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Book reviews

Environmental Consequences of Nuclear War. Volume I. Physical and Atmospheric Effects by A. B. Pittock, T. P. Ackerman, W. J. Crutzen, M. C. MacCracken, C. S. Shapiro and R. P. Turco (John Wiley & Sons, 1986). ISBN 0 471909181. Pp xi + 359, £35 Sterling.

The explosion of nuclear weapons over Hiroshima and Nagasaki in 1945 and post-war testing of more powerful devices prompted questions on possible effects on the atmosphere. Meteorologists pointed out that the energy released by such devices is small when compared with that of the atmosphere and observed that the effects appeared to be local and transitory. Their principal concern was to monitor and forecast the transport of radioactive debris and the level of potentially harmful fallout both in the vicinity of the test site and in other regions.

The publication in the 1970s of the results of a number of scientific studies of the environmental effects of nuclear war led the International Council of Scientific Unions, in 1982, to arrange the collaboration of more than 300 scientists from over 30 countries in a series of workshops and meetings at which the matter was discussed. The outcome of these discussions has been summarised in two volumes; Volume I – Physical and Atmospheric Effects, Volume II – Ecological and Agricultural Effects. This review deals only with Volume I (which includes a six-page Executive Summary from Volume II).

The task of summarising the outcome of the discussions on physical and atmospheric effects was undertaken by six principal authors (one from Australia, one from the Federal Republic of Germany and four from USA) assisted by seven collaborators (five from USA, two from USSR). Volume I contains eight chapters dealing with the direct effects of nuclear explosions, scenarios for nuclear war, generation of dust and smoke, atmospheric responses, meteorological and climatic effects, chemical pollutants and perturbations, radiological dose and research recommendations. The principal authors surely had a difficult task in distilling and reconciling what must have been a wide-ranging and sometimes conflicting set of views expressed at the workshops and meetings. The result is a lucid exposition accompanied by clearly presented figures and tables with copious references to relevant literature (over 350 references cited).

The major emphasis in Volume I is on the generation of dust and smoke by explosions in the nuclear war scenarios (Chapters 3, 4, 5), the transport of dust and smoke by the atmospheric circulation, the impact on the vertical temperature structure and the general circulation, and the effect on rainfall, temperature and sunlight at the earth's surface. There is heavy reliance on numerical models to simulate these processes, which seems unavoidable in the absence of direct observations of the effect of multiple nuclear explosions over industrial and urban areas. One gains the impression that the modellers may have benefitted from greater input from cloud physicists with field experience on the meso scale.

The authors have been careful to draw attention to model limitations and the uncertainties associated with assumptions in the scenarios and the extent of fires. The greatest uncertainty would seem to be associated with the vertical transport of dust and smoke, and rain-out from convective clouds generated by fireballs, within the first six to twelve hours.

The hazard of radioactivity generated by the nuclear war scenarios has less emphasis than is warranted, in particular with reference to the ingestion of globally distributed fallout of ^{90}Sr and ^{131}I. The results from monitoring fallout in Australia from French weapons tests at Mururoa in the 1960s and 70s and over European countries from Chernobyl in May 1986 suggest that nuclear war as envisaged in the scenarios would produce levels of radioactivity from long-lived isotopes hazardous to populations over a large portion of the globe.

Four hundred words of general conclusions by the SCOPE-ENUWAR Steering Committee (which had oversight of the project), a 12-page Executive Summary by the principal authors and summaries at the end of each chapter of Volume I warn of the direct effects of the nuclear explosions, the high levels of radioactivity, and the potential for major long-lasting perturbations of the atmosphere which could lead to large reductions at the earth's surface of temperature, rainfall and sunlight for long periods.

The uncertainties associated with these findings, and especially those relating to the effects of dust and smoke, are stressed repeatedly in Volume I and in earlier literature. Unfortunately these uncertainties have been ignored in many popular accounts in newspapers, magazines and electronic media which have depicted a 'nuclear winter'. It is significant that the principal authors have specifically excluded this term from Volume I.

