direction in a similar manner to the ordinary rocket, and in the experiments performed by Messrs. Nicholls and Hull this "reaction" pressure would be about ten times as great as the "radiation" pressure. This research has experimentally illustrated the repulsion, and has shown that a part of it at least is probably due to the "radiation" pressure; it now remains to determine more definitely the relative effect of each of the possible causes.

A CATALOGUE OF 1520 BRIGHT STARS.—As the "Revised Harvard Photometry," which will contain details of about nine thousand stars of magnitude 6·5 and brighter, is not yet ready, the Harvard College Observatory has published a smaller catalogue, which only contains 1520 stars, and does not give the detailed information which will be contained in the larger volume.

The catalogue gives, in tabular form, the H.P. number, the constellation name, the R.A. and declination, the magnitude and the type of spectrum for each star, and a comprehensive set of "remarks" describes the peculiarities appertaining to various stars included in the list.

A large edition of the catalogue has been prepared, and anyone interested may obtain a copy on applying to the director.

IRON AND STEEL INSTITUTE.

THE autumn meeting of the Iron and Steel Institute was held in the Town Hall, Barrow-in-Furness, on September 1, 2, and 3, with Mr. Andrew Carnegie, the president, in the chair, and was very largely attended. After an eloquent address of welcome from the Mayor, Mr. Carnegie delivered a short presidential address, in which he traced the progress made in the metallurgy of iron and steel since the Institute's last visit to Barrow twenty-nine years ago. After various business announcements had been made by the secretary, Mr. Bennett H. Brough, the reading and discussion of the thirteen papers on the programme began. The first read was that by Mr. R. A. Hadfield on the alloys of iron and tungsten. This formed a monograph of sixty-eight closely printed pages. It contains historical details regarding the ores of tungsten, the metal and its alloys, and a large amount of physical data. It concludes with a carefully compiled bibliography of the subject, showing that a large amount of attention has been devoted to studies of this interesting metal and its employment in the manufacture of steel. Osmond, by his cooling curves, has brought out several peculiar points in the thermal behaviour of this steel, and Barrett has discovered that tungsten affects the conductivity of iron less than any other added element. Though tungsten-iron alloys will have an important future, there is no doubt that their use is not likely to be on the same large scale as some of the other special steels now produced. In the discussion some interesting details were added by Mr. F. W. Harbord and by Mr. J. E. Stead.

This paper was followed by a series of memoirs dealing with the heat treatment of steel. These were discussed together.

The paper read by Mr. J. E. Stead and Mr. Arthur W. Richards on the restoration of dangerously crystalline steel by heat treatment established facts of far-reaching importance. The microscope shows that heating at high temperatures causes a great development in the size of the crystalline grains, and reheating to about 870° restores the original or a better structure. If all structural steels in their normal rolled or forged condition are good, they can be readily deteriorated in quality by heating to a temperature a little above that to which steel is most commonly heated previous to rolling or forging. Steel made brittle by such heating, and dangerously brittle by heating at considerably higher temperatures, can be completely restored to the best possible condition without forging down to a smaller size or by remelting. Not only are the original good qualities of normally rolled steel, after making brittle, restored by the exceedingly simple treatment of heating to about 900° C. for a very short time, but such steel is made considerably better than it was. That brittle "soft steel" can be restored by reheating is well known, but that carbon steels can be actually made much superior to the original properly forged metal by reheating to 870° and cooling in air is a discovery. It is urged that in every large forge and smith's shop Le Chatelier pyrometers should be introduced, together with suitable furnaces for reheating the forgings.

Mr. J. E. Stead and Mr. Arthur W. Richards next read a remarkable paper on sorbitic steel rails. The term sorbitic is used for a transition condition of the carbide intermediate between the states in which it exists in hardened and annealed steels. The chief point of interest in the authors' work is the simple method employed for producing sorbite in steel. The usual custom has been to reheat and oil-harden, or to quench completely in water and reheat to dull redness. They avoid reheating, and quench the heads of the rails, and allow the residual heat in the rails to do the tempering. The results of the later experiments show clearly enough that by partially quenching the heads and allowing the rails to temper themselves, although the elongation is decreased, the contraction of area remains practically the same. A normal rail of 37 tons tenacity when made sorbitic is increased in strength to 45 tons without diminution of the contraction of area. A normal rail with 36½ tons tenacity is increased to 49 tons with a slight increase in the contraction of area. In other cases the tenacity is increased from 43 to 50 tons with a slight diminution in the contraction of the area. Pieces of the rail cut from the area of maximum sorbite on being tested by repeated reversals of strain showed greater toughness and endurance than the normal material. The wear is very greatly in favour of the sorbitic material, as would naturally be expected, and it is believed that, by treating the rails in the simple manner described, their life will be increased from 25 to 50 per cent. The results obtained should lead metallurgists to aim at replacing pearlite by sorbite in all structural steels that have to be subjected to friction, percussion, or vibration when in use.

