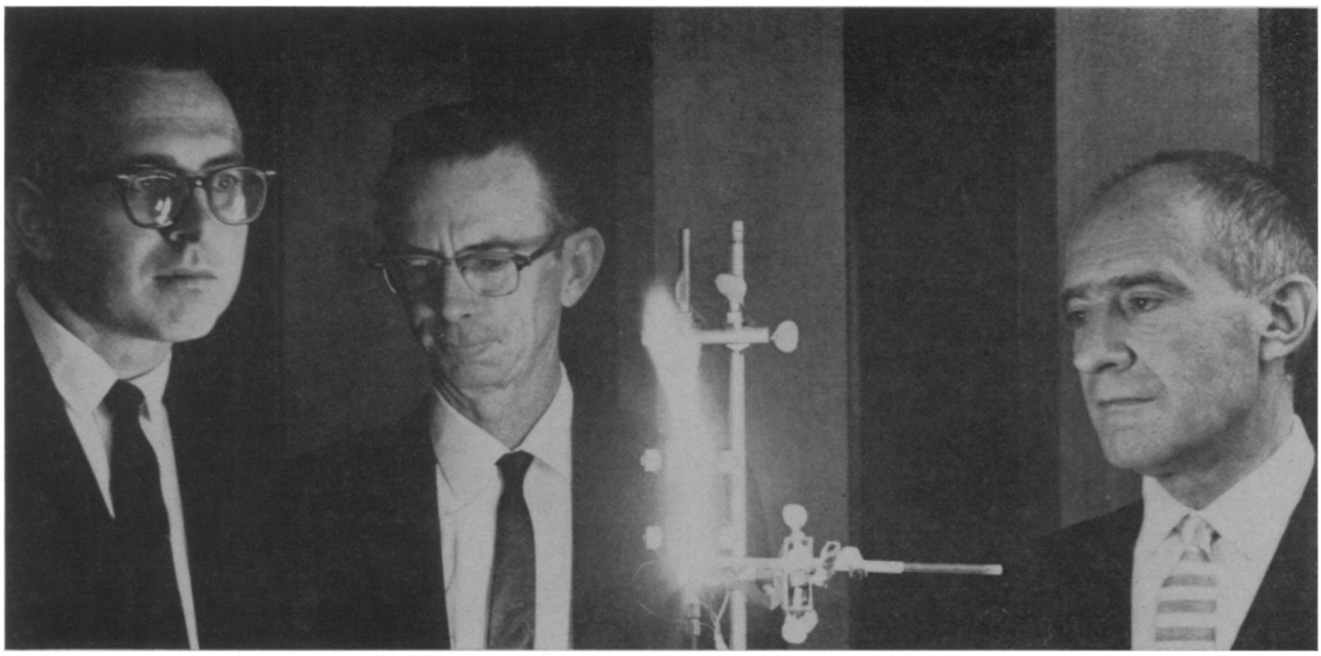


United Technology Center

Flame researchers (from left), Dr. A. G. Cattaneo, Wayne Babcock and K. L. Baker.

PLASMA PHYSICS

Musical flames may test engines, rockets

by Carl Behrens

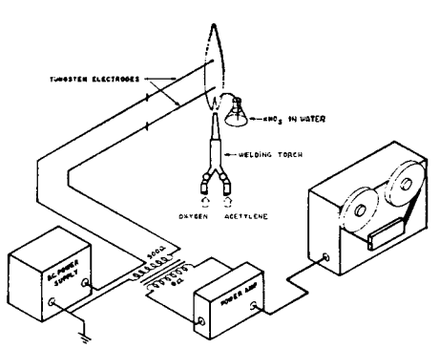
More than 100 years ago physicist John Leconte, noting that a gas flame at a concert jumped in time with certain notes from a cello, asserted that "we must look on all jets as musically inclined."

Since that time experimenters have shown that flames can actually accept and reproduce sound and music, acting as loudspeakers. Their experiments aimed sound waves at the flame, which picked them up and amplified them.

