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Final Report

to

The National Science Foundation

COMBUSTION GENERATED NOISE

NSF Grant No. GK 32544

Work performed at

School of Aerospace Engineering

Georgia Institute of Technology

Atlanta, Georgia 30332

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Principal Investigator

I. Summary of Technical Accomplishments

The work performed under Grant No. GK 32544 was funded jointly by Air Force Office of Scientific Research Grant No. AFOSR-72-2365. Since it is virtually impossible to separate tasks, as to the sponsor of each, this summary includes the results of all work performed on the program during the period March 1972 through 1 July 1974.

The experimental accomplishments have been as follows:

1. Sound power output, spectra and directionality have been measured for open turbulent flames burning in an anechoic chamber using the fuels acetylene, ethylene, propylene and propane with air at atmospheric pressure and ambient temperature. The independent dimensionless groups which have been varied are Damkohler's first similarity group, Reynolds number, Mach number and fuel mass fraction. Primary work has been with fuel lean flames but equivalence ratios to 3.5 have been studied. The results for sound power output and frequency of maximum radiated power have been empirically correlated with the dimensionless groups above.

2. The volume of active reaction has been measured for the above flames by direct photography filtered near the primary CH band emitted from such flames. This volume has also been correlated with the above dimensionless groups as an aid in understanding the scaling laws deduced.

3. Optical measurements of C_2 emission have been made to determine the correlation of the time derivative of the emission intensity

with the far field pressure measurements, again to understand the scaling laws achieved.

4. The flames above have been enclosed in a simulated infinite tube and sound pressure measurements have been made in the tube to determine the effects of wall reflection and possible feedback effects upon the generated noise.

Concurrent with the experimental effort the following theoretical and data reduction effort has been carried out:

1. A theory of the directionality characteristics of noise radiation from flames has been carried out to explain why these effects are weak.

2. The theory of combustion noise as originally developed by the Principal Investigator has been used to satifactorily explain the correlation developed in experimental Task 1 above. Furthermore, a deduction of the theory is that Task 1 above should have yielded the results that were indeed obtained.

3. The theory of noise radiated from flames when enclosed in a tube was developed in order to reduce the data of Task 4 above and to determine the expected change in radiation characteristics when the flames are enclosed.

The detailed technical results are attachments to this summary report.

II. Summary of Educational Accomplishments

Under sponsorship of this grant Dr. B. N. Shivashankara obtained his Ph.D. performing the sound and light radiation experimental work with open turbulent flames. Dr. Shivashankara continues as a Post Doctoral Fellow to make contributions on the enclosed flame work.

Mr. Raymond J. Strickland received an M.S. degree while being supported on a Graduate Research Assistantship for a full year under this program. He developed the flame-in-tube experiment.

Mr. M. Muthukrishnan was supported under this program in the initial stages of his Ph.D. program. He worked on the data collection and reduction for the flame-in-tube experiment.

Mr. John C. Handley, a research engineer and part time graduate student working toward his Ph.D., was partially supported on this program.

This program has enabled other support to be brought to Georgia Tech in the noise area because of the attendant facilities build-up. Consequently, future educational objectives will be attained as a direct result of this program.

III. Attachments

A. Reprints of Papers:

1. Strahle, W. C.,"Refraction, Convection and Diffusion Flame effects in Combustion Generated Noise," Fourteenth Symposium (International) on Combustion, The Combustion Institute, Pittsburgh, p. 527 (1973).

B. Papers Published in Proceedings, Preprinted, Currently under Review, or Accepted for Publication:

1. Shivashankara, B. N., Strahle, W. C. and Handley, J. C., "Decomposition of Combustion Noise Scaling Rules by Direct Flame Photography," Presented at 4th International Colloquium on Gas Dynamics of Explosions and Reactive Systems, San Diego (1972). Accepted for publication in Astronautica Acta.

2. Strahle, W. C. and Shivashankara, B. N., "Experiments on Combustion Generated Noise," Proceedings of the First Interagency Symposium on University Research in Transportation Noise, Vol. II, p. 536. (1973).

3. Strahle, W. C. and Strickland, R. J., "Wall Reflection and Feedback Effects in Combustion Gneerated Noise," 10th JANNAF Combustion Meeting, CPIA Publication 243, Vol. II, p. 343 (1973).

4. Shivashankara, B. N., Handley, J. C. and Strahle, W. C., "Combustion Noise Radiation by open Turbulent Flames," 10th JANNAF Combustion Meeting, CPIA Publication 243, Vol. II, p. 355, (1973).

5. Shivashankara, B. N., Strahle, W. C. and Handley, J. C., "Combustion Noise Radiation from Open Turbulent Flames," AIAA Paper No. 73-1025 (1973). Accepted for publication in AIAA Progress Series book.

6. Strahle, W. C., "A Review of Combustion Generated Noise," AIAA Paper No. 73-1023 (1973), accepted for publication in AIAA Progress Series book.

7. Shivashankara, B. N., Strahle, W. C. and Handley, J. C., "An Evaluation of Combustion Noise Scaling Laws by an Optical Technique," AIAA Paper No. 74-47 (1974). Under review for AIAA Journal.

8. Shivashankara, B. N., Strahle, W. C., Handley, J. C. and Muthukrishnan, M., "Combustion Generated Noise," Proceedings of the Second Interagency Sumposium on University Research in Transportation Noise, Vol. II, p. 708 (1974).

C. AFOSR Reports:

1. AFOSR Interim Scientific Report AFOSR-TR-73-1899 (1973).

2. AFOSR Interim Scientific Report (No number as yet assigned) (1974).