Because of the uncertainties there will be differences of opinion in the scientific community regarding the probability and intensity of the major long-lasting perturbations in the atmosphere described in Volume I but even the most sceptical will be unlikely to argue that there would be no significant perturbation. It follows that there should be general

community awareness of the potential threat and the uncertainties associated with it. It would be unrealistic to expect that Volume I would find a wide readership in the general community but the general conclusions and Executive Summary should be readily understandable to the intelligent reader and should be mandatory reading for all politicians and community leaders. A detailed examination of Volume I will be needed by those scientists who are asked for an opinion on the findings. There is an obvious need for further research to reduce the uncertainties.

W. J. Gibbs

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Environmental Consequences of Nuclear War. Volume II. Ecological and Agricultural Effects by Mark A. Harwell and Thomas C. Hutchinson et al. (John Wiley & Sons, 1985). ISBN 0 47190883. Pp 523, £43.50 Sterling.

This book is the product of many Committees and workshops established by the Scientific Committee on Problems of the Environment (SCOPE). The mandate of SCOPE is, in part, to assemble, review, and assess the information available on human-induced environmental changes and the effects of these changes on humans. This volume is the 28th title in the series of volumes published by SCOPE.

The book is a synthesis by a veritable army of eminent scientists with a brief for consensus. Selected and guided by a SCOPE-ENUWAR (Environmental Effects of Nuclear War) coordinating office at the University of Essex, forty-four authors have collaborated to produce Volume II. Scientific societies with national responsibilities for science, including the Australian Academy of Science, have participated in workshops for scientific knowledge of physical effects and biological response of nuclear war.

The style that follows from summarised workshop reports and statements, has a readability level for recommending to insomniacs dependent on Gibbon's *The rise and fall of the Roman Empire.*

The foreword by nine authors provides the organisational history to the topic. They state that it is not yet possible to provide a single estimate of the likely consequences for humans and their societies, of the physical and biological changes projected to be possible after a nuclear war.

For the environment, the predictive effect of a major nuclear war would be greatly simplified if the rapidly evolving models of world climate could be complemented by general models of the functional characteristics of the world's ecosystems and their response to environmental perturbations. This capability will depend on future research.

A biome approach has been chosen as the appropriate level for generalisation of potential effects of nuclear war. Separate sections address northern hemisphere temperate terrestrial ecosystems, aquatic ecosystems, tropical ecosystems and southern hemisphere ecosystems. This synthesis by many of the world's leading ecologists, is one of the great strengths of the book, and it is difficult to name another book that provides such a wealth of detail on as many functional components and ecosystems of the world as this volume.

Following an excellent Foreword, Executive Summary and Introduction, the main body of this work is divided into three parts.

Part I examines the ecological effects of nuclear war in terms of ecological principles that relate to chilling the biosphere. This chilling is a direct consequence of a tactic that allows multiple nuclear detonations to generate smoke and soot from urban and forest fires. Suspended in the atmosphere, this radiation screen would, in turn, lower light levels so profoundly at the earth's surface, that there would follow a decrease of temperature. The combined effects of reduced temperature and low light, with exposure to ionizing radiation from gamma rays and fast neutrons have immediate and long-term effects on biological systems; specifically ecosystems, agricultural systems and human systems. The physical basis for this scenario is clearly critical and this is explored in Volume I (Pittock et al.).

The very large areas of each of the world's ecosystems provides a buffer from perturbations resulting from the direct effects of nuclear detonations. The initial ionizing and thermal radiation limited to a relatively small area around the explosion, is relatively insignificant in the scale of the ecosystems in which they occur. However thermal radiation has the potential for damaging ecosystems insofar as nuclear detonations may initiate fires in grasslands or forests. The seasonal timing of such detonations is therefore important, and explored in detail for both plant and animal populations. This detail extends to the migration, behaviour, physiology and even instincts for survival, of the major groups of animals over acute (first few weeks after detonation), intermediate (one to six months) and chronic (one to several years) intervals of time.

Modelling studies that are sufficiently advanced for studying chronic perturbations to ecosystems, are described for deciduous forests and mixed conifer-hardwood forests of eastern USA. The responses resulting from the FORNUT simulations are too complex for review here but they illustrate the potential for long-term reductions in primary production that would last for decades after the perturbations ceased, and the climate returned to normal. Extrapolating from some of these effects, the authors conclude that the animal population would

undergo more significant changes than the relatively stable modelled tree communities.

