On the 19th and 24th the Section of Physics will again meet; Mechanics on the 22nd and 25th; Chemistry on the 23rd; Biology on the 26th and 29th; and Physical Geography, Geology, Mineralogy, and Meteorology on May 30 and June 1 and 2.

The following are the arrangements which have been made in the Section of Mechanics:—22nd May.—Mr. Barnaby, C.B., Director of Naval Construction to the Admiralty, Naval Architecture; Mr. W. Froude, M.A., F.R.S., Fluid Resistance; Mr. Thomas Stevenson, Lighthouses. 25th May.—Mr. F. J. Bramwell, F.R.S., Prime Movers; Mr. Hackney, B.Sc., Furnaces; Général Morin, Directeur du Conservatoire des Arts et Métiers, Paris, Ventilation; Professor Zetzsche, Electric Telegraphs.

A general idea of the arrangements in other sections will be obtained from the list in last week's NATURE, p. 34.

Besides these Sectional Meetings, several *soirées* have been arranged, the first of which, that of Physics, took place last night. A Geographical *soirée* will be held on Saturday night.

Several visits have, moreover, we believe, been arranged, including one to H. M. S. *Challenger*, which is expected home every day.

The following are the names of some of the distinguished foreigners who have come to London in connection with the Loan Collection:—*Germany:* Dr. R. Schöne, Herr Wilhelm Kirchner, Dr. Biedermann, Dr. Neumayer, W. Verners, C. Desaga, Herr Lingke, M. Borus, Dr. Julius Fettbach, Dr. H. Rohrbeck.—*Russia:* Baron von M. Wrangell, M. Heard, Dr. Selim Lemström, Capt. M. Rkeman, R.A., M. Ovsiannikow, Prof. A. von Oettingen.—*Italy:* Il Com. Blaserna, Prof. De Eccher, Cav. Meucci.—*Austria:* Baron von Ettinghausen, Dr. Albert von Ettinghausen, Dr. Leopold Pfaundler.—*Holland:* Prof. Dr. P. L. Rijke, Dr. J. W. Gunning, Dr. D. de Loos, Prof. Dr. J. Bosscha.—*Switzerland:* M. Soret, M. Hagenbach, M. Forel, M. Wartmann, Prof. Favre, M. E. Gautier, M. Th. Turrettini, M. E. Sarasin, Prof. E. Hagenbach-Bischoff, M. R. Pictet.—*Belgium:* A. Renard, Prof. C. de la Vallée Poussin, Prof. G. Dewalque.—*Spain:* Señor Juan E. Riaño,.—*Orange Free State:* His Honour, the President of the Orange Free State.—*France:* M. Tresca, M. Golaz, M. Breguet, P. Jablochkoff.—*Norway:* Prof. P. Waage.—*Sweden:* Dr. Christian Lovén.

SECTION—PHYSICS.

Opening Address by W. Spottiswoode, F.R.S., &c.

THE opening of this Exhibition may prove an epoch in the science of Great Britain. We find here collected, for the first time within the walls of one building, a large number of the most remarkable instruments, gathered from all parts of the civilised world, and from almost every period of scientific research. These instruments, it must be remembered, are not merely masterpieces of constructive skill, but are the visible expression of the penetrative thought, the mechanical equivalent of the intellectual processes of the great minds whose outcome they are.

There have been in former years, both in this country and elsewhere, exhibitions including some of the then newest inventions of the day; but none have been so exclusively devoted to scientific objects, nor any so extensive in their range as this. There exist in most seats of learning museums of instruments accumulated from the laboratories in which the professors have worked; but these are, by their very nature, confined to local traditions. The present one is, I believe, the first serious, or at all events the first successful, attempt at a cosmopolitan collection.

To mention only a few among the many foreign institutions which have contributed to this undertaking, we are especially indebted to the authorities of the Conservatoire des Arts et Métiers of Paris, the Physical Museum of Leyden, the Tayler Foundation of Haarlem, the Royal Museum of Berlin, the Physical Observatory of St. Petersburgh, the Tribune of Florence, and the University of Rome.

Among those in our own country, we have to thank the Royal Society, the Royal Institution, the Ordnance Survey, the Post Office, the Royal Mint, the Kew Observatory, besides various other institutions and colleges, which have freely contributed their quota.