A paper on the heat treatment of steel rails high in manganese was contributed by Mr. J. S. Lloyd (South Russia). Steels containing more than 1 per cent. of manganese have not hitherto been fully studied, and a research carried out in Russia by the author shows that, at the ordinary normal heat suitable for rolling ingots, steel containing 0·46 per cent. of carbon and 1·33 per cent. of manganese is made exceedingly brittle if it is not further treated, but is allowed to cool on the mill floor. Slowly cooling in the furnace after heating for eighteen hours at 950° makes the material about twice as ductile as it was in the original rail, but the tenacity is considerably reduced. The heating to the rolling temperature causes an enormous development in the size of the crystals, but these are broken up and become about one-eighth of the dimensions by heating to 950° C. and slowly cooling afterwards, and the structure so obtained is twice as fine as it was in the normal rail.

Some further experiments on the diffusion of sulphides through steel were described by Prof. E. D. Campbell, of the University of Michigan. They appear to sustain the conclusions drawn from his work—that iron is permeable by sulphides when heated above 1200° C., and that the sulphur content of the iron is not necessarily increased by the passage of the sulphide through it. In fact, in a slightly oxidising atmosphere the sulphur content of the steel may be even less after the diffusion than it was before. The author is not prepared at present, from the experimental data at hand, to give a positive explanation of the manner in which sulphides permeate or diffuse through iron. The most plausible hypothesis would seem to be that the sulphides originally present in the iron fill more or less completely the interstitial spaces between the crystals of iron; that above 1200° these sulphides are very fluid, and may be drawn out of the steel by capillary action of some absorbent such as asbestos, and their place taken by some other sulphides, provided these latter are sufficiently mobile to find their way into the extremely minute spaces between the steel crystals. If the sulphide replacing the original sulphide contain less sulphur than the latter, or if absorption by the asbestos continued after the sulphides had ceased to enter the iron from within, the diminished percentage of sulphur in the steel at the hot end would be readily accounted for.

The paper by Prof. A. Stansfield on the overheating and burning of steel was a report on work carried out by him as Carnegie research scholar, its publication having been delayed by his appointment to the chair of metallurgy at Montreal. The memoir covers thirty-six pages. The burnt structure of very much overheated steel is shown to be largely due to the partial melting which results from heating the steel above a given temperature. This melting causes brittleness directly, and indirectly by the admission of oxygen to the steel. According to American metallurgists the latter stage would alone be called burning, but as the effect of partly melting the steel is quite distinct from that of overheating below the zone of partial fusion, the author would prefer to apply one word to the whole of the changes that take place in this zone. If the word burning is still employed, it should be remembered that it is essentially a partial melting of the steel, though often accompanied by oxidation. The following stages have been recognised:—(1) overheating (below the point of incipient fusion); (2) partial melting, called burning; (*a*) merely producing segregation of carbon in the joints; (*b*) accompanied with liquation and producing flaws; (*c*) further liquation and oxidation in the flaws. (1) Steel that has merely been overheated can be completely restored by heating just above its highest recalescence point and allowing to cool. (2) Steel in the stage (*a*) can be restored by suitable annealing; in the stage (*b*) forging would also be needed; and in stage (*c*) it would be restored with great difficulty, if at all.

The paper on the heat treatment of steel submitted by Dr. William Campbell (New York) is a report on research carried out by the author as Carnegie research scholar. It forms a pamphlet of ninety-three pages. The steel used contained 0·50 per cent. of carbon, 0·98 manganese, 0·094 silicon, 0·098 phosphorus, and 0·08 sulphur. The structure of the steel used was found to depend upon the two constituents present, namely, the ferrite and the pearlite. The pearlite will certainly show the finest structure when the steel has been heated to just above Ac_1, or when it has been transformed into martensite. Heating to temperatures above this point will cause a coarsening of the structure. The higher the temperature the coarser the structure. Above Ac_1 the ferrite begins to diminish in size, due to its being dissolved in the martensite. This will continue until the whole of it is dissolved, when the change Ac_{2-3} is complete. Then the finest structure of the whole will be found where these two changes balance. This point is apparently just below the point where Ac_{2-3} is complete. The best finishing temperature is such that the bars leave the rolls as near Ar_{2-3} as possible. The bars would necessarily have to be drawn from the furnace at a higher temperature, which is about 740° C. in this case, allowing for a cooling of, say, 40° C. or more during rolling. In comparing the results obtained with those of pure carbon steel, the effect of the manganese present must be taken into consideration.

