LETTERS TO THE EDITORS

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Endoradiosonde

An arrangement that could send out information about conditions inside a living person could supply scientific information and also become a diagnostic tool in clinical work. For this purpose one would desire a radio method that could perform under approximately physiological conditions. Accordingly, we have produced a small capsule that a person can swallow, and which contains the sensing transducer and the radio transmitter. This device has successfully operated during its passage through the gastro-intestinal tract.

During the past five years, at the University of California, attempts were made to perfect a passive telemetering transmitter in the form of a resonant circuit, one of the reactances of which would change in response to the variable under observation. The change in characteristic frequency was to be detected from outside the body by a 'grid-dip meter' that cyclically scanned the frequency-range. Even with several detector coils around the body to compensate for changes in orientation of the passive transmitter, the signal fell off so rapidly with distance that it was clearly desirable that the transmitter generate its signal from an associated power source.

Several alternatives exist using transistor oscillators. The person could be placed within a coil and energy induced into an internal secondary winding at a frequency quite different from that of the outgoing signal. However, a self-contained battery seemed superior. In one experiment the battery consisted of a gold and iron electrode with the internal fluids of the subject acting as the electrolyte. The low power properties of a junction transistor made such a single-cell battery adequate though the 'line voltage' varied. The stability of a self-contained miniature cell, thermostated by the body, permitted the use of simpler circuits with an overall saving of volume.

Some variables of interest are pressure, temperature and chemical composition. Pressure can be sensed by the motion of a diaphragm which moves a piece of iron within the coil of a tuned circuit controlling the oscillator frequency. The transistor itself is quite sensitive to temperature and so it can perform this sensing operation. In general, chemical analysis by potentiometry at present seems impractical because of interfering biochemical substances. However, investigation is now under way to determine a suitable combination of electrodes and circuitry to telemeter *p*H.

For easy detection of the radiated signal, a high frequency seemed desirable, though considerations of signal penetration or 'skin depth' plus the factor of transistor efficiency caused us to select a frequency in the hundred-kilocycle range. Using readily available components, the capsule is 2·8 cm. long and 0·9 cm. in diameter. Radiation is mostly from the coil itself acting as a loop antenna or primary winding relative to the receiving loop, though a small antenna could trail along behind and thus possibly also help orient the device along the direction of motion. One can track the unit through the body with a small tuned antenna or, for more precision, by X-ray observation.

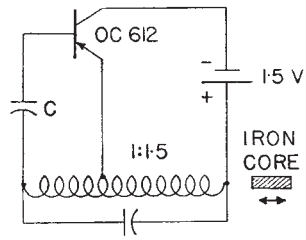

Fig. 1. Circuit of radio transmitter swallowed to transmit internal temperature and pressure. The transistor generates two frequencies and acts as a thermometer. Pressure modulation results from motion of powdered iron near coil. *C* is roughly 0·01 mfd., depending on particular transistor

The circuit that was finally evolved uses a grounded emitter connexion as shown in Fig. 1. The phase difference between collector and base allows the use of a single tapped coil (Hartley oscillator) across all of which the tuning condenser is connected to yield a given frequency with as small a coil as possible. The base connexion is through a condenser which not only results in emitter bias from the single collector battery but also, if its capacity is high enough, gives a blocking or quenching action. The radio-frequency transmits information about the pressure practically independent of temperature. The repetition-rate of the radio-frequency bursts depends on, and transmits, temperature. The burst repetition-rate does show a dependence on the pressure, but since the indication of the latter is unambiguous the temperature indication can always be corrected to the true value. Thus the tuning of a standard radio receiver indicates pressure and the tone of its output signal indicates temperature.

Calibrations are made outside the body just before and possibly after an experiment. It is actually possible under laboratory conditions to calibrate the pressure-sensing device while it is inside the subject. Since there is a sealed air space in the capsule behind the diaphragm, exposing the subject to changing atmospheric pressure allows calibration of the pressure sensitivity. Extrapolation to zero pressure, or return to any fixed value, makes possible a temperature reading completely independent of pressure. In principle, one could use a feedback system to change the external pressure on the subject until the transmitted reading was always returned to a fixed value. The external pressure would then measure the internal pressure independent of linearity or sensitivity, that is, no calibration would ever be necessary. Questions of interaction with changing temperature indications also would not arise, though in general the method seems impractical.

The concept of a radio transmitter inside a person originated because of a desire to get information about processes in the bladder during micturition. The generalization of this idea in the case of endoradiosondes that are swallowed would indicate the study of peristaltic activities including pathological conditions, the testing of spasmolytics, the monitoring of freezing anæsthesia, the possible indication of emotional states as in a 'lie detector', and the observation of metabolic activity.

This work was performed while one of us (R. S. M.) was on leave from the University of California Medical Center as a Guggenheim Fellow.

Note added in proof. A *p*H transmitter based on the reversible mechanical expansion of certain co-

polymers with acidity has been submitted for publication to the *Lancet* since the above was written. Chemical analysis based on mechanical expansion might be extended to oxygen tension with a chelate encased in polyethylene. Since the battery runs for two weeks, extended *in vivo* animal experiments of these types are possible.

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April 10.

