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Times, Tides and William III

The title of this paper is based on a centuries old proverb and a much-quoted passage from Shakespeare. The proverb is:

'Time and tide wait for no man';

the Shakespearean passage occurs in the tragedy of *Julius Caesar* when, after the protagonist has been assassinated, Brutus tells his fellow-conspirator Cassius:

> There is a tide in the affairs of men,
> Which, taken at the flood, leads on to fortune;
> Omitted, all the voyage of their life
> Is bound in shallows and in miseries...[1]

Whoever looks dispassionately at the life of the third William of Orange cannot fail to be struck by the aptness of both proverb and quotation as a common denominator for the 'faits et gestes' of the Stadholder-King. In fact, the rise to international prominence from a loveless and humiliating childhood, after having been deprived of his ancestral rank by an anti-Orangist faction that upon the death of his father had seized power overnight, a full week before he was born..., that phenomenal rise constitutes a saga of near-epic dimensions. And in it, all the major characters can be seen to have been forced to a constant reckoning with Time and Tide, figuratively no less than literally.

But while the preoccupations of William and his immediate entourage, on the whole, remained strictly practical, there were also those whose minds grappled with the scientifically and psychologically creative implications of the two concepts concerned. These implications underwent revolutions that were to prove hardly less 'glorious' than the political one which has brought us here together. In this paper we will focus on the manner in which, in the period under consideration, ideas about the essence of 'time' and the action of 'tide' underwent a basic change. It was a change that had repercussions long after King William and Queen Mary had been laid to rest under their modest commemorative tiles at the entrance to St. George's Chapel in Westminster Abbey. It even resulted in the heart-warming fact that, where scientists and instrument-makers led the way, the poets and painters of Holland and England followed suit.

[1] W. Shakespeare, *Julius Caesar*, IV, iii, 218–21.

I

Our story, then, must start with the recognition that, in the age under review, many people's capacity for awareness of the passage of time was drastically revised. This was the direct result of what, in present-day jargon, we would have to describe as a nascent 'democratisation' in timepiece-ownership – a 'democratisation' that was one of the consequences of the rapidly increasing manufacture and sale of clocks and watches that could both be afforded by the average well-to-do citizen and were tolerably reliable.

In our context, it is significant that those twin qualities of accuracy and affordability were largely the outcome of the mathematical and technological acumen of one and the same Hollander, the great Christiaen Huygens. He, after all, gave the world a new pendulum as regulator for stationary clocks and a spiral balance spring for watches – both well before the Glorious Revolution.

Earlier this month, in London, at the first of our Symposia on 'Science and Civilization under William and Mary', we have been regaled by an abundance of colourful detail about clockmakers in our two countries. What was particularly revealing was the extent to which contacts between practitioners had proved as fruitful as they were frequent. Here in Amsterdam, at our second Symposium, one now feels tempted to suggest that it can never have been pure chance that led Robert Boyle to confess in 1633:

> My Wonder dwells not so much on Nature's clocks (if I may so speak) as on her Watches.[2]

Almost a century later, the naturalist and poet, the Rev. Henry Baker repeated Boyle's *dictum* and then declared smoothly:

> Indeed, upon comparing the Structure of a Mite with that of an Elephant, I believe we shall concur in the same Opinion.[3]

To us, a mentality that after so many years still associates the image of a clock with that of an elephant and the image of a mite with that of a watch seems unusual. It seems so especially, since the association of thought had been taken up long before. It was in 1672, only a decade after Boyle, that Samuel Butler wrote a verse-satire on the Royal Society, entitled 'The Elephant in the Moon'[4] which dealt with an amateur-astronomer, eager to observe our celestial satellite but sadly misled by a fly on the lens of his telescope and a mouse in its tube.

Baker's quip occurs in the Preface to one of the most popular and most

[2] R. Boyle, *Considerations touching the Usefulness of Experimental Natural Philosophy* (1662), as in M. Nicolson, *Science and Imagination* (1956) p. 224, a collection of papers which have proved most valuable in the present context.

[3] See below, n. 5.

[4] Samuel Butler, 'The Elephant in the Moon' in *Three Poems*, The Augustan Reprint Society no. 88 (1951).

widely translated science-books of the period, his *The Microscope made Easy*, first published in 1742.[5] The title clearly implied that, once such an instrument could be freely acquired, people would be able and – ideally – also be sure to see for themselves 'infinity in a drop of water, eternity in a grain of sand' – imagery adumbrated by the Leiden Doctor of Medicine, Thomas Browne, in that first ever psychography of a physician, his *Religio Medici* of 1637 (translated into Dutch, it may be worth mentioning, in the very year of the Glorious Revolution!).[6]

But then – quite apart from the sociological importance of such writers' introducing elephants, mites, drops of water and grains of sand to get their message across – what counts is that personal scientific observation could yield general metaphors because, like clocks and watches, microscopes and telescopes were coming to be generally obtainable from instrument-makers – if at a price.