To enumerate even the chief of the individual instruments of historical interest would be a task beyond the limits both of my powers and of your patience. But I cannot refrain from naming as especially worth notice among the astronomical treasures, a quadrant of Tycho Brahé, telescopes of Galileo, a telescope of Newton, some lenses by Huygens, one of Sir W. Herschel's grinding machines for specula, and a telescope made by himself in intervals between his music lessons during his early days at Bath, at a time when, to use her own words, his sister Caroline "was continually obliged to feed him by putting victuals by bits into his mouth." This also is probably the "mirror from which he did not take his hands for sixteen hours together," and with which he may have seen for the first time the Georgium Sidus. To come to later days, we have the original siderostat of Foucault, lent from the Observatory of Paris, a compound speculum by the late Lord Rosse, the photoheliograph from Kew, and from still more recent times a complete transit of Venus equipment, from the Royal Observatory at Greenwich.

Turning to other branches of physics, we have a "composed microscope," now nearly three centuries old, constructed in 1590 by one Zacharias Janssen, a spectacle-maker, possibly a connection, or at all events a worthy predecessor, of M. Janssen, the celebrated astronomical spectroscopist. We have an air-pump, and two "Magdeburg hemispheres," with the original rope traces by which horses were attached in the presence of the Emperor Charles V., in order, if possible, to tear them asunder, when exhausted by the air-pump. We have the air-pump of Boyle, the compressor of Pappin, Regnault's apparatus for determining the specific heat of gases, Dumas's globe for the determination of vapour densities, Fizeau and Foucault's original revolving mirrors and toothed wheels, whereby the velocity of light was first determined independently of astronomical aid, Daguerre's first photograph on glass, and the earliest astronomical photographs ever taken. To these may be added De la Rive's instruments for statical electricity; the actual table and appurtenances at which Ampère worked; and some contrivances as if fresh from the hands of Faraday himself.

Yet rich as is this part of our collection, and interesting as it might be made in the hands of one versed in the history and anecdote of the past, we must not linger even about these pleasant places. Indeed a museum of only the past, venerable though it might be, would be also grey with the melancholy of departing life. For science should be living, instinct with vigour and organic growth. Without a continuance into the present, and a promise for the future, it would be like a tree whose branches are broken, whose growth is stopped, and whose sap is dried. And if I may carry the simile a stage further, an exhibition of the present, with no elements of the past, would be like the gathered fruits to be found in the market-place, ready to hand, it is true, but artificially arranged. But when past and present are represented in combination, as has been attempted here, the very newest achievements will be found in their natural places as ripened and ever-ripening fruit in the garden from whence they have sprung.

In reviewing the series of ancient, or at least now disused, instruments, one thing can hardly fail to strike the attention of those who are accustomed to the use of the

modern forms. It is this—how much our predecessors managed to achieve with the limited means at their disposal. If we compare the magnificent telescopes, the exquisite clockwork, the multiplicity of optical appliances, now to be found in almost every private, and still more in every public, observatory, with those of two centuries past; or, again, if we look at the instruments with which Arago and Brewster made their magnificent discoveries in polarised light, in contrast to those with which the adjoining room is literally teeming, we may well pause to reflect how much of their discoveries was due to the men themselves, and how comparatively little to the instruments at their command.

And yet we must not measure either the men or their results by this standard alone. The character of the problems which nature propounds, or which our predecessors leave as a legacy to our generation, varies greatly from time to time. First, we have some great striking question, the very conception and statement of which demands the very highest powers of the human mind; unless, indeed, the clear and distinct statement of every problem may be regarded as the first and most important step towards its solution. Next follow the first outlines of the solution sketched in bold outline by some master hand; afterwards, the careful and often tedious working out of the details of the problem, the numerical evaluation of the constants involved, and the reduction of all the quantities to strict measurement. It is in this part of the business that the more elaborate instruments are especially required. It is for bringing small differences to actual measurement, for detecting quantities otherwise inappreciable, that the complex refinements with which we are here surrounded become of the first importance. But happily this somewhat overwhelming complication is not of perennial growth, for, curiously enough, by a kind of natural compensation, it relieves itself. In reviewing from time to time the various aspects of a problem in connection with the instrumental appliances designed for its solution, the essential features come out by degrees more strongly in relief. One by one the unimportant parts are cast aside, and the apparatus becomes reduced to its essential elements. This simplification of parts, this cutting off of redundancies, must not, however, be understood as detracting from the merit of the original devisors of the instruments so simplified; the first grand requisite is to effect what is necessary for the solution of the problem, then follows the question whether it can be done more simply or by some better process.

And this leads me in the next place to advert for a moment to the advantages which may accrue to the cultivators of science, and through them to the nation at large, from a national collection of scientific apparatus. Through the liberality of our foreign neighbours, and through the exertions of our own countrymen, we have here a magnificent specimen, an almost ideal exemplar, of what such a collection may be. By bringing together in one place, and by rendering accessible to men of science generally, the instrumental treasures already accumulated, and constantly accumulating, we should not only portray in, as it were, living colours the history of science, we should not only be paying just tribute to the memory of the great men who have gone before us, but we should afford opportunities of reverting to old lines of thought, of repeating with the identical instruments important but half-forgotten experiments, of weaving together threads of scattered researches, which could otherwise be taken up again only with difficulty, and after an expenditure of much and irretrievable time.

