produce fertilisation. But last winter Mr. Meehan's specimens took to producing seed in abundance, two to six perfect seeds in every capsule. This showed that some other circumstance had come into play which affected the reproductive organs, insect aid having been as much absent as in other cases.

INSECTIVOROUS PLANTS.—Dr. C. Cramer, of Zürich, publishes, under the title "Ueber die Insectenfressenden Pflanzen," a useful epitome of all that has at present been recorded respecting the singular phenomenon of "Insectivorous Plants." In a series of papers in *Flora*, on the Mechanics of the Movements of these plants, A. Batalin calls attention to a hitherto neglected paper of Oudemans, published (in Dutch) in 1859, in which he describes the greater part of the phenomena of irritation in Venus's fly-trap (*Dionæa muscipula*), agreeing in almost every point with the description subsequently given by Darwin and others.

SPONTANEOUS MOVEMENTS IN PLANTS.—M. E. Rodier, of Bordeaux, has described a singular series of automatic or spontaneous movements in a well-known water-plant, *Ceratophyllum demersum*. They consist of a rhythmical motion caused by a curvature of the axis extending over six hours, which is neutralised in the course of the next twelve hours, and followed by a curvature in the opposite direction extending over four hours, which is again neutralised in four hours, the whole cycle thus extending over a period of twenty-six hours. The movement appears to be entirely unaffected by light.

DISCOVERY OF OXYGEN IN THE SUN BY PHOTOGRAPHY, AND A NEW THEORY OF THE SOLAR SPECTRUM[1]

I PROPOSE in this preliminary paper to indicate the means by which I have discovered oxygen and probably nitrogen in the sun, and also to present a new view of the constitution of the solar spectrum.

Oxygen discloses itself by bright lines or bands in the solar spectrum and does not give dark absorption lines like the metals. We must therefore change our theory of the solar spectrum, and no longer regard it merely as a continuous spectrum with certain rays absorbed by a layer of ignited metallic vapours, but as having also bright lines and bands superposed on the background of continuous spectrum. Such a conception not only opens the way to the discovery of others of the non-metals, sulphur, phosphorus, selenium, chlorine, bromine, iodine, fluorine, carbon, &c., but also may account for some of the so-called dark lines, by regarding them as intervals between bright lines.

It must be distinctly understood that in speaking of the solar spectrum here, I do not mean the spectrum of any

[1] Paper by Prof. Henry Draper, M.D. Read before the American Philosophical Society, July 20, 1877. We are indebted to Dr. Draper's kindness for the plate and illustrations which accompany this paper.

limited area upon the disc or margin of the sun, but the spectrum of light from the whole disc. I have not used an image of the sun upon the slit of the spectroscope, but have employed the beam reflected from the flat mirror of the heliostat without any condenser.

In support of the above assertions the accompanying photograph of the solar spectrum with a comparison spectrum of air, and also with some of the lines of iron and aluminium, is introduced. The photograph itself is absolutely free from handwork or retouching. It is difficult to bring out in a single photograph the best points of these various substances, and I have therefore selected from the collection of original negatives that one which shows the oxygen coincidences most plainly. There are so many variables among the conditions which conspire for the production of a spectrum that many photographs must be taken to exhaust the best combinations. The pressure of the gas, the strength of the original current, the number of Leyden jars, the separation and nature of the terminals, the number of sparks per minute, and the duration of the interruption in each spark, are examples of these variables.

In the photograph the upper spectrum is that of the sun, and above it are the wave-lengths of some of the lines to serve as reference numbers. The wave-lengths used in this paper have been taken partly from Angström and partly from my photograph of the diffraction-spectrum published in 1782. The lower spectrum is that of the open air Leyden spark, the terminals being one of iron and the other of aluminium. I have photographed oxygen, nitrogen, hydrogen, and carbonic acid, as well as other gases in Plücker's tubes and also in an apparatus in which the pressure could be varied, but for the present illustration, the open air spark was, all things considered, best. By other arrangements the nitrogen lines can readily be made as sharp as the oxygen are here, and the iron lines may be increased in number and distinctness. For the metals the electric arc gives the best photographic results, as Lockyer has so well shown, but as my object was only to prove by the iron lines that the spectra had not shifted laterally past one another, those that are here shown at 4325, 4307, 4271 4063, 4045, suffice. In the original collodion negative many more can be seen. Below the lower spectrum are the symbols for oxygen, nitrogen, iron, and aluminium.