This development was as significant as the epistolary connection between Dutch and English scientists, professional or amateur, and as stimulating as contemporary efforts at regularly popularising their findings in print. In London, the Royal Society's prestigious *Philosophical Transactions* and the independent *Athenian Mercury* were as essential in this respect, as in Amsterdam the *Nouvelles de la Republique des Lettres* or in Rotterdam the *Dictionnaire Historique et Critique*. The latter two, incidentally, were both Huguenot publications, and therefore in French.

Needless to say, the group of people we are dealing with was limited. But the pervasive effect of this popularisation contrasted starkly with a former culture-pessimism such as that of the much-quoted cleric John Donne. This foremost metaphysical poet actually went to the length of having himself portrayed with closed eyes in a winding-sheet. He produced a critical 'Anatomy of the World' in the wake of a nascent scientific vogue and somewhat later, in another poem, written for his patron to commemorate 'The First Anniversary' of the death of the latter's daughter, he lamented:

> And new Philosophy calls all in Doubt ...

In the same poem, composed as early as 1611, he continued with a typically gloomy reference to the revolutionized post-Galilean universe of his day, sighing:

> 'Tis all in peeces, all cohearence gone,
> All just supply, and all relation.[7]

[5] Henry Baker, *The Microscope made Easy. Or The Nature, Uses, and Magnifying Powers of the best Kinds of Microscope Described, Calculated, and Explained for the Instruction of such, particularly, as desire to search into the Wonders of the Minute Creatin, tho' they are not acquainted with Optics.* (1754), p. xv.

[6] Th. Browne, *Religio Medici* (1643); the Dutch translation appeared at Leiden in 1665, where a Latin translation had been published in 1644.

[7] John Donne, 'The First Anniversary' (1611), lines 205 and 211–14, in *Epithalamions, Anniversaries and Epicedes*, ed. W. Milgate (1978).

The big change took place in the next generation. It was the Rev. Thomas Traherne who once again summed up man's duty to read back the Book of God's Words into the Book of God's Works when, in the 27th of his *'Centuries of Meditations*, he wrote:

> You never enjoy the world right, till you see how a sand exhibiteth the wisdom and power of God.[8]

Obviously, to the technically equipped or scientifically informed, a grain of sand under their microscopes would by now carry as eloquent a message as an insect held there or a drop of water. But then, to us, the point in recalling Boyle's preference for the smaller timepieces to the bigger, when seeking to express his age's sense of wonder at the revelation of some of the long-hidden 'Arcana Naturae' (the 'Secrets of Nature', as discovered by Van Leeuwenhoek's sensational and completely self-made new microscope[9])..., that point lies in Boyle's specific choice of imagery. For it divulges that, after they had been closely studied, these lately unveiled Mysteries – from the most spectacular to the most modest, seemingly insignificant, and 'to the Vulgar despicable' (as he put it) – apparently one and all suggested the mechanistic precision of clockwork.

Precision is not an aesthetic luxury. Any wheel that is meant to revolve and, through cog-action, to set other wheels in motion requires machined precision – if it is to do its work at all smoothly. Otherwise the entire mechanism will rattle and ultimately grind to a halt. In Dutch usage the phenomenon has actually given rise to a popular critical metaphor: when we want to indicate, for instance, that a verbal presentation is not running smoothly, we simply say: 'Dat rammelt!' – which quite literally means 'This rattles!'.

Again – once it had been technically achieved and especially when produced in the form of a small, portable timepiece – precision in time-keeping was felt to be nothing short of miraculous. Such a timepiece made it possible to check more or less exactly on certain phenomena of nature, like sunrise and sunset, irrespective of whether it was bright day or dark night. It thus quite understandably won a central place not only in the astronomer's calculations, but also, and well beyond purely scientific practice, in the contemporary Virtuoso's 'universe of discourse' – i.e. in the vocabulary-bound think-

[8] Rev. Th. Traherne, 'Meditation no. 27' in *Centuries, Poems and Thanksgivings*, ed. H.M. Margoliouth (1958). Like Donne, Traherne was a metaphysical poet, but unlike him he wrote several hundred brief religious meditations, gathered in 'Centuries', for the benefit of a friend. These were never published until 1908.

