by normal aragonite needles, and have a very low and consistent (Fig. 2) magnesium/calcium ratio. In addition, other massive *Porites* specimens from the same area have been found to be pure aragonite. We believe these data are inconsistent with a detrital origin for the calcite.

The possibility of a diagenetic origin is not eliminated a priori but would require that extensive recrystallization occur on a time scale of months in the interior of an intact aragonitic structure in a normal marine environment. If true, this would necessitate a reevaluation of rates and mechanisms of carbonate diagenesis. Wise (*9*) has discussed the possibility of early diagenesis triggered by boring algae. Although algal bores, both with and without recrystallization, can be identified in some of our specimens, most of the atypical crystal formations (Fig. 1) are not associated with any evidence of boring. As noted above, the low-magnesium content argues against direct algal deposition.

It is our opinion that this skeletal calcite is of biogenic origin, deposited by the coral as an alternate form of calcification. The production of calcite in larval skeletons of normally aragonitic corals has already been reported (*10*). The data presently on hand do not suggest any clear-cut species or environmental control over the occurrence of the calcite in mature, living coral colonies. However, this discovery opens up a number of exciting avenues for research in the areas of coral genetics, calcification mechanisms, and the use of coral growth and skeletal chemistry as environmental indicators.

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21 April 1975

New Flow-Through Centrifuge Without Rotating Seals Applied to Plasmapheresis

Abstract. *The flow-through centrifuge eliminates complications arising from rotating seals. Preliminary studies on plasmapheresis demonstrated negligible platelet injury and no evidence of hemolysis during 12 hours of operation. Thus the system may provide a broad application to cell washing and elutriation, zonal centrifugation, and countercurrent chromatography.*

The conventional flow-through centrifuge utilizes rotating seals which can become a source of leaks between the inflow and outflow lines; these rotating seals represent a weak point in the machinery in terms of the performance life, complexity, and fragility of the pieces and the necessity for a continuous and comparable degree of lubrication. When these continuous-flow centrifuges are adapted for an on-line blood separation—as applied to the collection of blood cells—rotating seals become critical in terms of platelet injury, red cell hemolysis, and obstruction of the channels by aggregates and impaired lubrication of the rotating seals. To overcome these problems we have developed a flow-through centrifuge which functions efficiently without rotating seals.

The principle of the system has been introduced by Adams (*1*) and is illustrated in Fig. 1. A bundle of flexible tubes is connected to a bowl at one end while remaining stationary at the other end, forming a loop as shown. When the bowl rotates at an angular velocity of 2ω around the vertical axis and the loop simultaneously revolves around the same axis at ω, the tube bundle remains free from twisting. In so doing, the tube bundle counterrotates around its own axis at $-\omega$.

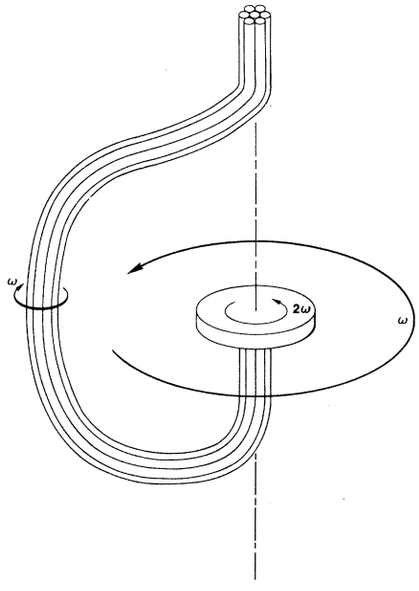

Fig. 1. Principle of the centrifuge: a bundle of tubes is connected to a bowl at one end and tightly supported at the other end, forming a loop. The bowl rotates around the central axis at an angular velocity of 2ω while the loop simultaneously revolves around the same axis at ω. This operation can be performed without twisting the bundle.

The design of the flow-through centrifuge based on this principle is shown in Fig. 2. The frame of the centrifuge head consists of three parallel horizontal plates rigidly linked and driven by the motor shaft as a unit. The frame holds a centrifuge bowl (center), a countershaft (right), and a tube-supporting hollow shaft (left), all mounted in ball bearings. A stationary pulley mounted on the motor housing is coupled through a toothed belt to an identical pulley mounted at the bottom of the countershaft to counterrotate this shaft with respect to the rotating frame. This motion is further conveyed to the centrifuge bowl by 1 : 1 gearing between the countershaft and the centrifuge bowl. This arrangement doubles the angular velocity of the centrifuge bowl. To support the heavy counterrotating flow tubes, the hollow shaft is actively counterrotated at $-\omega$ by means of a pair of toothed pulleys (1 : 1 ratio) coupled to the hollow shaft and the countershaft.