The SPUR (Simulation of Production and Utilisation of Rangelands) model for grasslands indicated that the above-ground biomass fell to nearly zero in the aftermath of a summer-onset nuclear war, and these levels would remain until the second growing season. However primary productivity would recover during the first growing season to follow a winter-onset nuclear war. The same model simulated soil losses some 22 to 27 times greater than normal, in the second year of a nuclear war. The effects diminished somewhat in the second year, but were markedly greater in the second year following a summer than a winter-onset nuclear war. The authors urge caution in the interpretation of the wealth of detail presented in these and other ecosystems which range from Soviet lakes to tropical mangroves. It is difficult to avoid trivial oversimplification in review.

Among the effects drawn together by the Australian workshops, is the study of cool-storage transport of Australian plant produce at 1 to 10 degrees centigrade in dark containers on ocean-going ships. They concluded from this and other considerations that effects during the chronic stage when precipitation is lowered by one half, and temperature reductions below freezing, that forests, semi-arid and arid ecosystems could absorb these without signifiant effect, as they do periodically without a nuclear war.

Part II examines the agricultural effects of nuclear war. The analytical approach and the models described in this part will probably interest most readers of this journal. The response of crops is based on much smaller scales of time and space than ecosystems and the key to predictions by the authors are based on average conditions rather than weather experienced at a location or given time, for which cumulative thermal time are important to yields. No change in the final and monthly variance in temperatures is assumed for the climatic analyses in this volume.

An interesting harmonic analysis of long-term mean daily minimum temperatures from North American stations was undertaken for the SCOPE-ENUWAR project, to obtain the dates and rates at which growing seasons in May and September cross the threshold of -2°C. For mid-latitudes, the sensitivity of the length of the growing season, defined as the number of consecutive days during which the mean daily temperature remained above -2°C, was found to be about 10 to 12 days per degree centigrade change in the mean temperature. This growing season reduction factor can lead to total loss of agricultural yield if insufficient time exists for crops to mature, even if the total thermal time as characterised by degree-days is adequate at temperate latitudes. Australian agriculture seems to be better buffered than some other countries, and there is clearly a need for future research programs to provide comparable models.

Part III deals with the human effects of nuclear war with emphasis on the vulnerability of storage, dietary requirements and redistribution of food crops. A simple model is developed to relate the proportion of pre-war agricultural production to the percentage of pre-war population, over three defined climatic scenarios. The historical and projected fate of Argentina, Australia, Brazil, Canada, China, India, Japan, USA and the USSR are then explored in detail.

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High-Power Laser Radiation in Atmospheric Aerosols by V.E. Zuev, A. A. Zemlyanov, Yu. D. Kopytin and A.V. Kuzikovskii (D. Reidel Publishing Co., The Netherlands, 1985). ISBN 90-277-1736-2. Pp xiii + 291, $US59.00

Remote sensing of atmospheric parameters using lasers is a burgeoning discipline with expansion in the field showing little signs of slowing. A subject of great interest to those who use lasers to sound the atmosphere is the extent to which the interaction of lasers with aerosols and cloud particles in the atmosphere causes non-linear effects on the attenuation of the laser light through the medium. These effects become evident when the high-power laser light intensity exceeds some threshold and they render the linear solution of laser propagation quite invalid. This book covers a wide area of the physical consequences of irradiating clouds and aerosols with high-power laser radiation. Non-linear interactions with the medium can limit the propagation of laser beams through the atmosphere quite dramatically, or on the other hand, if the power is adjusted accordingly, laser beams can punch clear channels through clouds through which a following laser beam can travel with a much reduced attenuation.

As explained in the introduction, many books devoted to the problems of propagation of high-power laser radiation have already been published. The present monograph attempts to generalise the most important results of both theoretical and experimental investigations which are not described in the aforementioned monographs.

The investigations are necessarily a trifle parochial as the authors admit that the bulk of the book contains results of investigations carried out at the Institute of Optics, Siberian Branch of the USSR Academy of Science, Tomsk, under the scientific guidance and participation of the authors.

Inevitably, most of the bibliography refers to Russian journals printed in Russian, but of course many Russian journals do have English translations.

'Aerosols' in the context of the present book encompass haze, fog, cloud and also precipitation.

