SCIENCE

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AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

COVER

Aragonite crystals in carbonate-cemented sandstone of Pleistocene age from the Atlantic Continental Slope. This aragonite is unusually depleted in carbon-13 and is probably derived from the oxidation of Quaternary methane (about × 45,500). See page 690. [John C. Hathaway, U.S. Geological Survey, Woods Hole, Massachusetts]

Pollution that assaults the lungs, the digestive tract, the ear ...and how effective instruments can lead to abatement

The Lungs

Until very recently, Molecular Rotational Resonance (MRR) Spectroscopy often seemed like a brilliant scientific breakthrough destined to remain an ivory tower curiosity for lack of a practical application in the real world of quantitative analysis.

In its pristine form, MRR allowed the scientist to look into molecular structure by measuring changes in the absorption of microwave energy which result from transitions between rotational energy levels in a polar molecule. Because differences exist in the composition or geometry of individual molecular species, there is a characteristic MRR spectrum for each molecule. Absorption peaks are unique for each molecule and MRR readily differentiates between them, even in a complex mixture, because of its inherent specificity. In the usual case, measuring the frequency of a single absorption line completely identifies the molecule.

MRR has recently been shown to be a practical quantitative tool too. In a paper published in the *Journal of Chemical Physics* (46, 3698, 1967) the response of the HP 8400B MRR Spectrometer was shown to be linear with concentration from the lowest detectable limit to 100%. More recent work with common air pollutants (SO_2, NO_2, hydrocarbons) has demonstrated that MRR gives a quantitative response for each gas, even in the complex mixtures that are commonly associated with air pollution samples. The actual sensitivity limit for SO_2 has been determined at 3.5 nanograms without using concentration techniques (... this corresponds to a concentration of 11.6 ppb in a one liter sample). To further enhance its usefulness in the quantitative analysis of air pollutants, most MRR experiments are carried out at low pressures—typically 10-15 μ Hg—a condition that greatly reduces the rate at which the pollutants react with each other.

Precisely where the MRR Spectrometer fits into the pattern of analytical chemistry is still being studied. Based on the work reported above, it certainly should be considered for air pollution analysis, especially for calibrating on-site air pollution monitors. Results of experimental work in air pollution and other significant analyses with the MRR Spectrometer are published regularly in *Molecules and Microwaves*, a copy of which awaits your request.

The Digestive Tract

In the days before Rachel Carson's *Silent Spring*, the only popular connection between pesticides and the human digestive tract was benign: one was reassured that large parts of the world would be hungry, even suffer famine, except for the beneficial effect of pesticides on agricultural production. Nowadays, it's more common to hear warnings from respected scientific sources that pesticides constitute a real and present danger to life on this planet because they are ingested as residues in the food we eat and the liquids we drink.

These are not mutually contradictory arguments so much as they are accurate descriptions of both sides of the split personality of pesticides. The only conceivable solution to this very human dilemma is better control of the use of pesticides, and more careful analysis of pesticide residues in foodstuffs.

Enter the gas chromatograph (GC). While the men engaged in pesticide detection are many and far-flung, instrumentation for this sensitive work falls almost solely on the GC. On this basis, Hewlett-Packard has directed much research effort towards perfecting both instrumentation and technique. Although pesticide detection is still most often recorded in the nanogram range, an HP GC—more than four years ago—separated a laboratory pesticide sample at the picogram level. Most of this chemical detective work is being performed on the HP Model 402 High-Efficiency GC—an instrument perfected especially for this and other biochemical research. HP's pesticide analysts prefer to use this instrument equipped with an electron capture type of detector. The latter employs a radioactive tritium source to produce electrons whose capture by the pesticide molecules is a direct measure of their presence. Recently, HP chemist-designers have perfected a new electron capture detector that employs a radioactive Ni^{63} source that is more stable at higher temperatures thereby holding out a promise of more searching pesticide detection than the older tritium type can accomplish.

Sometimes the inherent difficulty of pesticide analysis is resolved by improvements in technique rather than hardware. HP chemists have developed special techniques for the analysis of pesticide residues in many foodstuffs, and sample extraction techniques for the analysis of bovine and human milk.

If you'd care to pursue this subject in more depth, write for Applications Lab Report 1003, yours on request.