No close observation is needed to demonstrate to even the most casual observer that the oxygen lines are found in the sun as bright lines, while the iron lines have dark representatives. The bright iron line at G (4307), on account of the intentional overlapping of the two spectra, can be seen passing up into the dark absorption line in the sun. At the same time the quadruple oxygen line between 4345 and 4350 coincides exactly with the bright group in the solar spectrum above. This oxygen group alone is almost sufficient to prove the presence of oxygen in the sun, for not only does each of the four components have a representative in the solar spectrum, but the relative strength and the general aspect of the lines in each case is similar. I do not think that in comparisons of the spectra of the elements and sun, enough stress has been laid on the general appearance of lines apart from their mere position ; in photographic representations this point is very prominent. The fine double line at 4319, 4317, is plainly represented in the sun. Again there is a remarkable coincidence in the double line at 4190, 4184. The line at 4133 is very distinctly marked. The strongest oxygen line is the triple one at 4076, 4072, 4069, and here again a fine coincidence is seen, though the air spectrum seems proportionately stronger than the solar. But it must be remembered that the solar spectrum has suffered from the transmission through our atmosphere, and this effect is plainest in the absorption at the ultra-violet and violet regions of the spectrum. From some experiments I made in the summer of 1873 it appeared that this local absorption is so great, when a maximum thickness of air intervenes, that the exposure necessary to obtain the ultra-violet spectrum at sunset was two hundred times as long as at mid-day. I was at that time seeking for atmospheric lines above H like those at the red end of the spectrum, but it turned out that the absorptive action at the more refrangible end is a progressive enfeebling, as if a wedge of neutral tinted glass were being drawn lengthwise along the spectrum towards the less refrangible end.

I shall not attempt at this time to give a complete list of the oxygen lines with their wave-lengths accurately determined, and it will be noticed that some lines in the air spectrum which have bright analogues in the sun are not marked with the symbol of oxygen. This is because there has not yet been an opportunity to make the necessary detailed comparisons. In order to be certain that a line belongs to oxygen, I have compared, under various pressures, the spectra of air, oxygen, nitrogen, carbonic acid, carburetted hydrogen, hydrogen, and cyanogen. Where these gases were in Plücker's tubes a double series of photographs has been needed, one set taken with and the other without Leyden jars.

As to the spectrum of nitrogen and the existence of this element in the sun there is not yet certainty. Nevertheless, even by comparing the diffused nitrogen lines of this particular photograph, in which nitrogen has been sacrificed to get the best effect for oxygen, the character of the evidence appears. The triple band between 4240, 4227, if traced upward into the sun, has approximate representatives. Again at 4041 the same thing is seen, the solar bright line being especially marked. In another photograph the heavy line at 3995, which in this picture is opposite an insufficiently exposed part of the solar spectrum, shows a comparison band in the sun.

The reason I did not use air in an exhausted Plücker's tube for the production of a photograph to illustrate this paper and thus get both oxygen and nitrogen lines well defined at the same time, was partly because a brighter light can be obtained with the open air spark on account of the stronger current that can be used. This permits the slit to be more closed and of course gives a sharper picture. Besides the open air spark enabled me to employ an iron terminal and thus avoid any error arising from accidental displacement of the reference spectrum. In Plücker's tubes with a Leyden spark the nitrogen lines are as plain as those of oxygen here. As far as I have seen, oxygen does not exhibit the change in the character of its lines that is so remarkable in hydrogen under the influence of pressure as shown by Frankland and Lockyer.

The bright lines of oxygen in the spectrum of the solar disc have not been hitherto perceived, probably from the fact that in eye observation bright lines on a less bright background do not make the impression on the mind that dark lines do. When attention is called to their presence they are readily enough seen, even without the aid of a reference spectrum. The photograph, however, brings them into a greater prominence. From purely theoretical considerations derived from terrestrial chemistry and the nebular hypothesis, the presence of oxygen in the sun might have been strongly suspected, for this element is currently stated to form eight-ninths of the water of the globe, one-third of the crust of the earth, and one-fifth of the air, and should therefore probably be a large constituent of every member of the solar system. On the other hand the discovery of oxygen and probably other non-metals in the sun gives increased strength to the nebular hypothesis, because to many persons the absence of this important group has presented a considerable difficulty.