An animated discussion followed the reading of these papers on heat treatment, in which Messrs. Westgarth, Ridsdale, Lange, Price-Williams, L. N. Ledingham, and Hadfield took part.

The probability of iron ore lying below the sands of the Duddon Estuary formed the subject of a paper by Mr. J. L. Shaw (Whitehaven). He adduces evidence to show that there is a limestone area probably carrying large bodies of ore, and advocates the putting down of exploratory boreholes. In the discussion Mr. G. J. Snelus gave further particulars of geological interest.

The paper by Mr. W. F. Pettigrew on coal as fuel at Barrow-in-Furness contained much of interest. In that district at the present time coal is obtained from Cumberland, Lancashire, and Yorkshire. As the prices at the pit, the cost of carriage, and the quality of the coal from these districts vary considerably, the author has carried out several experiments to find the relative value of coal obtained from the districts before mentioned, also from various parts of Scotland and South Wales. Experiments carried out with a locomotive showed that the sample of Yorkshire No. 1 gave the best results. This coal has excellent steaming qualities, is very clean, with an open clinker, and low percentage of ash. The Welsh coal was also good when tried, and equal in all respects to the Yorkshire coal, and would no doubt give even better results if properly fired, which was not the case during the trials, the men having had practically no experience with this kind of coal. The Cumberland coal was good, particularly one sample, but this was not found suitable for locomotive purposes. The other sample of Cumberland coal gave fairly good results, but it is a dirty coal, and necessitates the frequent cleaning of fires. The Lancashire samples were in some cases very good steaming coal, with a moderately low consumption, but several samples gave very bad results, and were quite unfit for locomotive purposes. The Scotch coals tested were fairly good, but in most cases a very heavy consumption was recorded. They are quick burning coal and dirty, but with an open clinker, which did not interfere in any way with the steaming. The consumption was from 20 to 40 per cent. higher than the Yorkshire coal.

Mr. C. H. Ridsdale (Middlesbrough) read a lengthy paper on the diseases of steel. In it he collated various types of defects, and traced them to their origin.

Mr. H. Ehrhardt, of Düsseldorf, contributed a paper describing a process for making weldless steel pipes and shells by which rings up to 8 feet in diameter and 10 feet in length are manufactured.

The regulation of the combustion and distribution of the temperature in coke oven practice was dealt with in a paper by Mr. D. A. Louis. Illustrations were given to show the design and character of the Brunck and v. Bauer coke ovens, two ovens of new design.

The influence of silicon on iron was dealt with in a paper by Mr. Thomas Baker. He prepared a series of alloys of silicon and iron with traces only of other elements, and studied the micro-structure and physical properties of each. Although the addition of silicon to iron increases the elastic limit and tenacity of iron, such increase is only obtained by loss of ductility, which loss, provided the material has been well annealed, is very small until the silicon reaches 3 per cent., after which it becomes very great, the ductility almost becoming zero with 4 per cent. silicon. The alloys gradually increase in hardness with the addition of silicon, and after exceeding 5 per cent. silicon require great skill and care in machining in order to avoid fracture of the bar. As the percentage of silicon increases the permeability for low magnetic fields increases, and the coercive force and hysteresis loss decrease. Prof. T. Turner (Birmingham) was the chief speaker in the discussion.

The proceedings concluded with the customary votes of thanks to the reception committee, and an invitation, tendered by Mr. Kirchhoff, of New York, on behalf of the American societies, that the Institute should meet in the United States next autumn was accepted.

In connection with the meeting an elaborate programme of visits and excursions was arranged, including the works of the Barrow Hæmatite Steel Co., the Askham blast furnaces, the Hodbarrow mines and sea-wall, the naval construction works of Vickers, Sons and Maxim, the Furness Railway locomotive works, the North Lonsdale iron works, and to Lake Windermere, Grasmere, and Blackpool. The social functions included a conversazione given by the Mayor, a ball by the reception committee, a garden party by Mr. Victor Cavendish at Holker Hall, and an illuminated *fête* at Furness Abbey.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

SATURDAY, October 31, has been fixed for the holding of a convocation of the University of Oxford for the purpose of electing a Chancellor of the University in the place of the late Marquis of Salisbury.

ARRANGEMENTS for next term have been published in connection with the Oxford University School of Geography. Nine lectures a week by different members of the staff will be given in various branches of geographical science, and practical instruction to supplement several of the courses of lectures has been arranged. A geographical scholarship of the value of sixty pounds is to be competed for on October 14, and candidates must have taken honours in one of the final schools of the university. Courses of instruction are now given also in preparation for the university certificate in surveying, and to meet the requirements of students reading for the university diploma in education.