[9] Latin translation of the title of Antoni van Leeuwenhoek's *Ontdekte Onsigtbaarheden* (Leiden 1686), published in his *Opera Omnia* (Leiden 1722).

Boyle, characteristically, published an 'Invitation to Communicativeness' as an 'Epistolical Discourse...inviting all true lovers of Vertue and Mankind to a free and generous Communication of their Secrets and Receits in Physick' (1659), published by Hartlib (cf. M. Boas, *Robert Boyle and Seventeenth Century Chemistry*, 1985, p. 17).

ing of the Gentleman-scientist who was often a cleric or a professional man, never an atheist.

It was their type of imagination that would be fired by the stunning parallel that could be drawn between a human watchmaker and the Creator; it would only have been by them that God was first seen as the Divine Watchmaker. In fact, for 'man, proud man' the act of winding up his newly acquired personal pocketwatch for the first time must have given him a tremendous kick. It must have made him feel in little as if he were setting a universe in motion, the replica in his band having mysteriously been 'interfaced' with the cosmos (which for convenience sake was still mostly seen as geocentric).

Of course, this is merely one aspect of the implications of mechanical timekeeping. Way back in the Middle Ages, when, forged by unknown blacksmiths, the first clocks were installed in the more affluent monasteries and on the bigger church-towers, what ensued was that ordinary people, too, were able to perceive time in terms of hours, half-hours and sometimes even quarter-hours. Church-towers, whose orientating function for the traveller had so far been limited to day-light visibility, were now given the super-added value of clock-towers – as on the flat coasts of Holland, by the installation of carefully tended fire-baskets and subsequently lanterns, church-towers had long been given the super-added value of functioning as light-houses. But then, the faithful were called to prayer by bells known in Middle-English as 'clocks' from Middle-Dutch 'clocke', a word which as modern Dutch 'klok' is still used both for the sound-producing instrument, as in 'klok luiden' (bell-ringing), and for the non-portable timepiece, as in 'kerkklok' and 'wandklok' (church-clock and wall-clock).

As a result, unlike the hour-glass, perennially fascinating in itself but needing to be turned over every so often, the big weight-driven mechanical clock first disassociated time from daily or seasonal events, such as the rising or setting of sun and moon, or summer- and winter-solstices; it helped people to get used to the brand-new belief in an independent world of mathematically measurable and therefore reliably calculable time-sequences. The clock, in effect, became the model of an abstract concept of the motions of the heavenly bodies. By the uninterrupted continuity of the dry ticking of its mechanism and the automatic, inexorable ringing of its bell, it charted entirely on its own the old cyclical rhythms of man's natural environment.

In Antiquity, it may be recalled in passing, people had long known that the idea of time arose out of, and was always linked to, the idea of motion. Conversely, motion could not be described except in terms of time. Speed was only to be calculated by dividing by the time-figure the figure for the distance covered in motion. Did this mean that time ceased when motion ceased? In other words, was time linear and only flowing in one direction, i.e. forward? Are our ideas of causality and simultaneity bound up with our axiomatic acceptance of a uni-directional flow – a flow, in other words, like that of the sand in an hour-glass?

It is no more than poetic justice, surely, that all this has taken us back to the grain of sand. The microscope had enabled us to see eternity in one single, stationary grain of sand; the innumerable grains of sand, unstoppably descending through the throat of an hour-glass till its top-chamber was empty, had shown us the flow of time.

It is true that this particular flow of measurable time was always limited by the size of the hour-glass's chambers. But the very fact of this limitation had an interesting psychological spin-off. For, as we can reverse the hour-glass to present us once more with the original time-sequence, people have wondered from very early on whether, by some similar reversal, we might not likewise see again the flow of events which had originally occurred during the flow of time indicated by the shifting of the sands in the hour-glass.

One answer, as we all know, is the so-called 'flash-back' created first in fiction-writing, then in film-making. It is a surrogate answer, of course, since it does not actually enable us to re-live a piece of our history. But in films it is a technique that allows a recorded sequence to be reeled off backwards and replayed in the process. Curiously enough, backwards projections of film-sequences are usually ridiculously fast; what they really demonstrate therefore is that only as long as the speed of the original recording is maintained in the projection, a minute is still a minute and an hour still an hour. Yet, no matter what its speed, backwards projection is not just comic but indeed uncanny in that 'live' any 'return to square one' is an utter impossibility.