Let me now turn for a moment to the other side of the picture. If the collection in the midst of which we are here assembled is an evidence of the valuable relics which still remain to us of the great men who have passed away, the circumstances under which some of them have found their way hither, and the vacant places due to the absence of others, are no less evidence of how much the preservation of such objects would be promoted by the establishment of a museum such as I have ventured to suggest. Many circumstances contribute to thrust into oblivion, or to put absolutely out of reach of future recovery, original apparatus. First, the paramount importance and immediate uses of an improved instrument or a new invention; next, in Government departments such as the Survey, the Post Office, &c., the imperative demands of the public service, which leave little or no time for a retrospect of the past; and if I may add a word from the experience of private individuals, the pressing calls of space and expense lead the possessors to throw away, or to utilise, by conversion of the materials to new purposes, apparatus which has done its work. I venture to particularise one or two considerations, which will probably have occurred to many of you, but which appear to me to illustrate the above remarks. In the case of the Ordnance Survey it is almost certain that the current work of the department would never have required, and it is doubtful whether any private interposition would have brought about, the removal of the disused instruments, here exhibited, from the cellars at Southampton. Again, the Post Office would hardly have been justified in devoting valuable time to the arrangement, or valuable space to the storage, of instruments no longer on active service, except at the call of a public department, or for a public purpose. And surely it would be a matter of serious regret that the time already spent upon the collection now before us should have no issue beyond the purposes of the present exhibition. To take another instance; we have here fragments, but only fragments, of Baily's apparatus for repeating Cavendish's experiments; but of Cavendish's own apparatus we have simply nothing. Again, Wheatstone's instrumental remains must inevitably have been broken up and scattered or destroyed, if there had not been found at King's College a resting-place, and authorities intelligent enough to appreciate and willing to receive them. Of other individuals from whom apparatus, now of historical interest, has been received, some from sheer lack of space have been breaking up old instruments, while others, from a modesty commendable in itself, were with difficulty persuaded of, and even now are only beginning to perceive, the value, in a national and cosmopolitan point of view, of their own contributions. Lastly, there is, I think, little doubt but that, if the objects in question were to go a-begging, they would be gladly received in some of the foreign museums which have so liberally contributed on the present occasion.

To put the suggestion in a more tangible form I would venture to suggest that, in the first instance, instruments whose immediate use has gone by, but which are nevertheless of historical interest, lent either by public departments or by private individuals, might remain here on permanent loan; further, that other instruments as they pass out of active service, for example, from the Admiralty, from the Board of Trade, from the Ordnance Survey, or from the other departments, should similarly find a place in this museum. In such a category also might be included the scientific outfit of the *Challenger*, and of the Arctic Expeditions, and likewise those of expeditions for the observations of the transit of Venus or of solar eclipses. To these might be added apparatus purchased for special investigations through the parliamentary grant annually administered by the Royal Society. And further if, as I would suggest, this deposit of instruments be made without alienation of ownership, then private societies or even individuals might be glad to avail themselves of such a depository of instruments not actually in use.

In making such a suggestion, it must of course be assumed that the custody of property so valuable in itself, and so delicate in its nature, would be confided to a

curator thoroughly competent for such a charge, but I abstain from entering prematurely into further details.

And now let me turn in conclusion to one more aspect of this great undertaking. We have here collected not only the instruments which represent the most advanced posts of modern science, but we have not a few of the men whose genius and perseverance have led the way thither; men who stand in the forefront of our battle against ignorance and prejudice and against the host of evils which a better scientific education must certainly dispel; we have men whose powers are competent for, and whose very presence is an inspiration to, further progress. But, while taking this first opportunity of offering them a hearty welcome, I shall however best consult both their feelings and your wishes by abstaining from any panegyric upon them in their presence, and by giving them an opportunity of speaking, and you of hearing them, upon some of their own subjects in illustration of the remarkable instruments which they have with so much pains and trouble brought under our view.

SECTION—MECHANICS.

Opening Address by Dr. C. W. Siemens, F.R.S.

IN opening the proceedings of the Conferences regarding Mechanical Science, it behoves me to draw attention to the lines of demarcation which separate us from other branches of natural science represented in this Exhibition.

