ENGINEERING AND SCIENCE

MONTHLY

APRIL 1948

BY-LINES

STANLEY E. SOHLER

Stanley E. Sohler received his grade and high school education in Portland, Oregon, and graduated from CalTech with a B.S. in Mechanical Engineering in 1941. From graduation until 1945, Stan worked with North American Aviation Inc., starting in the Scheduling Department and becoming head of the Manufacturing Coordination Department during his last three years with this company. Also, during the war, Stan taught Manufacturing Statistics at the War Training Classes at U.C.L.A.

In 1946 Stan spent about six months as production control manager with the Menasco Manufacturing Company in Burbank, and then a brief time with the Air Material Command at Wright Field, as chief of the Industrial Planning Branch, Plans Division.

With the Los Angeles Agency of the Massachusetts Mutual Life Insurance Company since March 1947, Stan was appointed supervisor last month.

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BEVERLY F. FREDENDALL

Beverly F. Fredendall '29, took post-graduate work in electronics and business administration at Columbia University and Illinois Tech after his graduation from C.I.T. He joined the National Broadcasting Company three years after it was organized and remained with that firm for 16 years. After the war, Fredendall joined the electronics division of Frederick Hart and Company, Inc., Poughkeepsie, New York, where he is still located doing research and advisory work on recording and electronic projects. Considered one of the country's experts in the recording field, Bev is a Professional Engineer, licensed by the State of New York, and secretary of the Dutchess County Chapter of the National Society.

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COVER CAPTION

Evening at the Athenaeum. Photograph by Edna Sommers, Photo Lab, C.I.T.

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The Truth Shall Make You Free

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ENGINEERING AND SCIENCE MONTHLY

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Index to Advertisers

With the Editor

RESPONSIVENESS of Tech alumni to varying fare in E&S as shown by letters to the editor was the subject of this column a few months ago. Since (and probably because of) that column several letters have been received and we are now convinced that our readers do read and react to what we publish.

Because of this conviction we anticipate some response to Stan Sohler's "An Airplane is Not a Rabbit" appearing herein. That this is a challenging article has been demonstrated by the comments of our editorial staff and consultants. We predict that some of our readers will write to us expressing their agreement with or disapproval of some of Stan's remarks. We hope they do and we believe that they will find Stan ready and able to defend his statements.

From where we sit it appears that the number of points awarded to various aircraft features in design competitions is particularly open to question. What we'd like to see is a defense of the present point distribution and of other features of the Air Forces' procurement policies. Do we have a reader who will rise to this challenge?

* * * * *

Sound recording has become a hobby of considerable popularity in addition to being an activity of almost indispensable value to industry, entertainment, education, and civil regulation.

Because of the growing complexity of recording as a science and the increasing interest in it as a hobby, our readers should find Beverly Fredendall's article on recording of considerable interest. Bev has been associated with the recording business for several years and knows it thoroughly from a professional standpoint.

This is not Bev's first contribution to E&S and we know from experience that he will reply carefully and promptly to any questions put to him through us.

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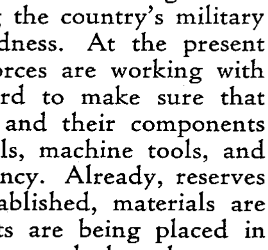
An Airplane is Not a Rabbit

By STANLEY E. SOHLER

THE RATHER OBVIOUS biological fact that airplanes will not reproduce themselves is one of the major headaches of the men who are charged with the responsibility of maintaining the country's military potential in a state of preparedness. At the present time, the Navy and the Air Forces are working with the Army-Navy Munitions Board to make sure that the manufacturers of airplanes and their components shall not lack facilities, materials, machine tools, and manpower in case of an emergency. Already, reserves of machine tools are being established, materials are being stockpiled, and war plants are being placed in stand-by reserve. Also it is expected that the manpower mobilization plans now being developed will insure an equitable distribution of skilled labor between industry and the armed services.