Does real time, then, merely exist in the way we experience or record it here and now, our awareness of time being only of time past? The problem, of course, lies in the 'we' in question, together with the 'here and now'. Have we not all sometimes experienced a moment as seemingly interminable and, say, a whole summer to have flown past as in a dream? Shakespeare described it perfectly when in *As You Like It* when he has Rosalind exclaim:

> Time travels in divers paces with divers persons,

which she very spiritedly elaborates with:

> I'll tell you who Time ambles withal, who Time trots withal, who Time gallops withal, and who he stands still withal.[10]

Time, we must conclude, is indeed a multi-faceted quantity.

For Isaac Newton this was not so. For him Time was a simple reality and, like space, absolute. For him events occurred at a distinct and definite moment in time – in exactly the same way as objects had a distinct and definite position in space. For him the principle of 'Time and Tide wait for no man' was indisputable. Only anti-science cynics like Pope, Swift and their friends of the so-called Scriblerus Club were happy to sneer:

[10] W. Shakespeare, *As You Like It*, III, ii, 325–29.

Ye Gods! Annihilate but Space and Time,
And make two Lovers happy...[11].

To help us solve the age-old conundrum of the elusiveness of Time, it has been suggested by certain modern scientist-philosophers that the best model for recognizing a multi-faceted quality in Nature is the phenomenon of Light. This is wonderful grist to our William-and-Mary mill. For what to us, as Tercentenarists, must be so gratifying is that, in order to understand the analogy between Time and Light, we need only cast our minds back to the history of the various light-theories – in particular those of their Anglo-Dutch sovereigns' contemporaries, Newton and Christiaen Huygens.

A fortnight ago, in London, we were offered a number of comments on how the Newtonian particle-theory of light and the Huygenian wave-theory should be viewed so as to be able, by the end of the day, to see that by now they constituted a Perfect Match. What this means is simply that some properties of light may be regarded as identical with what all waves demonstrate, and that other properties of light are only explicable when described in terms of particles. In fact, a wave-particle duality in the present-day definition of Light has thereby become inescapable. Other phenomena in Nature, such as Time, might therefore have to be accepted as being of the very same complexity.

II

So far, what has been adduced from the world of physics has of necessity been derivative.[12] But it has all been done with a purpose. This purpose was to offer, after the divers specialist angles of vision already tabled, a cultural-historical overview which joins the clocks and watches of Boyle's declaration about Nature's wonders in a new wonder, viz. that of science-inspired poetry. Has not the writer of *The New Atlantis* – who was also the great 'instaurator' of so much in the Royal Society – shown us the way? To me, one of Francis Bacon's most evocative phrases has always been:

Poesy is a Dream of Learning.[13]

Boyle's imagery will seem doubly intriguing when viewed in this perspective. For, having recognized that the first element in our Time and Tide proverb – Time – must be understood as a multifaceted concept like Light and that here Newton and Huygens together provided the basic insights, we must now add that the proverb's second element – Tide – likewise takes us back to Newton: in Book III of his *Principia* the flux and reflux of the sea, linked

[11] A. Pope, *Peri Bathous: or Martinus Scriblerus his Treatise of the Art of Sinking in Poetry*, in *Miscellanies* IV (1727), p. 52.
[12] Cf. L. Elton and H. Messel, *Time and Man* (1978), M. Shallis, *On Time* (1982), A. Rawlings, *The Science of Clocks and Watches* (1974) and S.W. Hawking, *A Brief History of Time* (1988).
[13] F. Bacon, *Of the Proficiency and Advancement of Learning, Divine and Human* (1605), Part II, iv. 1.

to the actions of the sun and moon, are irrefutably accounted for by the application of his Law of Gravitational Attraction.[14]

In that most mind-shaking of his works, Newton, it is true, did not demonstrate how to draw up tables of the exact time and height of a tide at any given place. What his calculations did enable him to provide, however, was the first cogent exposition of the phenomenon of tides. And what are tides but Nature's terrestrial clocks? Of all the great mysteries that have confounded mariners and astronomers ever since natural phenomena were first systematically studied, the tides had proved the least tractable and the most persistently frustrating. Now the end of the tunnel was in sight. But in order to produce reliable tidal data – let alone a workable longitude at sea – accurate time-measurement was indispensable. This, once more, takes us back to Christiaen Huygens and his inventions of the precision-pendulum and the spring-balance of 1657 and 1672.[15]

Is it too much of a cliché to say that, clearly, the period of William and Mary, together with the decades that immediately preceded and directly followed, was crucial (if not always revolutionary), not merely in its political, economic, and financial contexts but particularly in those of the sciences? Enlightenment was needed all-round.