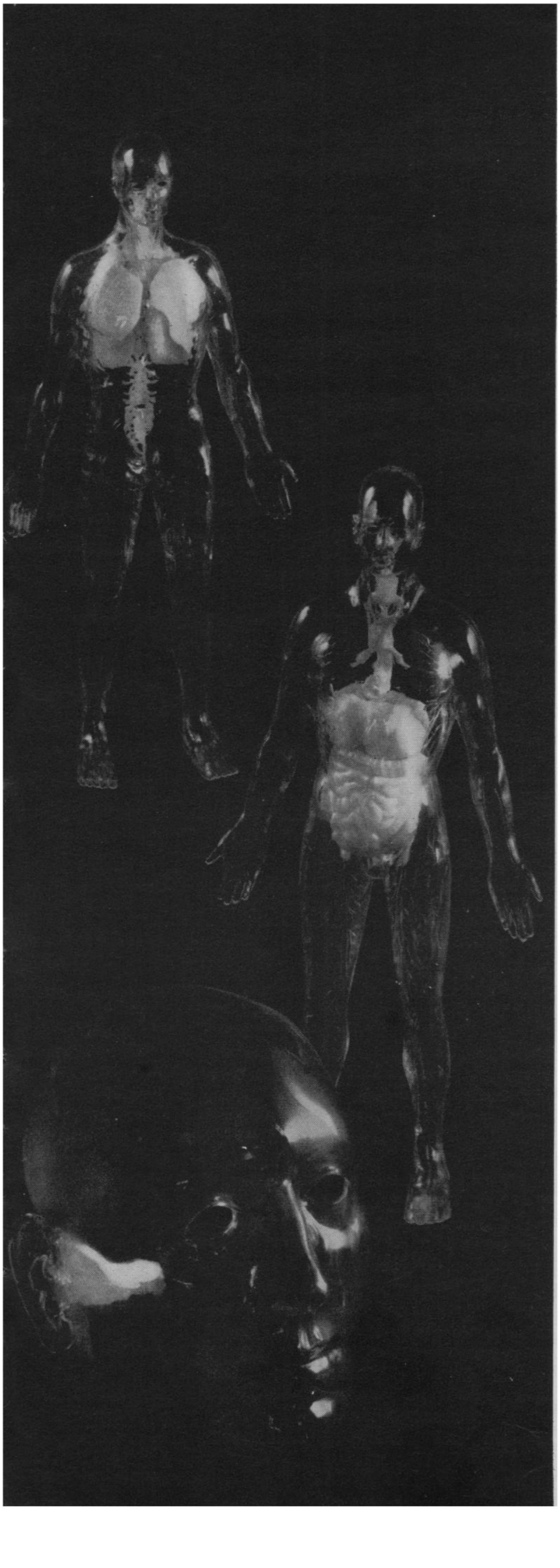
The Ear

Well played by a fine orchestra, Brahms can only be described as beautiful. But reproduced too loud on a cheap phonograph, it's noise. An increasingly widespread and serious form of pollution, noise can make us uncomfortable; prolonged loud noise damages hearing; very loud noises can cause pain, psychosis and even death.

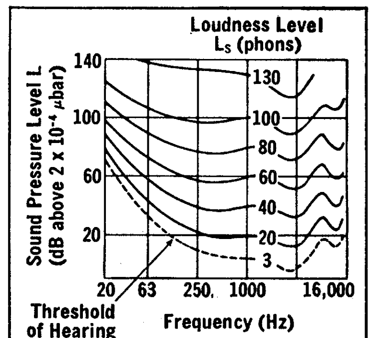
Obviously the time has come to control this form of 20th century environmental pollution. When HP scientists turned their talents to noise measurement, they ran into a very unusual problem. Objectively sound is simply a matter of rapidly changing air pressure, easy to measure with traditional sound level meters. But noise is really not an objective phenomenon: what the ear hears is a subjective sensation of loudness involving complicated physiological and psychological mechanisms.

For an instrument to measure sound as the ear hears it, it must imitate the unique properties of the ear. Take loudness level which is traditionally measured in *phons*. Although the logarithmic phon scale covers the large dynamic range of the ear—120 dB—it does not fit a subjective loudness scale. The trouble is that a noise that sounds twice as loud as another does not measure double the number of phons. So a subjective measure of loudness was developed by international agreement in which the unit is a *sone* and whose scale corresponds closely to the subjective sensation of loudness. For example, the comparison between a jet takeoff and a quiet conversation is 3:1 in phons (120 vs. 40) . . . and a much more realistic 60:1 in sones (256 vs. 4).

Neither is the frequency response of the human ear a straightforward thing: the ear responds differently to sounds of different



frequencies and loudness levels. Although there is a small variation from person to person, normal ears agree within a few dB with the plot reproduced here (ISO Recommendation 226).