A doughnut-shaped silicone rubber bag (800-ml capacity) equipped with three flow lines is fitted inside the centrifuge bowl. A transparent Lucite cover makes it possible for one to observe the contents under stro-

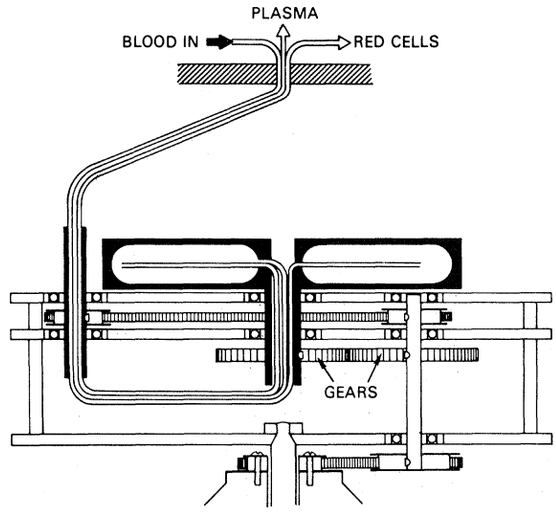

Fig. 2. Design of the centrifuge: the frame of the centrifuge body consisting of three horizontal plates carries three rotary structures—central bowl, countershaft (right), and tube-supporting hollow shaft (left). The coupling of the lower pulley of the countershaft to the stationary pulley on the motor housing causes counterrotation of the countershaft with respect to the rotating frame. This motion is then conveyed to the central bowl by 1 : 1 gearing to double the angular velocity of the bowl. The motion of the countershaft is also transferred to the tube-supporting hollow shaft by means of the pulley coupling (1 : 1 ratio). Thus the system satisfies all requirements indicated in Fig. 1.

boscopic illumination. Three silicone rubber tubes from the rubber bag are led down through the center of the centrifuge bowl, then upward through the hollow shaft, and finally through the center hole of the centrifuge cover where they are tightly supported. When properly balanced, the centrifuge bowl can be operated at speeds up to 2000 rev/min.

In order to demonstrate the capability of the apparatus, heparinized (1.5 mg/kg) sheep blood was introduced into the centrifuge directly from the animal (weight, 34 kg) while effluents of the plasma and red blood cells were returned (after sampling) to the animal. The flow rates through the individual lines were controlled by two roller pumps, one set on the whole blood line and the other on the plasma return line, the third line having a flow equal to the difference between the two pumps. With a constant feed rate of 60 ml/min, plasma free of red blood cells was harvested at 12 ml/min at 1000 rev/min or 18 ml/min at 1300 rev/min. During 12 hours of continuous flow of plasma at 18 ml/min, blood and plasma samples were collected at intervals so that changes in the platelet counts could be studied. Our results showed a 50 percent reduction in the blood platelet count within the first hour, and a reduction to 30 percent of the base line values by the 12th hour of operation without any evidence of red blood cell hemolysis. These results are similar to those reported from studies in which a membrane lung was used in a similar perfusion system without a centrifuge (*2*).

The scheme presented here provides a broad application to plasmapheresis, cell washing and elutriation, zonal centrifugation, and countercurrent chromatography (*3*).

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16 April 1975

Visual Tracking and the Primate Flocculus

Abstract. *Purkinje cells in the primate flocculus discharge specifically in relation to visual tracking, effectively generating a velocity profile of the target during pursuit. It is suggested that these neurons supply oculomotor centers with the velocity command signals needed to support pursuit eye movements.*

Primates have the remarkable ability to fixate and track small moving targets; selected images are thereby brought onto the fovea and stabilized for detailed visual processing. The tracking function is undertaken by the smooth pursuit system, which is believed to operate, at least in part, like a velocity servo (*1*). Responding to the slip of the target's retinal image, this system furnishes the velocity command signals needed by oculomotor centers to move the eyes at a rate which will nearly match that of the target. Although head movements occur frequently during tracking, they have remarkably little net influence on the pursuit system's task due to the action of the vestibulo-ocular reflex (*2*); this system senses head rotations and signals to the oculomotor centers to forge compensatory eye movements which offset the head motion and thereby stabilize the eyes in space. The ocular pursuit system thus deals with the actual motion of the target in space independently of any accompanying motion of the head. We now show that Purkinje cells in the primate flocculus fire specifically in relation to visual tracking; by introducing controlled head rotation into the tracking situation, we have demonstrated that Purkinje cell discharges can describe the track target's actual velocity. We propose that these cells constitute part of the smooth pursuit system and provide oculomotor centers with the target velocity information required for pursuit eye movements; we also cite data from clinical and lesion studies to support this thesis. We further suggest that the flocculus constructs this velocity profile of the track target from visual, vestibular, and oculomotor inputs, which we have demonstrated in the flocculus.

Single unit recordings were made in both flocculi of the awake rhesus monkey trained on a visual fixation task according to the paradigm devised by Wurtz (*3*). Microelectrodes were positioned with an implanted cylinder and attached microdrive (*4*). The monkey was seated in a special primate chair that could be oscillated about a vertical axis by a torque motor servo system, providing adequate vestibular stimulation. The animal's head was secured to the chair by implanted bolts, and its eye movements were recorded by d-c electro-oculography. A variety of small fixation targets were projected on a translucent screen; the monkey viewed the screen through a double-mirror optical system arranged like a horizontal periscope and mounted on the chair. The first mirror in this system was connected to a modified pen galvanometer immediately in front of the monkey's right eye (the left eye was masked), and could be used to oscillate the visual field back and forth in the horizontal plane. The smooth target movements needed to elicit tracking were obtained by driving the galvanometer power amplifier with a voltage waveform generator. Electrolytic marking lesions were made by passing current through the microelectrode; these served to locate specific recording sites and facilitate reconstruction of the electrode tracks.

Most of the unit activity in the flocculus attributable to Purkinje cells because of associated complex spikes (CS's) showed modulation of the so-called simple spike (SS) firing during visual tracking (32 of 43