



Oxford University, Oxford, England, was the locale of the technical sessions of the symposium. The inaugural session was held at the Royal Institution in London.

The 7th INTERNATIONAL SYMPOSIUM on COMBUSTION

A Report by E. S. Starkman

THE Seventh International Symposium on Combustion, the fifth such meeting since World War II and the first one outside of the United States, was held in London and Oxford, England, from August 27 to September 3, 1958. This seventh symposium, organized by The Combustion Institute and by The Institute of Fuels of Great Britain, was attended by 600 scientists and engineers, representing 19 nations.

The inaugural session of the symposium on Thursday morning, August 28, was held in the main lecture hall of the Royal Institution. The location was appropriately chosen since it was at the Royal Institution that Sir Humphry Davy carried out his early and historical experiments on combustion and explosion. The prototype Davy lamps, developed by him, and which made possible the safe illumination of coal mines, were exhibited by Sir Alfred Egerton, Honorary President of The Combustion Institute and Chairman of the British Committee, during his address on the combustion researches performed by this pioneer in the early 19th Century.

The opening meeting of the seventh symposium was also the occasion for The Combustion Institute to initiate the awarding of medals for outstanding contributions in the field of combustion. One of these was bestowed by Dr. Theodore von Karman on Dr. Bernard Lewis, of the United States, "for an outstanding major research program". Another was presented by Dr. A. R. J. P. Ubbelohde to Sir Alfred Egerton, of the United Kingdom, "for a life-work in the advancement of combustion science and technology". A third was conferred by Dr. Bernard Lewis on Professors S. Kumagai and H. Isoda, of Japan, "for excellence in experiment and

high discrimination in choice of combustion subject". The inaugural ceremonies were additionally made auspicious by the addresses of: Lord Brabazon of Tara, President of the Royal Institution; Sir Cyril Hinshelwood, President of the Royal Society; Dr. Bernard Lewis, President of The Combustion Institute; and Sir Alfred Egerton, mentioned previously. The remainder of the day on the 28th of August was devoted to a visit and inspection of the Combustion Laboratories of the Imperial College of London, and on Friday morning, August 29, the symposium moved (by special gas turbine-powered train) to the university city of Oxford, where the technical sessions were held.

That the bulk, interest, and diversity in combustion research are all quite apparently increasing is most evidenced by comparing the seven symposia held to date. Discounting the first two which were held prior to World War II and were under the auspices of the American Chemical Society, the number of papers presented at any one meeting would appear to be constant, remaining in the vicinity of about 100. The first symposium after the war, which took place at the University of Wisconsin in 1948, encompassed the total field of combustion; the next, at Massachusetts Institute of Technology four years later, was concentrated on the physics of combustion. The fifth symposium in 1954—only two years after the previous one—was at the University of Pittsburgh and was primarily concerned with chemical kinetics. At the sixth symposium, held in 1956 at Yale University, the theme was again one of broad concept and diversity. However, the sixth symposium represented the first occasion that a much larger number of papers were offered than could be placed on the program. Additionally, this happened even though in the interim there had appeared on the scene the excel-

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ent AGARD publications in the field, commencing with the papers presented at the December 1953 meeting of that group and continuing on approximately an annual basis. The AGARD activity undoubtedly reduced the number of submissions to the Combustion Symposia. Nevertheless, the theme of the seventh symposium, "The Physics and Chemistry of Flames", attracted well over 200 submitted papers. This is indeed an index of the increasing activity and interest in the field of combustion, particularly when it is noted that the theme of this meeting was to an extent restrictive.

OF the original submissions it was possible to place only 121 on the program. These were all printed in full for distribution prior to the meeting. Seventy-six of the papers were scheduled for ten-minute presentations. The remainder were available for discussion during the periods following the presentations. All 121 papers, as well as the discussions, are to be incorporated in the published proceedings of the meeting and will become available in the near future in a volume corresponding to those of the four previous Combustion Symposia.

The program of the Seventh Symposium on Combustion was indexed into subject matter and technical sessions as follows:

- Properties of Detonation Waves
- Transition to Detonation
- Spectroscopy of Flames
- Ignition and Limits of Inflammability
- Structure of Flames
- Mechanism of Combustion Reactions
- Combustion in Practical Flowing Systems
- The Hydrogen-Oxygen Reaction

- Ionization in Flames
- Turbulence in Flames
- Inhibition of Oxidation Reactions
- Special Fuels
- Instrumentation in Combustion Research
- Interaction of Flames and Surfaces
- Attainment of Equilibrium in Combustion Reactions
- Mechanism of Flame Propagation

It should be apparent that a thorough, exhaustive technical review of all the material presented, much less a review of each paper, would be a formidable task and one which is beyond the scope or intent of this report. Thus, the author will attempt only to give his own limited impressions of the technical aspects of the meeting, leaving the detailed information for the aforementioned publication of the proceedings.