At first sight it seems rather difficult to believe that an ignited gas in the solar envelope should not be indicated by dark lines in the solar spectrum, and should appear not to act under the law, "a gas when ignited absorbs rays of the same refrangibility as those it emits." But in fact the substances hitherto investigated in the sun are really metallic vapours, hydrogen probably coming under that rule. The non-metals obviously may behave differently. It is easy to speculate on the causes of such behaviour, and it may be suggested that the reason of the non-appearance of a dark line may be that the intensity of the light from a great thickness of ignited oxygen overpowers the effect of the photosphere just as if a person were to look at a candle flame through a yard thickness of ignited sodium vapour, he would only see bright sodium lines, and no dark absorption lines. Of course, such an explanation would necessitate the hypothesis that ignited gases such as oxygen give forth a relatively large proportion of the solar light. In the outburst of *T Coronæ* Huggins showed that hydrogen could give bright lines on a background of spectrum analogous to that of the sun.

However all that may be, I have no doubt of the existence of substances other than oxygen in the sun which are only indicated by bright lines. Attention may be called to the bright bands near G, from wave-lengths 4307 to 4337, which are only partly accounted for by oxygen. Farther investigation in the direction I have thus far pursued will lead to the discovery of other elements in the sun, but it is not proper to conceal the principle on which such researches are to be conducted for the sake of personal advantage. It is also probable that this research may furnish the key to the enigma of the D_3 or Helium line, and the 1474 K or Corona line. The case of the D_3 line strengthens the argument in favour of the apparent exemption of certain substances from the common law of the relation of emission and absorption, for while there can be no doubt of the existence of an ignited gas in the chromosphere giving this line, there is no corresponding dark line in the spectrum of the solar disc.

In thus extending the number of elements found in the sun we also increase the field of inquiry as to the phenomena of dissociation and recomposition. Oxygen, especially from its relation to the metals, may readily form compounds in the upper regions of the solar atmosphere which can give banded or channeled spectra. This subject requires careful investigation. The diffused and reflected light of the outer corona could be caused by such bodies cooled below the self-luminous point.

This research has proved to be more tedious and difficult than would be supposed because so many conditions must conspire to produce a good photograph. There must be a uniform prime moving engine of two-horse power, a dynamo-electric machine thoroughly adjusted, a large Ruhmkorff coil with its Foucault break in the best order, a battery of Leyden jars carefully proportioned to the Plücker's tube in use, a heliostat, which of course involves clear sunshine, an optical train of slit, prisms, lenses, and camera well focussed, and in addition to all this a photographic laboratory in such complete condition that wet sensitive plates can be prepared which will bear an exposure of fifteen minutes and a prolonged development. It has been difficult to keep the Plücker's tubes in order; often before the first exposure of a tube was over the tube was ruined by the strong Leyden sparks. Moreover, to procure tubes of known contents is troublesome. For example, my hydrogen tubes gave a spectrum photograph of fifteen lines of which only three belonged to hydrogen. In order to be sure that none of these were new hydrogen lines it was necessary to try tubes of various makers, to prepare pure hydrogen and employ that, to examine the spectrum of water, and finally to resort to comparison with the sun.

The object in view in 1873, at the commencement of this research, was to secure the means of interpreting the photographs of the spectra of stars and other heavenly bodies obtained with my 28-inch reflector. It soon appeared that the spectra of nitrogen and other gases in Plücker's tubes could be photographed, and at first some pictures of hydrogen, carbonic acid, and nitrogen were

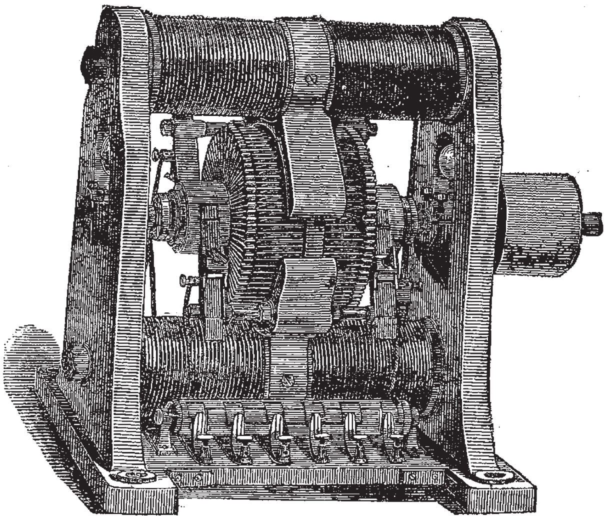

FIG. 1.—The Gramme Machine.

made, because these gases seemed to be of greatest astronomical importance on account of their relation to stars, nebulæ, and comets. Before the subject of comparison spectra of the sun was carefully examined there was some confusion in the results, but by using hydrogen the source of these errors was found out.