One minor, though no doubt symbolic, illustration of their contemporaries' sometimes perplexing experiences in the matter of time-awareness is what could happen to dates and calendars (another aspect of time-awareness, after all), when Dutch confronted English in the most spectacular amphibious operation of the century.

When on 17 July 1688 the Prince of Orange slowly folded the letter from the Immortal Seven inviting him to come over to England 'with sufficient strength', he is reputed to have turned to his chief advisor whispering 'Aut nunc, aut numquam' – 'it is now or never'. The Prince's 'now' – in the sense of his expedition's actual departure – in the end turned out to be the 11th of November. To the English Admiral, however, who had brought over the document in a fishing-smack, disguised as an ordinary seaman and whom William had wisely appointed to the Supreme Command of the invasion fleet at sea, it was only November 1st, the ten days difference in dates being the difference between the Old Style calendar and the one according to the New Style...

No commentator has ever bothered to ask himself what the psychological effect might have been, on the expedition's 'European' participants, of the realization that, although according to their own calendar they had weighed anchor on the 11th of the month, according to the calendar of the nation for whom they were to help restore its laws and liberties, this appeared to have

[14] I. Newton, *Philosophiae Naturalis Principia Mathematica* (1687), Book III, p. 435, cf. the *Systema Mundi*.

[15] See J.H. Leopold, 'Christiaen Huygens and his Instrument makers' in *Studies on Christiaen Huygens*, ed. J. Bos et al. (1980), pp. 221–233.

happened a week-and-a-half before. In fact, would William's army, on their clambering ashore at Torbay in the cold and rain of the 15th, have thought that, all things considered, such weather was to be expected in the middle of November? And would the good people of Brixham, as they waded out into the briny waters of their bay to welcome His Highness with loud cries of 'God bless you!', have imagined that it could not really be *that* icy since it was only a few days after October? Above all, would the Dutch have felt they were experiencing what we would call a 'déjà vu' situation?

The speculation may be irrelevant. We know that it was to take another 64 years before the English would change their Old Style or Julian calendar, introduced by the historical Julius Caesar, for the New Style or Gregorian calendar, corrected under Pope Gregory XIII and adopted on the continent as early as 1582. In the meantime, based as it was on different astronomical observations, this situation represented just one more source of misunderstandings on both sides of the Narrow Seas (although in 1688 its effect will at least not have had any of the physical discomforts liable to result from our present-day jet-lag).

So much for dates which, even in publications about our Tercentenary in the United Kingdom, have not as yet been streamlined. And in the reconstruction from diaries and journals of William's crossing, no real consensus has been reached about times and distances 'made good' (as mariners put it), either. At first it was generally assumed on both sides that on November 11 the fleet, with its regular army of roughly 11 000 foot-soldiers and 4000 horse plus some 700 volunteers, had at once headed for the East Coast of England, probably Yorkshire, or even for a landing area in Scotland, and that it had only changed course after 48 hours. To reach Torbay after such a detour in five days, however, would have required an average speed of between 10 and 11 knots. This would have been just possible for William's three squadrons of warships; but for his 250-odd hired merchantmen converted for transport service, and for his 60 Scheveningen fishermen to be used as lighters, (not to speak of sundry other small craft), this average would have been absolutely out of the question, since such craft would not normally exceed a speed 'over the ground' of 5 or 6 knots.

William's three fighting squadrons of 12 vessels and 1 flagship each had, on setting out from their naval base at Hellevoetsluis on the Haringvliet, in fact first sailed North on the ebb under the favourable Easterly, the long-awaited 'Protestant' wind. They had taken up station off the 'Maasvlakte', the shallows at the mouth of the Meuse, in order to await the transports. After having come out from the Haringvliet estuary by twos and threes, these hired merchantmen would have in turn sailed North in order to form up as 9 convoy-groups of between 22 and 24 bottoms at their rendez-vous with each group's naval escort. This was a manoeuvre of close-hauled sailing and heading upwind that must have taken some six hours.

But such was not the only reason why there had been a pause in the convoy's progress and no making at once for the East Coast of England. The

Prince's order to lie hove-to during their first night at sea was also the result of his flag-officers' unanimously agreeing on the inadvisability of attempting to pass the 'Heads', i.e. the Straits between England and France, with so massive a fleet in the dark. For collisions would have been unavoidable, no matter how beneficial both wind and tide.

