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QUARTERLY REPORT
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by

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Active Integrated Circuits

B. L. Cochrun

A gyrator based on feedback about a unilateral amplifier has been under study in this report period. The concept is as follows: Suppose a conductance g_{fb} is connected between the input and output terminals of a 3-terminal amplifier having

$$\begin{bmatrix} g_{11} & 0 \\ g_m & g_{22} \end{bmatrix}$$

as an admittance matrix. The admittance matrix for the amplifier with the feedback connection is

$$\begin{bmatrix} g_{11} + g_{fb} & -g_{fb} \\ g_m - g_{fb} & g_{22} + g_{fb} \end{bmatrix}$$

It is seen that the y_{12} and y_{21} terms have opposite signs if g_m is greater than g_{fb}, in which case the matrix is that of a lossy, possibly active, gyrator. The y_{11} and y_{22} terms may be removed or diminished by placing negative conductances at the two ports by further modification of the circuit.

Figure 1 shows how the idea can be worked with transistors. Transistor Q_1 and G_1 make up the amplifier having y_{21} equal to G_1 (assuming ideal transistors) and conductance G_2 is the feedback conductance. Transistor Q_2 together with Q_1 and G_2 forms a negative immitance converter to introduce the $-G_3$ term in the y_{11} element of the gyrator's admittance matrix; similarly Q_3 and G_4 work with Q_1 to put $-G_4$ into the y_{22} element. The matrix in Figure 1 assumes ideal transistors for the purpose of making the operation of the circuit clear. It is seen that the y_{11} and y_{22} elements of the gyrator matrix are made zero when both G_3 and G_4 are equal to G_2. The gyrator is passive when G_1 is made zero and G_3 and G_4 are equal to G_2 which makes the y_{12} and y_{21} elements equal in magnitude but of opposite sign.

The collector-base capacitance of Q_1 appears in shunt with G_2 and can introduce losses at high frequencies. This capacitance can be reduced by adding another transistor Q_4 as shown in Figure 2 which combines with Q_1 in a cascode circuit. The admittance matrix for Figure 2 is the same as for the circuit of Figure 1, assuming ideal transistors.

Another variation of the cascode circuit is shown in Figure 3 where G_4 has been relocated to form a gyrator which may be considered to be a curious interconnection of two negative immittance converters. The admittance matrix is altered by removing G_4 from the y_{21} element in the matrix of Figure 1. Gyrators of the type shown in Figure 1-3 are being studied to see if they hold advantages over kinds studied earlier.

Work on construction of a two stage 455 khz i.f. amplifier using gyrators as tuned amplifiers is under way and is expected to be completed in the next quarter.

Metallurgical Studies of Microcircuit Interconnections

W. B. Nowak

During this quarter, effort was directed along three general lines: (1) reflectivity measurements, (2) sample preparation, (3) analytical macroscopic solution of the diffusion problem.

(1) A reflectance standard is needed to calibrate the entire optical system including: light source (tungsten-iodide lamp), infrared absorption cell, filters, metallurgical microscope, and detector (solar cell). MgO, suitably prepared, is an accepted standard because of its uniform reflectance over the visible spectrum. Such a standard has been fabricated by burning Mg ribbon on a bed of freshly prepared MgO (itself prepared by burning Mg ribbon) and permitting the MgO vapors to condense on a glass microscope slide. This standard will be used for all subsequent relative spectral reflectance.

An evaporated, bimetal film (Au on Pd on a glass microscope slide) was examined for the uniformity of its spectral reflectance over a large portion of its surface. Good uniformity (± 5%) was found at wavelengths of 4900, 5380 and 5760 Å. However, larger variations of ± 15% were found at 6060, 6330 and 6780 Å. Visual inspection in a metallograph at the latter wavelengths did not reveal any obvious variations in reflectance (i.e. a mottled appearance); thus, the cause for the variations is not known. There may well be subtle changes not visually detected.

To avoid the problem of local variations in reflectance due to possible diffusion near pin holes and other gross defects in the films, the magnification of the microscope used for the reflectance measurements was reduced by lowering the magnification of the objective lens. The result is that reflectance is averaged over a spot approximately 2 mm in diameter.

(2) Evaporation masks for fabricating the diffusion couples have been designed and are being built. These masks will place 3 samples on each microscope slide: one each of the two metals and one of the bimetal couple.

Numerous discussions were held with NASA/ERC personnel and industrial representatives concerning a choice of metal system that would be both of practical interest and amenable to our laboratory techniques. Such a system seems to be Au-Pt-Ti. It is used commercially for beam-lead construction. The individual couples Au-Pt and Pt-Ti (especially the former) have, potentially, large changes in reflectance with alloy composition. Furthermore, films of these metals may be deposited by thermal evaporation from tungsten wire heaters. A brief look will also be given at the diffusion couple Al-Si, especially Al films on Si single crystal (111) substrates and Al films deposited on oxidized Si substrates but with a portion of the film touching unoxidized substrate.