An even more significant peculiarity of the ear is its response to the pitch and bandwidth of a noise. Broadband sounds, like those of jet aircraft, seem much louder than narrowband noise of the same sound pressure level. Thus accurate loudness measurements can be made only by taking into account the spectral distribution of the sound and relating it to empirically determined critical bandwidths. This phenomenon has given rise to the *Bark* scale: the audio range comprises 24 Bark, each of which equals the ear's critical bandwidth at a given center frequency.

Probably the most significant difference between objective and subjective measure of loudness occurs when two sounds are presented to the ear simultaneously. If the two sounds are widely separated in frequency, their partial loudnesses simply add to form the total loudness. But if they are not separated by a critical bandwidth, one sound masks the other: the closer together, the greater the influence. The noise analyst expresses this characteristic quantitatively in terms of *loudness density*, in sones/Bark.

The HP 8051A Loudness Analyzer is, in effect, a calibrated electronic ear that takes all of these subjective reactions of the human ear into consideration in measuring loudness based on ISO Recommendation 532 (Zwicker's Method). It listens to sound through a calibrated microphone or tape recorder, automatically produces a continuous spectral analysis and displays it as a plot of loudness density vs. subjective pitch. The instrument also computes and displays the total loudness of the sound, that is the integral of the Zwicker diagram.

The instrument is a great help in noise abatement studies because it shows how noise reduction techniques can be applied most effectively. Its spectral analysis points the finger at the most obvious sound-producing component, suggests what kind of sound-absorbing material may be needed, offers quick *before* and *after* comparisons of noise abatement programs.

A much more complex and versatile instrument for audio spectrum analysis, the recently announced HP 80501A Audio Data Processor combines the equivalent of a Loudness Analyzer with a powerful HP 2115A Digital Computer. The 80501A measures loudness with Kryter, Stevens, TALARM, SAE or dB weightings depending on the choice of standard computer programs. Results are available immediately: for example, the 80501A yields a complete analysis of aircraft noise while the plane is still overhead.

Our new 116-page Acoustics Handbook does justice to this rather complex subject. For your copy, write to Hewlett-Packard, 1507 Page Mill Road, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

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ANALYTICAL INSTRUMENTS

00970

there must be some awareness of the transition periods of science in order to develop perspective on the progress of man's society. For example, our chapter 13, "Transition from determinacy to indeterminacy," sets the stage nicely for the transition from the firm cause-and-effect attitudes of the Newtonian period to more recent developments in thermodynamics and atomic science.

We also use large lecture groups and small recitation groups, and believe that the laboratory work should be informal but involve individual effort as much as possible.

The most difficult aspect of any course has to do with clarifying concepts for the student. For this purpose, integration of concepts and topics to reveal common underlying features of disciplines is very important. We utilize several major themes, such as the probability concepts, the laws of thermodynamics, and energy conversions. By far the most effective theme for unifying and for relating natural phenomena with the personal world of the student evolves from the concepts and techniques associated with control systems. These involve feedback interrelationships and information and are more generally referred to as cybernetics. With this approach it becomes possible to *relate* situations to each other. The relationships may involve events that are in close proximity, or they may relate the past to the present and to the future. The *relevance* of things, which students complain is missing in college instruction, is brought home by this approach, for the elements and the functions that enter a situation or system may intermix mechanical gadgets and human activities. Feedback may be in the form of a mechanical thrust or an idea. When once the student learns to analyze mechanical or social situations in these terms he is not likely to regard science as outside his personal interests or capabilities.

We avoid frontal attacks on the "scientific" method, explanations, logic, or symbolism. The halo that is usually accorded the physical or "exact" sciences falls away when we discuss how poorly understood are their basic concepts. The halo is restored when we show how much has been accomplished despite this lack of basic understanding, but in the process the behavioral disciplines and the humanities also gain stature. In fact, science and the scientific effort emerge as very human activities.

We completely share the Berkeley conviction that "it is indeed possible to teach significant aspects of modern science to nonscience students and to do so in a manner that is intellectually stimulating, thought-provoking, and interesting to the students." We would add that this can be done on very many other campuses where the Berkeley-RPI campus "advantages" may not exist.

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. . . A growing number of secondary schools have been experimenting with unified science classes for the past 15 years, and there is even a group of college and high school teachers organized in a group called the "Federation of Unified Science Educators."