One impression which was received was that, at least for purposes of this report, the 16 subject headings above might have been further classified into 4 broad categories. These would be titled:

- Progress on Problems of Long Tenure
- New or Renewed Areas for Research
- Technique and Instrumentation
- Combustion in Practical Systems

Under the general heading of Progress on Problems of Long Tenure could be placed the subject headings of Ignition and Limits of Inflammability (10 papers), Structure of Flames (7 papers), Mechanism of Combustion Reactions (17 papers), the Hydrogen-Oxygen Reaction (5 papers), Ionization in Flames (5 papers), Turbulence in Flames (8 papers), Interaction of Flames and Surfaces (8 papers), Attainment of Equilibrium in Combustion Reactions (5 papers), and Mechanism of



Sir Alfred Egerton in his role as chairman of the session on ignition and limits of inflammability.



The president of the Combustion Institute, Bernard Lewis, receives the Institute's Medal for "an outstanding major research program" from Theodore von Karman.

Flame Propagation (9 papers). These 74 papers, being over 60 percent of the total, were within the theme of the meeting and accordingly represented the bulk of the program. Some of these 74 were limited to the presentation of experimental results and thus were not generally of an argumentative nature. However, the most interesting debates and the widest differences of opinion at the symposium arose over the remainder of the 74. Even though anticipated, the scheduled arrangements of approximately 40 minutes per session for presentations, 10 for opening remarks by invited discussors and 50 minutes for open discussion and debate, on many occasions did not give ample opportunity for complete exhaustion of argument. (On some points, no matter how much time was so scheduled, it would not have been sufficient for exhaustion of all argument.)

That progress is being made in the understanding of the chemistry and physics of flames was readily apparent at the seventh symposium, as evidenced by extension and refinement of existing theories as well as the introduction of new hypotheses (notwithstanding a persisting lack of agreement on the most probably correct analysis). The progress seems, however, to be a painfully slow process, and understandably so.

Under the category of Technique and Instrumentation could be placed the subjects of Spectroscopy of Flames (5 papers) and Instrumentation in Combustion Research (6 papers). Since the processes of combustion are highly transient and of brief duration even in systems designed to magnify the time constant, and the measurements of temperatures and pressures and identification of species intermediate in reactions are not obtainable except with instrumentation which has time constants in the microsecond range, one would predict that progress in understanding of combustion would

proceed in step with the development of discriminating instrumentation. While the 11 papers in the special subjects of Spectroscopy and Instrumentation have been singled out, an impression was received that a number of researches outside of the 11 mentioned above owed their existence as equally to instrumentation as to analysis and could well have been placed in an "Instrumentation" category. This is not intended as criticism but rather as commentary on the importance of instrumentation.

Enjoying an area of prominence were two sessions on detonation, Properties of Detonation Waves (7 papers) and Transition to Detonation (9 papers), and these would fit under the title of New or Renewed Areas for Research. There was also a session on Special Fuels (5 papers) and one on Inhibition of Oxidation Reactions (4 papers) which would be placed in the same category.

The subject of gaseous detonation has recently acquired a new and increased interest. This is in part due to the possibility of utilizing this high intensity form of energy release to reduce the size and perhaps complexity of combustion chambers through the creation of a standing detonation wave. It is also perhaps partially due to the possibility of using the products of the gaseous detonation, especially in a shock tube, as raw material in plasma research. Additionally, the temperatures of detonation processes might be made to span the regime between deflagration combustion and nuclear reaction.

The session on Special Fuels was largely devoted to investigations into the combustion of nonhydrocarbons and materials containing metals, such as boron, aluminum, zinc, titanium, and zirconium, as well as the silanes. Impetus for such study, as with detonation, is

partially due to the possibilities of thereby improving combustion performance in practical systems.

There were 11 papers included in the symposium under the category of Combustion in Practical Flowing Systems. These ranged from studies in open hearth furnaces, through ramjets, gas turbines, and into rockets.