(3) A start has been made in examination of solutions of the diffusion equations for our boundary conditions. Solutions of the analogous heat transfer problem will probably provide the necessary equations.

Work for the next quarter will involve calibration with the MgO standard, determination of the precision (repeatability) of our reflectance measurements, fabrication and reflectance measurements on Au/Pt bimetal films, and further literature search on the reflectivity of alloys.

Biophysical Studies

S. Fine

The following is a summary of progress during the past three months relating to the grant.

1. Publications

   Feigen, L., Mackeen, D. and Fine, S.
   "A Method for Detecting and Measuring Frequency of Surface Vibrations Using a Helium - Neon Laser" Review of Scientific Instruments, Vol. 40, No. 2, pp. 381-382, February 1969.

2. Presentations

   S. Fine - "Biological Studies on Laser Radiation, Particularly with Regard to the Eye."
   Howe Laboratories, Massachusetts Eye and Ear Infirmary, Harvard Medical School, Boston, Massachusetts, December 1968.

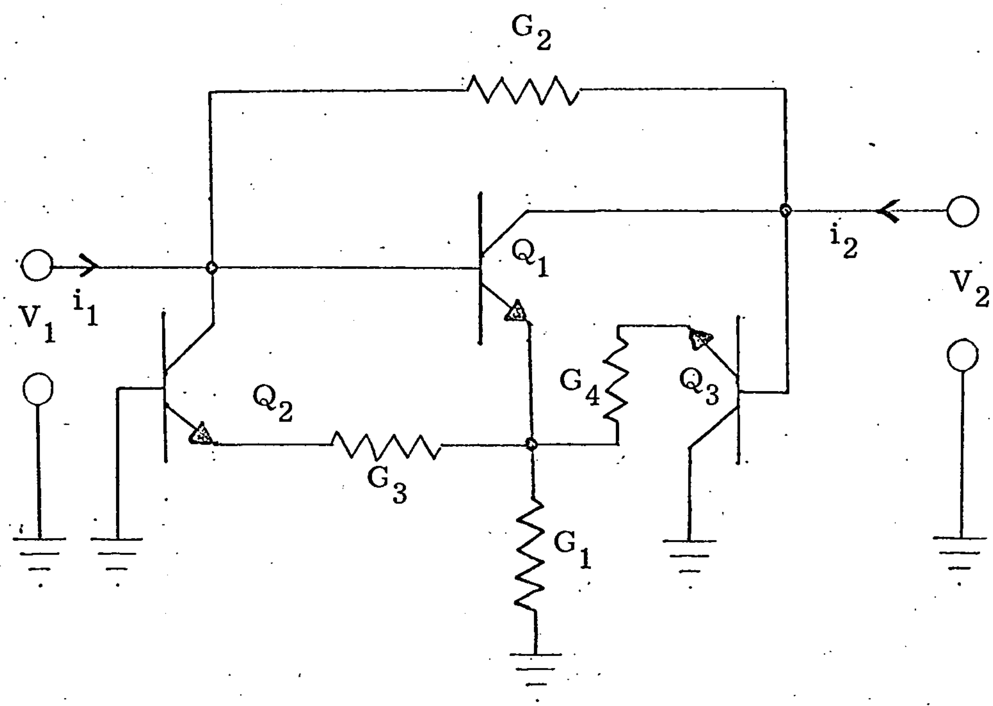
   S. Fine - "Control of Laser Hazards and Management of Accidents"- National Center for Radiological Health, Rockville, Maryland, February 28, 1969.

3. Laser and Related Studies

   Temperature and pressure studies on CO_2 corneal irradiation are continuing in order to determine the site of initial injury. A manuscript on pressure and temperature changes in the anterior aqueous chamber on CO_2 irradiation is in preparation. Attention is also being directed towards hazards associated with incoherent, narrow beam divergence radiation.

4. Rupture and Tensile Strength Measurements of Fresh and Treated Canine Aortic Tissue

   Rupture and tensile strength determinations on various methods of treatment in transverse sections of the canine aorta are continuing. Attention is also being directed to rupture and tensile strength measurements in longitudinal sections. Preliminary measurements appear to indicate that rupture and tensile strength is higher in the longitudinal direction.



$$Y = \begin{bmatrix} G_2 - G_3 & -G_2 \\ G_1 + G_3 + G_4 - G_2 & G_2 - G_4 \end{bmatrix}$$