One of the greatest of all problems in presenting unified science courses at the secondary level is that parents do not want their youngsters to take the courses because they are worried about College Board scores. If the colleges and universities introduce courses of this nature into their own programs, perhaps this will help solve part of the secondary schools' problem.

LEONARD C. BLESSING
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University Self-Government: Who Calls the Tune?

In response to Herbert J. Spiro's request for establishing self-government in the university communities (Letters, 23 May), I am reasonably sure that within the college communities the talent is available for self-government. However, his plea is rather (deliberately?) naive and Utopian: Give me what I want and leave me alone to do my own thing with no strings attached.

University self-government is certainly feasible in a small, privately funded university which may operate as a separate, independent, closed system. The problem comes about when state or federal tax money is used for operation. John Q. Public-Taxpayer is not likely to consent to a scheme of taxation without representation, and would not willingly hand over a bag of money and grant blanket authority to operate a university without also stipulating the range of responsibility and demanding that the administrators be held accountable. Whoever pays the piper calls the tune!

Within a democracy power is vested in the majority. In extreme situations of difference of opinion, 49.9 percent of the people may be dominated by 50.1 percent with the majority will expressed through the established channels of political action. Spiro recommends that various officers be elected by and held accountable to their constituents—a sound principle of political democracy, but who are these consenting constituents in his plans, where do the represented taxpayers fit in, and who are in fact being governed?

FINN LUNDE
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Humanitarian Research

In Langer's report of the West Coast version of the 4 March protest (14 Mar., p. 1176), I was puzzled by various criticisms of scientific government-sponsored research at Stanford and M.I.T. One student claimed, "The purpose of the people-sniffer and the bomb is to kill people. That's what it's all about." If those critics will take a good look at the agricultural research programs, they will find few, if any, students or professors expressing discontent over the U.S. government research programs, mainly because those who are in agriculture are dedicated to increasing the production of food and fiber for mankind the world over.

I am spending 2 years in Iran helping develop livestock feed so Iran can eventually produce enough meat and milk to feed her own population. Everywhere my colleagues are striving to increase crop and livestock production, and I believe the United States is doing more than any other nation in this humanitarian effort. And incidentally, many results of research in the physical and biological sciences have been applied beneficially toward increasing world food harvests.

If American professors and students think they have grievances, let them come to foreign lands for a visit. The United States will then look like the Garden of Eden.

JOSEPH MUIR
Box 13, Andimeshk, Iran

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The University as a Five-Legged Animal*

I have come to think that the really complete University should be a sort of five-legged animal. The left hind leg is scholarship—the knowledge of everything that a man has done or written or thought. The left front leg is teaching—the transmission of this knowledge to the next generation. The right hind leg is creativity—the generation or discovery of new insights or new knowledge in literature and the arts and the sciences. And the right front leg is public service—the application of all this knowledge in writing and consulting and inventing, for its value to industry and government and the public.

(From this point of view the real gap between "the two cultures" is not between the sciences and the humanities but between the creation-minded sciences and humanities and the storage-oriented sciences and humanities. Creative humanists, from Chaucer to Goethe and Browning, were making fun of storage-minded academics and pedants long before scientists appeared on the scene. The weakness of the humanities departments in not having enough top-rate creators and inspirers of the young continues to be one of the sad facts of university life today. Newton could do his lifework at a university now, but Mozart and Michelangelo and Shakespeare would more likely be working in New York lofts.)

To go on with our analogy, the fifth leg of the complete animal is innovation—the trunk of this wise elephant, let us say, reaching forward to grasp the future. By innovation I mean a different kind of public service—not the kind that simply meets the requests of existing industry or government or the military, but the kind that enlarges the achievements of man and transforms societies. I mean not merely achievements, such as atomic energy and radar, that generals did not even know they wanted, but input-output matrices and Keynesian economics, that show us how to avoid economic dislocations and depressions; or theories of information and feedback and competitive decision-making and operations analysis, that change our whole approach to problems of communication and conflict and organizational structure; or the application of chemistry and biochemistry and the new biology to effect spectacular reductions in disease and mental illness. Thinkers in industry and government, of course, have also been generators of innovation, from television to the Peace Corps, but recent studies have shown that the major innovative ideas are perhaps ten times as likely to be born in the intellectual centers of the great university communities. The universities are coming to be not only repositories of knowledge and trainers for the future but places where the most important contribution may be the search for new understanding and the combining of ideas into new patterns.