But in attempting to make a prolonged research in this direction, it soon appeared that it was essential to be able to control the electrical current with precision both as to quantity and intensity, and moreover to have currents which, when once adjusted, would remain constant for hours together. These conditions are almost impossible to attain with any form of battery, but on the contrary are readily satisfied by dynamo-electric machines. Accordingly, I sought for a suitable dynamo-electric machine and motor to drive it, and after many delays procured a combination which is entirely satisfactory. I must here acknowledge my obligations for the successful issue of

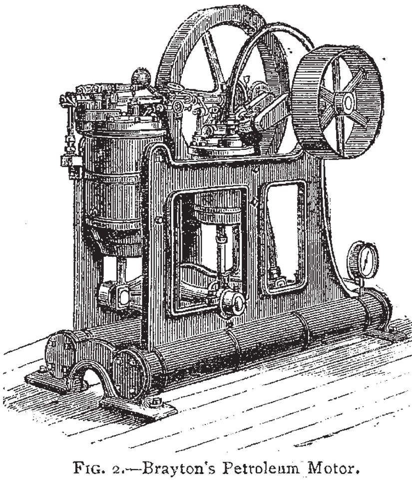

FIG. 2.—Brayton's Petroleum Motor.

this search to Prof. George F. Barker, who was the first person in America to procure a Gramme machine. He was also the first to use a Brayton engine to drive a Gramme.

The dynamo-electric machine selected is one of

Gramme's patent, made in Paris, and is a double light machine, that is, it has two sets of brushes, and is wound with wire of such a size as to give a current of sufficient intensity for my purposes. It is nominally a 350 candle-light machine, but the current varies in proportion to the rate of rotation, and I have also modified it by changing the interior connections. The machine can produce as a maximum a light equal to 500 standard candles, or by slowing the rotation of the bobbin the current may be made as feeble as that of the weakest battery. In practical use it is sometimes doing the work of more than fifty large Grove nitric acid cells, and sometimes the work of a single Smee.

The Gramme machine could not be used to work an induction coil when it first reached me, because when the whole current was sent through the Foucault interruptor of the Ruhmkorff coil, making 1,000 breaks per minute, the electro-magnets of the Gramme did not become sufficiently magnetised to give an appreciable current. But by dividing the current so that one pair of the metallic brushes, which collect from the revolving bobbin, supplied the electro-magnets, the other pair could be used for exterior work, no matter whether interrupted or constant. The current obtained in this way from one pair of brushes when the Gramme bobbin is making 1,200 revolutions per minute is equal to 100 candles, and is greater in quantity and intensity than one would like to send through a valuable induction coil. I usually run the bobbin at 622 revolutions per minute, and this rate will readily give 1,000 10-inch sparks per minute with the 18-inch coil. Of course a Plücker's tube lights up very vividly and generally; in order to get the maximum effect I arrange the current so that the aluminium terminals are on the point of melting. The glass, particularly in the capillary part, often gets so hot as to char paper. The general appearance of the machine is shown in Fig. 1.

As long as the Gramme bobbin is driven at a steady rate the current seems to be perfectly constant, but variations of speed make marked differences in the current, and this is especially to be avoided when one is so near the limit of endurance of Plücker's tubes. A reliable and constant motor is therefore of prime importance for these purposes. A difference of one per cent. in the speed in the engine sometimes cannot be tolerated, and yet at another time one must have the power of increasing and diminishing the rate through wide limits. The only motor, among many I have examined and tried, that is perfectly satisfactory, is Brayton's Petroleum Ready Motor.

This remarkable and admirable engine acts like an instrument of precision. It can be started with a match, and comes to its regular speed in less than a minute; it preserves its rate entirely unchanged for hours together. Moreover, it is economical, cleanly, and not more noisy than a steam engine. The one of two-horse power I have, ran for six months, day and night, supplying water and air to the aquaria in the Centennial Exhibition at Philadelphia. At any time on going into the laboratory it can be started in a few seconds, even though it has not been running for days.