Figure 1. A Gyrator Circuit

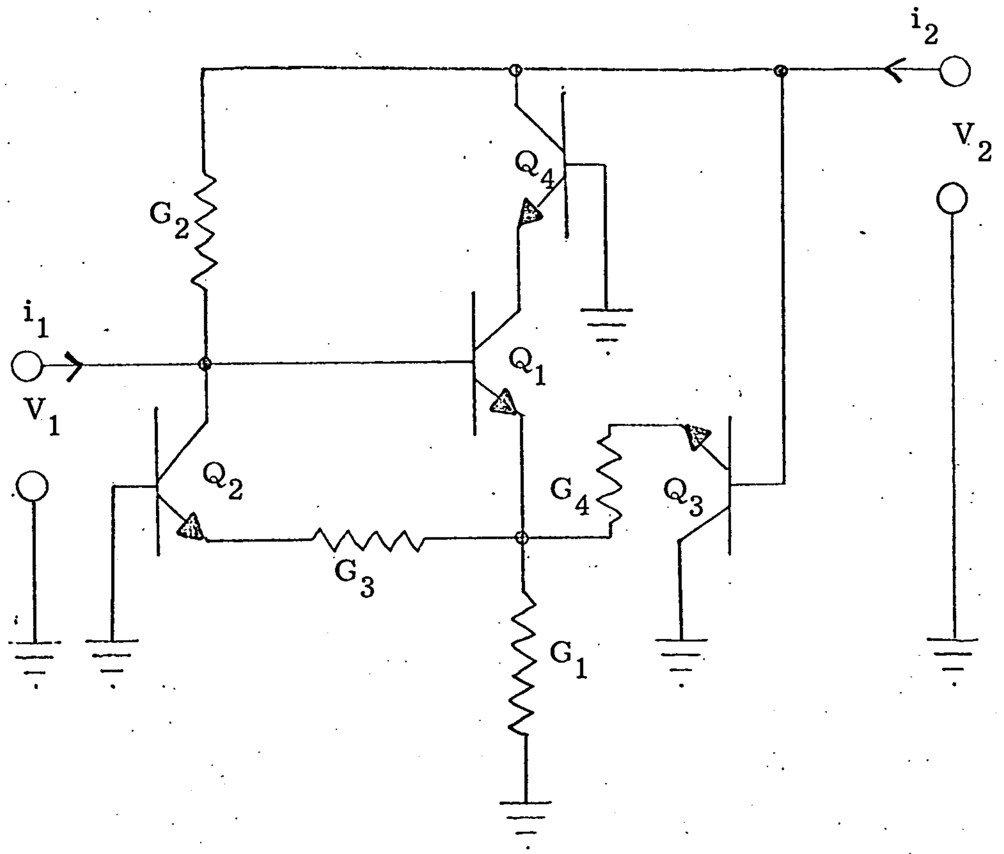
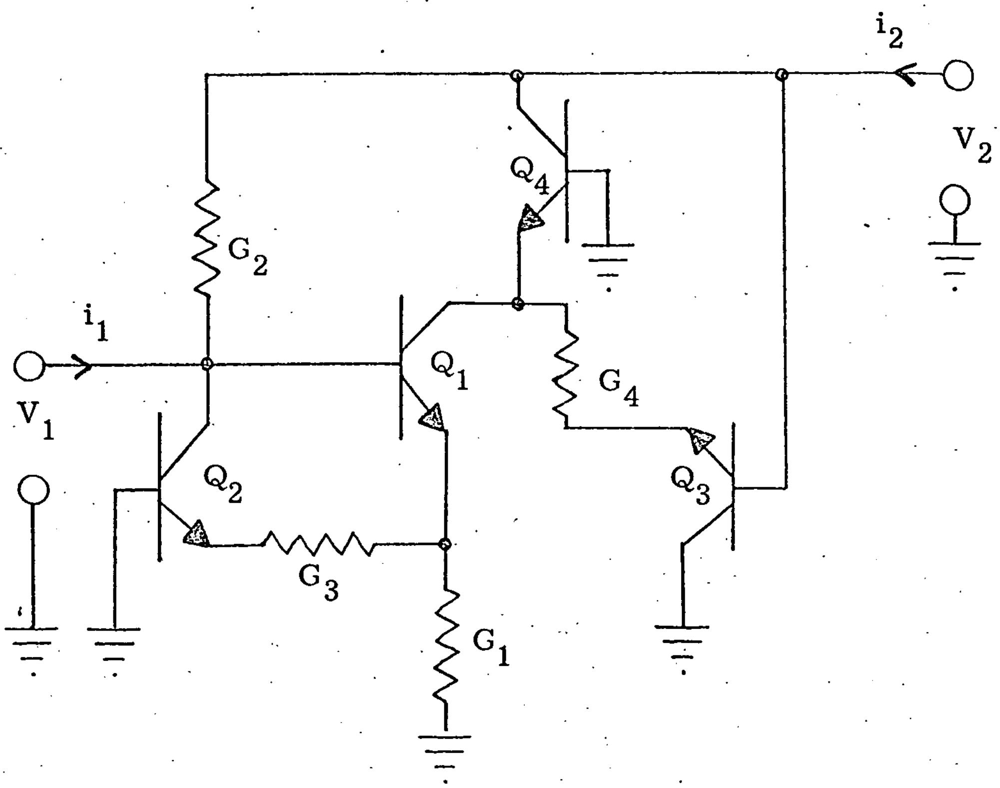


Figure 2. A Modification of Figure 1



$$y = \begin{matrix} G_2 - G_3 & -G_2 \\ G_1 + G_3 - G_2 & G_2 - G_4 \end{matrix}$$

Figure 3. Another Modification of Figure 1