King James had, largely on the strength of deliberate Dutch disinformation by interrogated fishermen, concentrated his troops in Yorkshire. That in due course the mouth of the River Exe in Devon was to be the invasion fleet's ultimate destination, had been decided on the pressing advice of Admiral Herbert; the Prince's order to sail for Torbay, given in mid-Channel, was dated 14 November, accordingly, and based besides on the fact that, on their second day the Easterly wind, for which prayers had been offered in churches and public places from September onwards, had backed through North-East to North-West. This prevented James's navy, stationed behind the shallows of the Gunfleet in the Thames estuary, from engaging the Dutch who had not only the benefit of the wind but also that of a strong flood.

In the North Sea and the Channel 'working the tides' is extremely important, especially when sailing South, since currents producing High and Low water are running in opposite directions on either side of the Straits. In the night of November 11 the fleet had been quietly drifting until the turning of the tide in the early morning of the 12th. On the 13th they sailed past the wind-bound English, losing only one vessel that ran aground as a result of rudder-failure and was subsequently taken. On the 14th, with the Prince's regimental drums and fifes playing on deck in order to further impress the spectators on the white cliffs of Dover (where such a limitless-seeming mass of sails and countless flags and pennants had never been seen before), they 'steamed' along the South Coast. Then, while fog closed in, they would nearly have missed the entrance to the Torbay if the wind had not veered from Northerly to South-Westerly and the sun had broken through the mists again. It was now a simple matter for the entire convoy to assemble in the bay; for the Dutch it was November 15th and disembarkation of the expeditionary force was started at once, while Admiral Herbert's squadron, which the Prince had ordered to 'prevent the English fleete... ffrom molesting mee'[16], was on guard station outside.

After landing the troops (rowed ashore in some dozens of beetle-like ships' boats), unloading was accomplished within 36 hours – horses (hoisted overboard and made to swim ashore), guns, ammunition, stores, catering equipment, coaches, waggons, portable printing press, portable mint, bullion

[16] The Prince of Orange to Admiral Herbert, 14 November 1688 (British Library, MS Egerton 2621, f.27). Possible invasion areas, considered in succession, had been: Southampton, Poole, and Exmouth; William had written to Bentinck on November 12 that he hoped to pass the 'Pas de Calais' on the morrow (N. Japikse, *Correspondentie van Willem III en Hans Willem Bentinck*, vol. II, part, p. 53).

(ferried across in the flat-bottomed fishing-vessels with whatever else makes up the train of an expeditionary force) and all.

Choosing the right time and reckoning with the right tides had been as essential for this unique navigational achievement as making the best use of the winds. What could be more symbolic than that it had been in the preceding year, i.e. in 1687, that the Newton's *Principia* should have appeared? The irony of history is that the book was published under the auspices of Samuel Pepys, the then President of the Royal Society, who was to be dubbed the 'Saviour of the Navy'.

But the Prince of Orange's logistics did not depend on Newton's findings. Another essential ingredient for success was the quality of operational direction.

We can only marvel at the string of helpful scientific observations, calculations, and discoveries which occurred in the century concerned. In the days before the time-speed-and-distance cluster could be established by marine chronometers and mechanical logs, before longitude and latitude could be calculated with precision sextants and reliable astronomical tables, and before compass data could be corrected through known figures for 'variation' and 'deviation', journal entries for 'E.P.' (estimated position) and 'E.T.A.' (estimated time of arrival) were never more divergent than at sea. Before electronic aids to navigation and communication, the maintenance of an effectively operating chain of command – quite apart from the use of fast-sailing, flat-bottomed signal-boats – was entirely dependent on sight and sound, i.e. on the correct reading of flags and pennants or the firing of gun-signals to port or starboard of flag-ships. It was no coincidence that under William, in 1693, the most extensive marine signal-book so far was produced – a manual of naval communication that was to be used for over a century by both the English and the Dutch.[17] And it speaks volumes that in the Prince of Orange's enormous fleet there were no stragglers and only one transport, as we have seen, was lost by technical misadventure.

Knowledge about light and colour had come to owe everything to the giants of the New Science, notably Newton, Huygens, Boyle and some of his Dutch and English contemporaries. John Locke, for example, in his famous *Essay concerning Human Understanding*, called

> Sight...the most comprehensive of all our Senses, conveying to our Minds the Ideas of Light and Colours, which are peculiar to that Sense...

But what was also conveyed by it was

> the far different Ideas of Space, Figure and Motion, the several variations of which change the appearances of its proper Object.[18]

[17] For the history of marine signals, see Albion, *Naval and Maritime History* (1963).