The book is perhaps more theoretical than experimental and attempts to describe mathematically all the observed physical processes. As a result there are quite a few theoretical curves against which observations could be compared. However, some experimental results, quite a few of which are rather preliminary, are included at the end of most chapters.

The layout of the book is such that phenomena occurring at ever greater laser intensities are covered in successive chapters, first for water droplets and then for dusty hazes.

In the first chapter, there is a standard but quite good account of optical properties of aerosols, including useful information on analytical gamma functions and an empirical formula describing spectral haze extinction. The second chapter gives a general cover of subexplosive effects of radiation on individual particles, although this includes boiling and vaporisation effects. Regular regimes of droplet vaporisation are defined, followed by the vaporisation processes of typical haze particles. Solid particles are different from liquid in that their phase transitions occur at higher temperatures, and molecular dissociation can occur. Carbon particles can burn at the high interactive temperatures encountered, and thermal 'aureoles' can occur around such particles. A phenomenon which can occur in transparent drops (water in the visible region) is the generation of capillary vibrations which can lead to mechanical deformations of the drops.

Chapter 3 describes beam clearing methods in clouds and fogs at subexplosive intensities. As such clouds normally attenuate within several hundred metres, evaporation of drops along a channel would obviously be of great benefit for laser communications and other applications. The efficiency of such scavenging is limited in the end by wind and turbulence, as well as by non-linear thermal interactions.

Chapter 4 covers non-linear effects which work against the efficient clearing of paths through droplet clouds when the laser power becomes too high. The very act of the beam heating the air and evaporating droplets causes deviations in the refractive index of the air and therefore distortion of a laser beam (self action).

The story continues in Chapter 5 where the laser intensity is sufficient to explosively evaporate the aerosol. In this case, the absorption of radiation is sufficient to literally blow the drop to pieces. Bubbles can grow violently inside the superheated droplet liquid causing explosive boiling. The optothermodynamic approach to the theoretical treatment is used. There is useful material on the dependence of absorbed energy necessary for total destruction of a droplet of a given radius and the radii of resultant shock waves and their increase with time. There is also a good account of experimental investigations including attenuation changes through a region of exploding droplets.

In Chapter 6, the subject switches to hazes, in which solid aerosols are considered which have much higher boiling temperatures than water droplets and which correspondingly exhibit much more intense effects such as self action and the formation of thermal aureoles around the particles. Laser transfer through combustible aerosols indicates first an increase in optical depth due to enhanced scattering due to thermal effects but finally a decrease in optical depth below the original value due to 'burning up' of the aerosols.

Chapter 7 deals with ionisation phenomena and optical breakdown. The latter phenomenon is the final limitation to maximum beam intensity propagation through a dusty atmosphere. In the case of optical breakdown, ionisation of the medium and formation of a plasma occurs. Dramatic effects can be observed visually when an intense laser beam propagates through particles such as corundum, with ionisation 'sparks' showing in individual particles.

The final chapter considers the use of non-linear effects to actually monitor a turbid atmosphere. The distortions of lidar returns through self action and other effects limit the applicability of the conventional 'linear' equation. On the other hand, the non-linear effects themselves and their physical manifestations carry information on the physical and chemical properties in the atmosphere. For instance, a spectrochemical analysis of aerosols can be obtained remotely by observing the emission and luminescent spectra from aerosols ionised by an intense laser beam. Results from such an experiment are given.

The book is published in camera-ready type format which is, however, quite clear and the graphs are clearly drawn.

The book is suitable for postgraduate students and for scientists and engineers who are involved in the field, or wish to know something about it. References are given at the end of each chapter.

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Long-Range Forecasting Research Report Series World Meteorological Organization, Geneva (seven reports in the series to date)

Dr Samuel Johnson said: 'Knowledge is of two kinds. We know a subject ourselves, or we know where we can find the information about it.' In an age of so-called information explosion, this aphorism has never been truer.

For individual scientists, the problem of keeping up with the literature continues throughout their career. One could say that they require both kinds of knowledge referred to by Samuel Johnson.

For the World Meteorological Organization (WMO), with its objectives 'to promote the

establishment and maintenance of systems for the rapid exchange of meteorological and related information', and, 'to encourage research and training in meteorology....', the problem is twofold. Firstly WMO needs to be truly international in its publication program and to serve the needs of 'rapid exchange of information' in ways which the standard journals do not.