Now engineers at United Technology Center in Sunnyvale, Calif., have carried the idea a step further, and made a flame from a welding torch convert electric signals directly into sound. The setup can fill a large room with music or speech.

The prospect of welding-flame woofers and tweeters replacing the traditional paper cone loudspeakers in the hi-fi rig is remote, says UTC's Dr. A. G. Cattaneo, despite the apparently high fidelity of the flame's reproduction. The complex flame system wouldn't add anything that couldn't be done more easily with conventional speakers.

But a more sophisticated development of the principle could be used for a number of important engineering applications, including cutting down noise from jet engines, he says. The additional sound energy might be used to detune the flame noise so it doesn't resonate with the engine housing.



UTC

Flame produces hi-fi sound.

The principle of electrically affecting a flame has been known for some time, according to Dr. Robert M. Fristrom of Johns Hopkins University's Applied Physics Laboratory, a center of flame research.

In a flame, the heat turns gas molecules into plasma, separating the electrons and the positive ions. If an electric field is applied, the electrons rush toward the positive pole and the ions move toward the negative pole. But since the ions are much heavier than the electrons, there is a net force in the direction of the negative pole, and the flame is bent by the electric field.

If the electric field is varied, as in an experiment Dr. Cattaneo reported in the Nov. 18 NATURE, then the flame moves in time with the variations, just as the cone in a loudspeaker moves in response to an electrical signal. And the movement of the flame causes sound waves just the way a loudspeaker makes them.

Imposing sound pressure within a burning flame might be a way of cutting jet noise, says Dr. Fristrom, because the burning rate of a gas is affected by pressure. If the burning rate happens to match the time it takes for the flame to fill the burning chamber, the flame noise resonates in the chamber. This acoustic loading, as it is called, contributes a large share of jet noise.

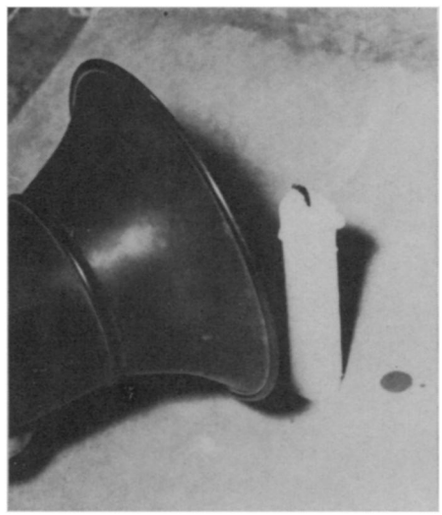
(see p. 44)

(continued from p. 43)

By detuning the burning rate through modifying sound pressure, the resonance noise might be cut out. Dr. Fristrom suggests that a sensor could put out a signal each time the resonance threatened to become serious, triggering the generator to alter the flame's sound output.

A big problem in such speculation, says Dr. Fristrom, is the amount of sound energy needed to shift the burning rate enough to be effective. That kind of question can only be worked out with experience, he says.

Another application that Dr. Cattaneo suggests is testing new rocket designs.



Early research: sound kills flame.

If a chemical rocket flame becomes unstable, it can shake the rocket apart. In order to test rockets for a tendency to become unstable, an explosive charge is set off in the chamber while the rocket is burning. The charge generates sound waves that could upset the rocket flame if it is vulnerable that way.

With the single charge, however, there is no control over the frequency of the sound imposed, says Dr. Cattaneo, and some frequencies can be more important than others.

With the proposed sound generator, the tester could scan over the whole range of frequencies, giving a much more complete test.

Not only does a flame vibrate with sounds; the movement is reflected in its output of light, reports Dr. Cattaneo. An image of the flame was aimed at a photocell connected through an amplifier to a loudspeaker. When music was imposed on the flame, it flickered; the flickering was picked up by the photocell and the music was reproduced by the loudspeaker.

"This is real basic research," says Dr. Cattaneo. "These effects have not really been taken into account before."