[18] J. Locke, *An Essay concerning Human Understanding* (1690), p. As early as 1664, Boyle had written *Experiments and Considerations touching Colours.*

Particularly at sea, this is only too true. In this connection the much recorded anecdote of the priest of an affluent Roman-Catholic family in a manor-house on the hill above Brixham bears repeating. As William's fleet appeared on the horizon, sailing into the bay under full canvas in the morning-mists of 15 November, this priest mistook the Dutch red-white-and-blue for the French colours and their orange pennants for white. Believing that the navy of Louis XIV had come to aid King James, he at once summoned the whole household to sing a 'Te Deum'. What happened when they were undeceived, is another story.[19]

To us, the special recording of so tiny an incident is illustrative of the extent to which the new awareness of the experience of the senses included that mysterious courier between the world 'out there' and the mind 'in here', the eye.

At our London Symposium it was emphasized that there was a gap of several decades between the publication of the various findings of scientists and amateurs in the *Philosophical Transactions* and their echoes or repercussions among the general public. There certainly was a curious recession in people's interest in scientific progress. Only when Newton died in 1727, a quarter of a century after William III, and a spate of 'In Memoriams' in verse and prose extolled the merits of the deceased, did a change of heart begin to show itself.

Foremost among the poet-eulogists was James Thomson who, linking up with the Latin verses which Newton's friend, Edmund Halley[20], the astronomer, had composed to be prefixed to the first edition of the *Principia*[21], skilfully passed in review each of Newton's innovative ideas. After successively having touched upon universal gravitation, the motions of the moon with their effect on the tides, and the appearance of comets, he brilliantly summarized the theme of the *Optics* thus:

[19] The most detailed journals are by the English army-chaplain, the Rev. John Whittle, *An Exact Diary of the late Expedition of His Illustrious Highness the Prince of Orange* (1689), by the Rev. Gilbert Burnet, *The Expedition of His Highness...for England* (Somers Tract IX, 1813), the *Journael* of Constantijn Huygens the Younger (ed. 1876), and Van Wassenaer van Rosande, *Journael van de Campagne van Engelandt 1688* (MS. in Algemeen Rijksarchief, The Hague).

For the meteorological picture, see J.L. Anderson, 'Climatic change, sea-power and historical discontinuity' in *The Great Circle*, V (1983), pp. 13–23; also S. Lindgren and J. Neumann, 'Protestant Wind, Popish Wind: the Revolution of 1688 in England' in *American Meterological Society*, vol. 66, no. 6 (1985) and J.L. Anderson 'Combined Operations and the Protestant Wind' in *The Great Circle*, IX, 2 (1987), pp. 96–107.

For a general outline of the crossing, see A. van der Kuyl, *De Glorieuze Overtocht* (1988).

[20] For an English translation of Halley's Ode by L.J. Richardson, see F. Cajori (ed.), *Sir Isaac Newton's Mathematical Principles of Natural Philosophy* (1934), pp. xiii–xv.

[21] The title-page reads in full: *Philosophiae Naturalis Principia Mathematica*, Autore J.S. Newton, Trin. Coll. Cantab. Soc. Matheseos Professore Lucasiano, & Societatis Regalis Sodali. IMPRIMATUR. S. Pepys, Reg. Soc. Preases. Julii 5. 1686. Londini, Jussu Societatis Regiae ac Typis Josephi Streater. Prostat apud Bibliopolas. Anno MDCLXXXVII.

Even Light itself, which everything displays
Shone undiscovered till his brighter mind
Untwisted all the shining robe of day;
And from the whitening undistinguished blaze,
Collecting every ray into his kind,
To the charmed eye educed the gorgeous train
Of parent colours...[22]

To the 18th-century poets, light was the source of beauty because it was the source of colour. In 1729 Richard Savage wrote 'The Wanderer', a long poem of reflections by a solitary figure on his travels in search of the new perceptions of nature. It is this wanderer who, at sunrise, acutely feels that

... the face of things,
All night beneath succesive shadows miss'd,
Instant begins in colour to exist![23]

Of course, it is Newton's prism that is primarily associated with the colours of the rainbow. And it is in Thomson's fascinating blank verse of *The Seasons* that the excitement generated by Newton's newly discovered world of colours is expressed most suggestively. Written in 1728, the poem is made up of four sections; in the one on 'Spring' the rainbow is described as:

Shooting up immense [it] every hue unfolds
In fair proportion running from the red
To where the violet fades into the sky...