Secondly, WMO has to try to serve the research, training and information exchange needs of developing countries for whom access to information is an important economic issue. Samuel Johnson's 'knowing where we can find the information' is perhaps as significant a problem for small developing countries as is the high cost of the standard journals.

Does WMO serve its objectives with its publications? In reviewing the *Long-Range Forecasting Research Report Series* of WMO, I have tried to keep this question in mind.

For Australian scientists the issue of 'knowing where they can find the information' is usually quite well handled for them by their reasonably well-stocked libraries. However, in a quick survey of the long-range forecasting (LRF) research community in Australia, I found that Bureau of Meteorology officers had greater knowledge of and access to the series than did non-Bureau officers. This reflects the difference between WMO saleable publications which are widely advertised, and reports produced under WMO programmes which are not saleable and are less widely publicised. The report series being reviewed falls in this latter category, and while available on request from WMO and distributed to member countries on publication, such reports are nevertheless less well known in the general scientific community.

Quality of production

By and large the quality of production has remained high throughout the series. Only minor typographical and grammatical errors can be found and in my version of No. 6 in the series, six pages were missing at the back of Volume I (however other copies sighted were complete). In conference papers submitted by individual authors, there is still a tendency for the inclusion of computer drawn maps and charts unsuitable for reproduction, size reduction, or indeed, overhead viewing at a conference. I know I have been guilty of this myself in the past, but it is about time this practice is firmly discouraged by editors of conference proceedings, especially now that computer graphics have improved so much.

Although the series has been produced over a wide span of years, is there really any reason to change the name of the series midstream? For the first four issued, the series was called Long-Range Forecasting Research Publication Series, which was changed to Long-Range Forecasting Research Report Series for the most recent three publications/reports. I would have thought this might cause problems for librarians conscientiously attempting consistency, continuity and correctness in their cataloguing.

Discussion of individual publications/reports

Series No. 1: Proceedings of the WMO – CAS/JSC Expert Study Meeting on Long-Range Forecasting (Princeton, 1-4 December 1982).

This report contains a set of position papers on aspects of LRF such as:

- structure of atmospheric variability
- predictability and prospects for prediction
- dynamics
- boundary influences and observational requirements

and a suite of assessments and detailed recommendations on each of the topics covered.

As the first report in the series, the position papers constitute a useful summary of knowledge as of 1982. However, they contain more than their fair share of the aforementioned illegible global charts (computer drawn).

Prior to this Expert Study Meeting, a questionnaire was distributed to the 50 or so participants to assess research priorities pertinent to LRF. It was interesting to note, in 1982 prior to the full recognition of the magnitude of the 1982-83 El Nino-Southern Oscillation (ENSO) event, that the respondents to the questionnaire ranked an understanding of blocking as a higher priority than the understanding of El Nino (Appendix C, page 237). It would be interesting to conduct that survey again today.

Series No. 2: Five-Day Mean 500 hPa Height and Mean Sea Level Pressure Fields for the Northern Hemisphere (1946-1977).

There are four volumes in the set, one each for winter, spring, summer and autumn. They contain sequential pentad maps with a brief introduction for each volume; no tabulated numeric data is included. The maps are well laid out on the page for rapid scanning by fanning through the leaves for glimpses of trends or patterns or for searching for analogs. The data cover 32 years, from 1946-1977. No mention is made of why this period was chosen – is it a consistent set with respect to analysis technique, or was there some other reason for stopping at 1977? Otherwise, for a data set published in 1983, using modern computer techniques, why was the period not extended to say 1980, making it a 35-year data set?

Volume 1 (winter) duplicates 5 pentads contained in the spring volume. Consequently it is 66 pages longer than the other three volumes, for no apparently useful reason. A minor error on page 5 of Volume 1 refers to the volume containing the spring data when it actually contains the winter data. These four volumes of maps are generally considered to be of limited usefulness in the LRF research community of Melbourne.

Series No. 3: Long-Range Weather Forecasting: Recent Research.

This report contains a good summary of advances over recent decades in LRF. Such summaries are valuable as landmark identifiers, and more of them would be a useful way to tell the story of scientific progress in this area to a sometimes sceptical audience.