In many schools, one or more of these five legs is missing. The undergraduate colleges are weak on research and public service and so have trouble getting faculty and funds, while the great research schools are often weak on teaching and have trouble with their neglected students. But the schools that are weak on systematic innovative thinking are betraying in a deeper sense the society that supports them and that can find in no other place the new solutions and the new trained leaders it needs in facing the complex and terrible new problems of the next 10 years.—JOHN PLATT, *Associate Director, Mental Health Research Institute, University of Michigan, Ann Arbor*

* Adapted from an address presented before the Midwest Conference of College Administrators, Ann Arbor, October 1968.

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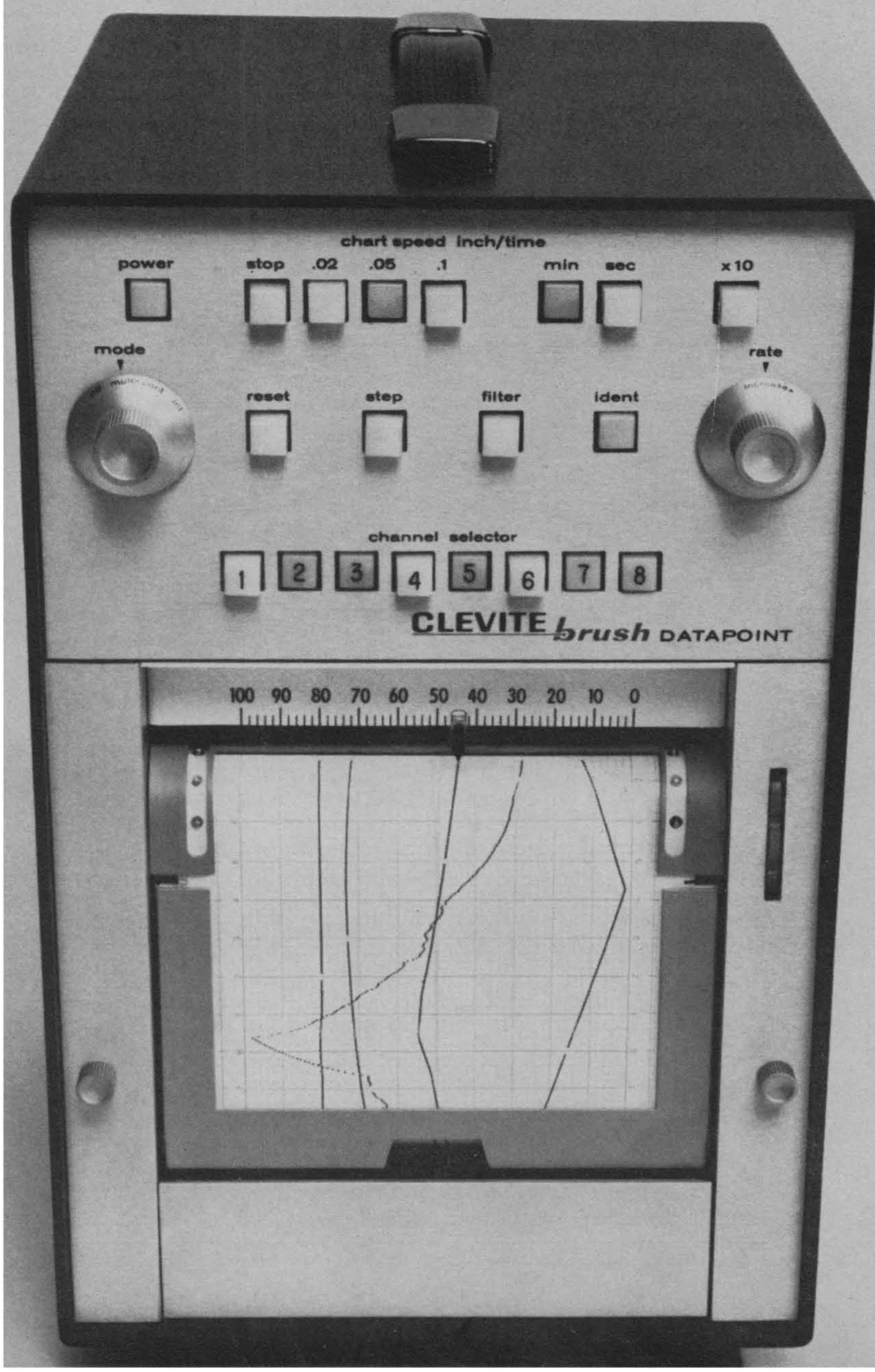

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