He then directly, as it were, addresses the dead scientist, calling out in terms reminiscent of his own In Memoriam:

There, Oh awful Newton, the dissolving clouds
From, fronting on the sun, thy showery prism,
And to the sage-instructed eye unfold
The various twine of light by thee disclosed
From the white mingling blaze.[24]

In the period concerned, 'awful' (without the 'e') simply meant 'filling with awe' and it is remarkable how beautifully condensed the effect of rainbow-creating sunrays behind a shower has been rendered by the poet.

Interestingly enough, the swing of the pendulum in public appreciation of a previous century's scientific progress may be observed in the Romantic poets' feelings about this phenomenon. Their most representative poet is

[22] James Thomson, 'To the Memory of Sir Isaac Newton', *The Complete Poetical Works* (1908), pp. 436–442. See also M.H. Nicolson, *Newton demands the Muse* (1946), where much of the present material was first collected and elucidated.
[23] Richard Savage, 'The Wanderer' (1729), *Works of the English Poets* (1779), vol. 45, p. 50, lines 105–8.
[24] J. Thomson, *The Seasons*, 'Spring' (1726), lines 203–12, as in *Poetical Works* (1908).

John Keats and they can be found in his 'Lamia', a long narrative poem on a mythological basis dealing with illusion and reality. In it he asks:

... Do not all charms fly
At the mere touch of cold philosophy?

Then he illustrates this rejection of natural philosophy with:

There was an awful rainbow once in heaven;
We know her woof, her texture; she is given
In the dull catalogue of common things.

And finally he roundly denounces science by lamenting:

Philosophy will clip an Angel's wings,
Conquer all mysteries by rule and line,
Empty the haunted air and gnomed mine –
Unweave a rainbow.[25]

Confronted by a rainbow, Keats, like Thomson, was only and exclusively filled with awe. But, unlike Thomson, he spurned scientific analysis – a state of mind taken even further by Blake for whom Bacon, Locke and Newton should all burn in hell. Yet, it is this same passionate enemy of the Enlightenment, William Blake, who was to adjure us

To see a World in a grain of Sand
And Heaven in a Wild Flower.
Hold Infinity in the palm of your hand
And Eternity in an Hour.[26]

With his 'grain of Sand' Blake, consciously or unconsciously, returns us to the century of William and Mary, while his 'Eternity in an Hour' once more brings in the multi-faceted quality of Time. For the opening of this paper the ancient proverb of 'Time and tide wait for no man' was offered, together with the Shakespearean quotation

There is a tide in the affairs of men,
Which, taken at the flood, leads on to Fortune...

Now, in conclusion, it may suffice to say that, once we accept that the phenomenal outcome of William's daring 'Grand Design' was perhaps above all else due to his exceptional sense both of Time and of Tide. In the course of this Hour – no matter whether it may have seemed an Eternity to some – we have pondered the implications and the significance of the history of

[25] John Keats, 'Lamia' (1819), as in *Lamia, Isabella, The Eve of St. Agnes, and other Poems* (1820), Part II, p. 41.
[26] William Blake, *Auguries of Innocence* (1803?) (1863), p. 1. Blake's violent attacks on Bacon, Newton, Locke c.s. are among his 'Annotations to Sir Joshua Reynolds' *Discourses' (see Poetry and Prose of William Blake*, ed. Keynes, (1927), pp. 985–1010, and Nicolson, op. cit., p. 165).

these two concepts in the age under review. We have also allowed our imagination to play with Colour, Light and Sight. In doing so we have touched upon the remarkable relationship between creative minds in England and Holland.

The figure that proved to be central in our tour through the spiritual background of it all was Isaac Newton. A year after the death of this greatest genius of the age, the poet Alexander Pope offered as a tombstone-epitaph:

> Nature and Nature's Laws lay hid in Night,
> God said 'Let Newton be!' and all was Light.[27]

In our own days a variation has been coined, brilliantly returning us to earth. Created by the late Sir John Squire, that variation reads:

> It did not last, the Devil howling 'Ho!
> Let Einstein be!' restored the status quo.[28]

Could these lines serve as our coda? In the light of everything we have heard of pros and cons about William at this Conference, the spirit, at any rate, of the latter couplet may prove salutary.

[27] Alexander Pope, 'Intended Epitaph for Sir Isaac Newton', in *The Poems*, Twickenham ed. (1962), p. 808. The couplet was superscribed in capitals with 'Quem Immortalem, Testantur Tempus, Natura, Coelum: Mortalem Hoc Marmor Fatetur', since the epitaph had been meant for a monument in Westminster Abbey; they are, however, actually carved above the fireplace in the room of his birth at Woolsthorpe.

[28] J.C. Squire, *Collected Poems* (1959), p. 50.