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THE NATURAL HISTORY OF THE JENISSEI

AN account of the Swedish Overland Expedition to the Jenissei in the summer of 1876, the cost of which was defrayed by Mr. Oscar Dickson of Gothenburg, has appeared in the *Göteborgs Handels Tidning*. The expedition was under the leadership of Dr. Hjalmar Théel of Upsala, who was accompanied by Botany-Docent W. Arnell, Philosophy-Candidate F. Trybom, Zoologist, and Rector M. Brenner, Botanist, from Finland. Docent Sahlberg, Entomologist, from Helsingfors, also went with the expedition to the Jenissei with the intention of prosecuting independent researches there. The party travelled by Nischni-Novgorod, Perm, Tjumen, Tomsk, and Krasnojarsk on the Jenissei, arriving at the last place on June 8.

We regret that our space permits of our giving only the following account of the natural history of the Jenissei by Dr. Théel:—

The Jenissei has a length of about 1,660 English miles below Krasnojarsk. The banks are sometimes pretty high and bold, sometimes low, alternating in this respect with each other, so that, when the left is high, the right is the opposite. Where the bank is low and exposed to inundations, willows thrive beyond everything. The high banks are clothed with *Pinus obovata* and *cembra*, and larch. At Jeniseisk the river is about 1½ versts broad, gradually widening northward, till at Kurejka it is five versts broad. Between Tolstonos and Goltschika the river widens and assumes the appearance of a lake more than sixty versts wide. Here the tides are quite observable. At Dudinskoj a depth reaching twelve fathoms was found.

The Russian population of the Jenissei Valley is very sparse and uncivilised, and inferior, as far as the fine arts are concerned, to some of the Asiatic races. Cattle rearing is in its infancy, though there are perhaps few regions more suited for it than the valley of the Jenissei. Cows are met with as far as Dudinskoj, but their proper management did not appear to be understood. At villages on the upper Jenissei, with as many as forty or fifty cows, a glass of milk could scarcely be obtained. The making of cheese is completely unknown, the making of butter nearly so. There are horses as far north as Dudinskoj, sheep only to Vorogova, and no goats north of Jeniseisk. Cultivation is at a still lower standpoint, rye not being at present grown below Antsiferova, sixty-seven versts north of Jeniseisk, and oats to Zotina, 60° 55′ N. lat. Potatoes are grown to Turuchausk, but are there very small. For some years Skoptzi settled on the Chantajka river, 68° 20′ N. lat., have successfully grown potatoes.

Fish forms the principal food of the people, and during summer nearly every one is a fisher. Fishing is carried on with various kinds of nets, with lines and hooks, and even with leister and torch. There are found in the Jenissei pike, ruffe, perch, burbot, *Cyprinus curassius*, tench, *Thymallus vulgaris*, several species of the family *Leuciscus*, among them one which strongly resembles our common roach, a kind of *Petromyzon*, *Gasterosteus pungilius*, a kind of bullhead (*Cottus*), &c. All these are of inferior importance for domestic use, and mostly serve as food for dogs. The more valuable are the sturgeon, salmon, and coregonus. There are two varieties of sturgeon, the common sturgeon or "Ossetrina," *Accipiter sturio*, and the sterlet, *Ac. ruthenus*. The *Ossetrina* is caught along the whole Jenissei, and sometimes reaches a weight of 225 lbs. The sterlet is not found north of Dudinskoj, and commonly weighs 3 or 4 lbs., but sometimes reaches 18 lbs. There is another called the prickly sturgeon, "Kosterska," believed to be the young of the *Ossetrina*. There are many varieties and transition forms of sturgeon, rendering their proper classification difficult. The salmon is most numerous in the upper course of the river at Minousinsk, where a profitable fishery is carried on. Two types are distinguished, "Tajmen" and "Kunschja." The former is caught in greatest numbers in the upper course of the river, and weighs 40 to 60 lbs.; the latter is found in lakes on the *tundra*, and very seldom in the Jenissei below Dudinskoj. At the Nichandrovska Islands a salmon, probably a Tajmen, was caught, which was nearly five feet long and weighed between 80 and 100 lbs. Of the Coregonus the following species were found in the Jenissei:—Njelma (*C. leucichthys*), Tschir