In the Department of Applied Science we have collected here apparatus of vast historical interest, including the original steam cylinder constructed by Papin in 1690, the earliest steam-engines by Savery and by James Watt, the famous locomotive engine the "Rocket," by which George Stephenson achieved his early triumphs, as well as Bell's original marine engine, and a variety of models illustrative of the progress of hydraulic engineering and of machinery for the production of textile fabrics. In close proximity to these we find a collection of models illustrative of the remarkable advance in naval architecture which distinguishes the present day.

It would be impossible to deny the intrinsic interest attaching to such a collection or its intimate connection with the progress of pure science; for how could science have progressed at the rate evidenced in every branch of this Exhibition, but for the great power given to man through the mechanical inventions just referred to. Yet were Mechanical Science at these Conferences to be limited to the objects exhibited in the South Gallery (and separated unfortunately from apparatus representing physical science by lengthy corridors filled with objects of natural history), we should hardly find material worthy to occupy the time set apart for us. But, thanks to the progress of opinion in recent days, the barrier between pure and applied science may be considered as having no longer any existence in fact. We see around us practitioners, to whom seats of honour in the great academies and associations for the advancement of pure science are not withheld, and men who, having commenced with the cultivation of pure science, think it no longer a degradation to follow up its application to useful ends.

The geographical separation between applied science and physical science just referred to, must therefore be regarded only as accidental, and the subjects to be discussed in our section comprise a large proportion of the objects to be found within the rooms assigned more particularly to physics and chemistry. Thus all measuring instruments, geometric and kinematic apparatus, have been specially included within our range, and other objects such as telegraphic instruments, belong naturally to our domain.

With these accessions, mechanical science represents a vast field for discussion at these conferences, a field so vast indeed that it would have been impossible to discuss separately the merits of even the more remarkable of the exhibits belonging to it. It was necessary to combine exhibits of similar nature into subdivisions, and the Committee have asked gentlemen eminently acquainted with these branches to address you upon them in a comprehensive manner.

Thus they have secured the co-operation of Mr. Barnaby, the Director of Construction of the Navy, to address you on the subject of Naval Architecture, and of Mr. Froude to enlarge upon the subject of fluid resistance, upon which he has such an undoubted right to speak authoritatively. Mr. Thomas Stevenson, the Engineer of the Northern Lighthouses, will describe the modern arrangements of Dioptric lights, which mark a great progress in the art of lighting up our coasts. Mr. Bramwell has undertaken the important task of addressing you on the subject of Prime Movers, and Prof. Kennedy upon the kinematic apparatus forwarded by Prof. Reuleaux, of Berlin. M. Tresca will bring before us his interesting subject, the flow of solids. Mr. William Hackney will address you upon the application of heat to furnaces, for which he is well qualified both by his theoretical and practical knowledge. Mr. R. S. Culley, Chief Engineer of the Postal Telegraphs, will refer you to a most complete and interesting historical collection of instruments, revealing the rapid and surprising growth of the electric telegraph.

Measurement.—Regarding the question of measurement, this constitutes perhaps the largest and most varied subject in connection with the present Loan Exhibition. In mechanical science, accurate measurement is of such obvious importance, that no argument is needed to recommend the subject to your careful consideration. But it is not perhaps as generally admitted, that accurate measurement occupies a very important position with regard to science itself, and that many of the most brilliant discoveries may be traced back to the mechanical art of measuring. In support of this view I may here quote some pregnant remarks made by Sir William Thomson in his inaugural address delivered in 1871 to the members of the British Association, in which he says—"Accurate and minute measurement seems to the non-scientific imagination, a less lofty and dignified work than looking for something new. But nearly all the grandest discoveries of science have been but the rewards of accurate measurement and patient long-continued labour in the minute sifting of numerical results. The popular idea of Newton's grand discovery is that the theory of gravitation flashed upon his mind, and so the discovery was made. It was by a long train of mathemetical calculation, founded on results accumulated through prodigious toil of practical astronomers, that Newton first demonstrated the forces urging the planets towards the sun, determined the magnitude of those forces, and discovered that a force following the same law of variation with distance urges the moon towards the earth. *Then* first, we may suppose, came to him the idea of the *universality of gravitation;* but when he attempted to compare the magnitude of the force on the moon with the magnitude of the force of gravitation of a heavy body of equal mass at the earth's surface, he did not find the agreement which the law he was discovering required. Not for years after would he publish his discovery as made. It is recounted that, being present at a meeting of the Royal Society, he heard a paper read, describing geodesic measurement by Picard, which led to a serious correction of the previously accepted estimate of the earth's radius. This was what Newton required; he went home with the result, and commenced his calculations, but felt so much agitated, that he handed over the arithmetical work to a friend; then (and not when, sitting in a garden he saw an apple fall) did he ascertain that gravitation keeps the moon in her orbit.

Faraday's discovery of specific inductive capacity, which inaugurated *the* new philosophy, tending to discard