[Attention may be directed to a paragraph in *Nature* of May 4, p. 898, referring to a similar device demonstrated at the Rockefeller Institute and briefly announced on April 9.—*Editors.*]

The Sunward Tail of Comet Arend-Roland

Comet Arend-Roland (1956*h*) displayed in late April a remarkable spike-like tail directed roughly towards the Sun. This tail developed from a diffuse fan-shape on April 22 to a long and narrow spike attaining its maximum reported length of 15° on April 25.9 U.T., according to the observation of Fogelquist[1]. By April 29 the sunward tail had essentially disappeared. Van Biesbroeck[2] reported it as being a "slender jet 4° long" on April 24.1 and estimated a length of some 13° on April 25. No observations of length on April 26 are yet available to me, so it appears that the maximum extension of the sunward tail took place some time during April 25–26.

The direction of the spike has been measured on six photographs of the comet, and the deviations of the Sun from the great circle projections are plotted in Fig. 1. The photographs, which were transmitted to *Sky and Telescope Magazine*, were made by R. Fogelquist (Upsala, Sweden); C. F. Capen, jun., and B. A. Smith (State College, New Mexico); T. Sjogren (Hovas, Sweden); E. Mendoza and M. Krebs (MacDonald Observatory); and W. S. Butts (Pullman, Washington), and have been used with their permission.

From Fig. 1 it is apparent that the sunward tail swung round in position angle fairly uniformly with time and that its extension passed through the Sun within an hour or two of April 25, 17h., 1957. The Earth crossed the plane of the comet's orbit on April 25, 18h., 1957, according to the orbit calculated by Candy[3]. This time of crossing appears to be established to within an hour, in complete agreement with the time that the spike pointed towards the Sun.

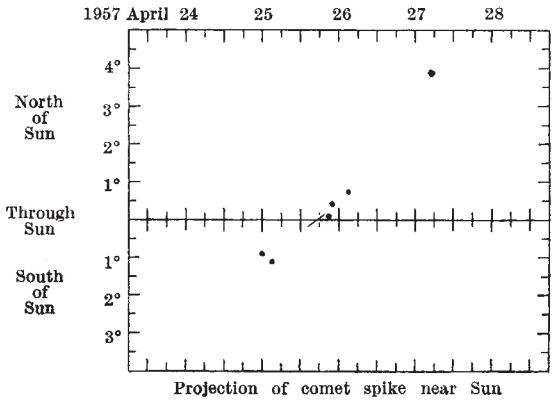

Fig. 1

No extraordinary physical theory appears necessary to account for the growth of the sunward tail by more than 10,000,000 miles in a few days and its similarly rapid decline. The sunward tail must almost certainly have resulted from the concentration of cometary debris over an area in the orbital plane. Seen at moderate angles to the plane, the material possessed too low a surface brightness to be easily observed, but seen edge-on it presented a concentrated line of considerable intensity.

The icy model[4] for the cometary nucleus provides a ready explanation for the sunward tail. The ices and free radicals sublimating from the surface of the nucleus carry with them a certain amount of fragile low-density meteoritic debris at ejection velocities somewhat smaller than the gaseous kinetic velocities. Sizeable pieces of icy material should be included in this ejection process, but at very low velocities. Once in space, under the action of sunlight, the individual icy fragments suffer sublimation on the sunward side. A jet action effectively reduces the solar attraction of an icy fragment for a short time and may move the remaining meteoritic debris away from the Sun with respect to the nucleus at velocities up to 1 km./sec. or even more. Such material will be confined largely to the plane because small velocities of ejection normal to the plane can change the inclination of the individual orbit by only a small amount. The effects of light pressure and corpuscular radiation on small low-density particles will again tend to spread them in the orbital plane.

Occluded ices and gases, escaping slowly from the meteoritic particles, can provide a small source for molecular radiations, so that the sunward tail need not give an entirely continuous spectrum. Arend-Roland is very likely a 'new comet' in the sense used by Oort[5]; Candy finds a slightly hyperbolic orbit. Even so, the comet may well have ejected the orbital debris during this first close perihelion passage.

The above deduced geometrical aspects of the sunward tail are essentially those described clearly by Bredichin[6] as early as 1877.

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May 15.

[1] Fogelquist, F., U.A.I. Circ. No. 1598 (May 10, 1957).
[2] Biesbroeck, G. Van, Harv. Ann. Card, No. 1358 (April 26, 1957).
[3] Candy, M. P., U.A.I. Circ. No. 1585 (Feb. 20, 1957).
[4] Whipple, F. L., *Astrophys. J.*, **111**, 375 (1950); **113**, 464 (1951).
[5] Oort, J., *Bull. Astro. Neth.*, **11**, 91 (1950).
[6] Bredichin, T., *Ann. l'Obs. Moscow*, **3**, 1 (1877).

Absorption Spectra arising from the Photolysis of Lead Tetramethyl

In a recent communication[1], details were given of some unknown absorption features occurring during the flash photolysis of lead tetramethyl. While continuing this work, exposures have been obtained in which the most intense band at 3196 A. is apparently resolved into a series of *Q*-like heads. The satellite band at 3096 A. is also characterized by a central strong line-like feature and this also could be attributed to a *Q* head. There is no doubt that the bands 3196 A. and 3096 A. are related, since they