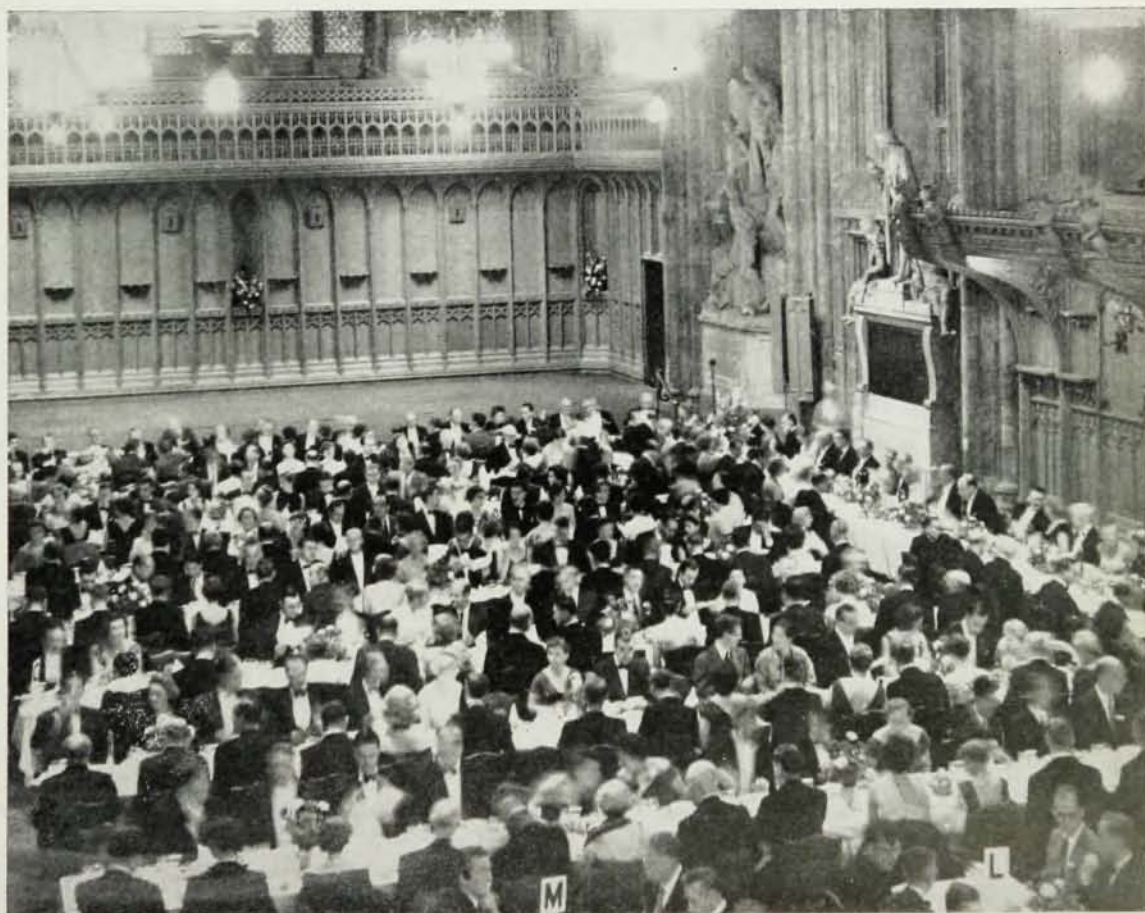
WHILE it was obvious from an examination of the material of the seventh symposium that gains are being made in the theoretical approaches to the chemical kinetics, and the mass, momentum, and heat transfer processes of the combustion phenomenon, it is always a disappointment that there is as yet no great break-through in the boundary between science and technology. Flame stability in turbojets and ramjets, instabilities in rocket engine combustion, knock phenomena in piston engines, partial combustion products in these same devices, along with a number of other performance limiting problems are all far from being understood—much less solved. The situation is perhaps best characterized by reference to the Round Table discussion at the symposium. This was appropriately titled, "The Study of Combustion: Is It an Art or a Science?"

The Seventh International Combustion Symposium, as did the previous symposia, brought together the scientists and the engineers in the field of combustion. It provided them with the opportunity for mutual enlightenment and appreciation of problems and difficul-

ties. It is encouraging to note that there are no indications of change for future symposia in this admirable relationship between the two groups in the field.

This report would be sadly lacking in content if it left the impression that the Seventh Symposium on Combustion at London and Oxford was entirely technical. For, as has been pointed out, a symposium is literally "a drinking together". The British Committee deserves the utmost of commendation, not only for an excellent job of arrangement of technical program, but also for one unsurpassed in hospitality and social aspect. Among the many noteworthy social arrangements were those of the Reception by Harmer Nicholls, Parliamentary Secretary to the Ministry of Works, at Lancaster House, St. James Palace; the visit to Blenheim Palace; attendance at the performance of "Hamlet" in the Shakespeare Theatre at Stratford-upon-Avon; and the Air Show at Farnborough. At the top of the list of all of these and one occasion which literally fits the definition of symposium was an event not soon to be forgotten. This was a banquet which defies description, especially arranged for participants in the symposium and held on the evening of Thursday, August 28, at Guildhall in London.

The British Committee for the Seventh International Combustion Symposium set an extremely high goal for those who will be responsible for the Eighth, which is to be held at the California Institute of Technology, in Pasadena, California, during the summer of 1960.



The banquet was held at Guildhall in London.