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used for observing the stomach. Probably the best example of this type of instrument is the submarine periscope. All of these instruments are called image relay systems because they consist of lenses which reimage the scene several times in the course of the length of the tube.

Many of the present day optical problems are special tasks, and only one instrument of its kind is needed. For this reason, need for such an instrument is often met by attempts to make up a system with readily available lenses. Satisfactory systems can usually be put together in this way if the relaying is done properly.

We have described a few of the standard ways of relaying images optically and have shown that the main problem is to reduce the secondary color and field curvature. Secondary color, sometimes called residual color, refers to the color which cannot be completely eliminated in the usual achromatic lens. Since an optical relay consists of several such lenses, the residual color tends to accumulate rapidly.

The rules to remember when laying out a relay system can be briefly stated as follows: The relaying should be done in as large a tube as practical; all the intermediate images should be made as large as the tube will permit; the scene should be reimaged as few times as possible; and the working distance of the lens nearest to the object should be kept short.

R.E.H.

Secondary Color in Optical Relay Systems. By Robert E. Hopkins. *J. Opt. Soc. Am.* 39: 919, November, 1949.

Humidity and Piano Tuning

It is common practice to tune a piano just before an artist performs on it. One reason is that humidity in the air causes the wood structure to swell, thus altering the tension on the strings with changes in humidity. This is true even though most of the string tension is sustained by the metal plate. The rise and fall in the tuning of a six-foot grand piano has been observed over a period of nearly two years, and quantitative observations indicate that, within the three central octaves, the tuning rose 0.3% in frequency (0.05 semitone) on the average when the relative humidity increased 10%. The tuning was accordingly higher in the summer than in winter, and while the total change is not great in a climate as equable as that of San Diego where the experiment was performed, a tuning at each change of season is likely to be desirable in regions where (indoors) there are marked changes in humidity.

The equilibrium moisture content of wood is known to be a function of the relative humidity. A working hypothesis has been developed to relate this fact to the physics of the string supports. Two parameters thus appear by which may be described the piano's response to changes of humidity: the tuning-humidity coefficient and the time constant. The latter is the time required for the change of tuning to follow a steadily changing humidity. For this particular piano the time constant was of the order of fifteen days.

Information of the kind obtained in this experiment can be helpful in keeping the instruments of an orchestra in

tune with each other. Related research, however, is still required in studying annual cycles of humidity and in finding what departures of average piano tuning from standard are tolerable to listeners.

R.W.Y.

Influence of Humidity on the Tuning of a Piano. By Robert W. Young. *J. Acous. Soc. Am.* 21: 580, November, 1949.

Mathematical Biophysics

Beginning with the work of Mendel or, more accurately, with its rediscovery at the turn of the century, there has been a steady increase in the application of probability theory to genetics, carried out in recent years by Haldane, DeWinton, Sansone, Mather, Geiringer, and others. Hilda Geiringer, in an article appearing in the June issue of the *Bulletin of Mathematical Biophysics*, treats the linkage theory for the case of tetraploids (four analogous chromosomes) and establishes the corresponding genotype distribution for succeeding generations, assuming certain probability distributions for various genetic events, and an initial distribution of genotypes.

The *Bulletin's* other June features include a paper by John Z. Hearon on the kinetics of biological systems. It deals with equilibrium states within a cell which result from a system of consecutive chemical reactions where the products of one reaction are involved in the next. Cellular structure imposes geometric restrictions on the system, in which diffusion forces are operating. A previous paper considered a closed system in which no substance entered or left the cell; the present paper extends the results to open systems involving sources and sinks from and to the outside.

N. Rashevsky has contributed two articles, the first being a diffusion problem which treats quantitatively the phenomenon of the noncorroded area shown by two spheres in contact with each other while immersed in a corrosive solution. The second relates the mathematical theories of the central nervous system and of social behavior. A neural mechanism previously postulated by H. Landahl in the theory of learning is taken as the framework within which "choices" of actions are made.

Russell H. Kesselman's contribution deals with tissue growth and cancer incidence. Assuming certain relations between the birth and death rates of cells, the presence of growth-promoting factors, the availability of food in the surrounding medium, and the presence of the toxic products of metabolism, formulas are derived for the rates of growth and decay of a tissue.

The paper of Joseph G. Hoffman on the mitotic index is primarily a critique and generalization of the older view that the mitotic index is proportional to the duration of mitosis. A more general expression for the relation is derived for the case of exponential growth of the population which is shown to reduce to simple proportionality if the product of the growth constant and the duration of mitosis is small.

The Bulletin of Mathematical Biophysics. Vol. 11, No. 2, June, 1949, the University of Chicago Press. Taken from a review by A. Rapoport.

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