To my mind, this report would have benefitted from some diagrams, for occasionally the authors laboured to describe accurately in words a phenomenon or feature, where a diagram would have helped. As a southern hemisphere inhabitant who likes to nitpick about those from the northern hemisphere who neglect to assign their season to a particular hemisphere when discussing global climate, I found an example of such lack of clarity in the third paragraph of page 15. (In this paragraph, the northern winter is discussed followed by a sentence on the southern hemisphere, which by inference from the preceding sentences could refer either to the southern winter or to the events occurring synchronously with the northern winter.)

On page 16, Keshavamurty's (1982) paper has been incorrectly quoted as reporting that 'anomalous westerlies over the *east* equatorial Pacific resulted from the imposition of warm SST anomaly in the *central* equatorial Pacific (although not from warm SSTs in the *east* Pacific)'. Replacement of the first *'east'* with *'west'* would reflect Keshavamurty's results, viz. his Figs 7 and 13. Finally, while LRF was defined as extending out to ten years (page 2), the forecasting of long-term trends over this time-scale was not mentioned (although cycles were discussed), nor was the influence of trends or climate drift on the stability of current techniques discussed in any detail.

In spite of these minor problems, Report No. 3 provided a timely status report on LRF research.

Series No. 4: Report of the Session of the Commission for Atmospheric Sciences Working Group on Long-Range Weather Forecasting Research (Geneva, 2-6 April 1984).

This report concentrates principally on organisational matters and recommendations from the meeting of the working group. The definition of LRF presented in this report (No. 4) differs substantially from the definition presented in Report No. 3, in terms of time-scale (a month to a season used in No. 4 and a month to a decade used in No. 3). In practice, however, current work concentrates on the seasonal scales.

Series No. 5: Meeting of Experts on Ocean-Atmosphere Interaction Relevant to Long-Range Weather Forecasting (Geneva, 14-16 November 1984).

This report of the meeting of experts contains:

- recommendations from the meeting
- overview of sea-surface temperature (SST) and long-range weather forecasting
- survey of national usage of SST data and analyses
- background information on some SST analysis schemes and data held.

Series No. 6: Proceedings of the First WMO Workshop on the Diagnosis and Prediction of Monthly and Seasonal Atmospheric Variations over the Globe (combined with NOAA's Tenth Annual Climate Diagnostics Workshop) (College Park, USA, 29 July-2 August 1985).

Like its title, this report is very long. It contains a large collection of papers covering:

- regional climate events
- ENSO diagnostics and modelling
- studies of fluctuations in the atmospheric circulation
- dynamics and modelling of quasi-stationary flow
- dynamical and statistical-empirical prediction
- overview of 1982-1985 climate anomalies.

Consequently, it provides a very good collection of information and data, and contains a considerable body of data which might not be published in the standard journals because of space and cost limitations.

Series No. 7: An Atmospheric Climatology of the Southern Hemisphere based on Ten Years of Daily Numerical Analyses (1972-1982).

This report contains a ten-year climatology with the month-by-month climatic means included in print form in the body of the report, and the individual monthly means and monthly anomalies from the ten-year mean for the month, included in microfiche form at the back. The data and the maps have already been very useful to many Australians working on Australian climate, and no doubt will prove useful to others in the southern hemisphere as well as researchers in the northern hemisphere who wish to maintain a global perspective on large-scale climate and its variability.

Conclusion

Judging by the response of the Melbourne LRF research community to the report series, WMO has performed a useful function by its publication. Of those questioned on the matter, all thought the series ranked in usefulness approximately equally with the standard journals, and two-thirds of those questioned considered the timeliness of publication of individual volumes was satisfactory (no mean feat for WMO). The Melbourne LRF research community generally found the series good background material, and some scientists found it a frequent useful reference. Given this moderately high praise by Australian scientists, I can see no reason why the series would not be excellent value for smaller and/or developing countries – by providing low cost up-to-date surveys of the current world-wide state of knowledge on the subject matter. WMO appears to be filling a useful niche in the publication scene with this series, and is serving the needs of both developed and developing countries. Consequently, WMO is fulfilling its relevant objectives in producing this series, by making available to all meteorological communities the two kinds of knowledge referred to by Dr Samuel Johnson.

M. E. Voice

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