However, all of these things must be done regardless of the nature of the specific air weapons which would have to be produced in volume in case of war. It is the purpose of this article to indicate the manner in which the individual engineer, whether chief designer or draftsman, can make a positive contribution to the military security of the United States.

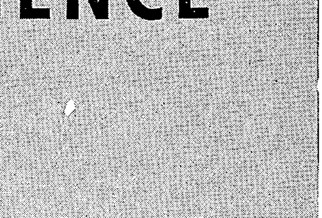
In 1946, the Navy and the Air Forces authorized study contracts with aircraft and component manufacturers to obtain the industry's own recommendations concerning the feasible peacetime preparedness measures which would substantially accelerate the production of air weapons in case of emergency. As was expected, all the companies pointed out the need for a supply of resources such as the facility, machine tool, and material programs already under way. However, when it came to the "internal preparedness" measures, nearly all of the aircraft companies stated that the first step would have to be **redesign for volume production, even on the models currently in peacetime production** (not including carry-over World War II models).



Aerodynamics Group
Dream Airplane

Drawings by C. W. Miller, Aerodynamics Department, North American Aircraft Corp.

In view of the probable nature of the start and prosecution of any future war, it is courting national suicide to plan to devote vital time and skill, after we are attacked, to the redesigning and retooling of air weapons currently in peacetime production. This situation poses the obvious question: "If we spend millions to develop air weapons which are of value to the country **only in case of war,** why do we authorize the peacetime production of models whose design **is not not ready for immediate use in case of war?"**



Stress Group
Dream Airplane

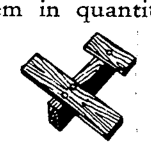
Actually, the apparently short-sighted design policy of most aircraft companies can be traced directly to the development and procurement policies of the Air Forces. This "policy" is really not a positive policy at all, but rather the costly lack of a clearly defined internal responsibility. In simplified terms, the Air Forces engineering divisions interpret their own responsibility to end when they have awarded and administered the basic research and construction contracts for two or three experimental models **having the maximum possible performance.** The procurement divisions interpret their responsibility to be the securing of the **maximum number** of airplanes **within limited budgets.** As a natural result, a minimum of re-engineering expense is allowed under the production contract to correct the basic lack of "producibility" in the experimental model. Neither division is given, or accepts, the responsibility for the "producibility" of the design.

The real key to the whole design problem lies in the policy and practice of these military engineering divisions. In most cases, an airplane model has its inception with the Air Staff's strategic planners, who visualize a certain kind of probable mission and the corresponding performance characteristics which will be needed. It is the job of the engineering divisions to notify manufacturers of what is desired and to evaluate the resultant design proposals submitted by the manufacturers. This first step is the one which really creates and fixes most of the problems encountered at later stages of the design development.

The invitation to submit a design proposal goes into considerable detail about the performance characteristics which are desired, but the only reference to producibility is a routine paragraph buried in a voluminous "Designer's Handbook". In reality, the inclusion of this paragraph is only lip service, because all the manufacturers know that when a point-by-point evaluation of their design proposal is made for the purpose of awarding an experimental contract, the suitability of the design for volume production will receive a maximum 30 points out of a possible 1000. Despite the many delays in World War II airplane production because of the lack of engineering suitable for volume production (the B-24 at Willow Run, for example), the Air Forces are still using exactly the same weight for producibility in all design competition evaluations as was used before World War II.

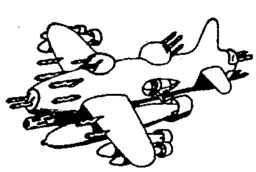
In other words, the manufacturer's design division has no incentive to call in experienced production men for their advice and assistance. In fact, there is actually an incentive to keep the production men away, because some of their producibility suggestions may require added airframe weight. This added weight in turn means decreased performance and reduced chances of winning the design competition. Yet, at this stage of the model development, the general configuration and the basic structure become pretty well fixed, and, except for correction of technical defects, will not be greatly changed through the subsequent experimental and low production stages. The net result is a model which can be built at low peacetime rates without too much trouble, but which has to be more or less completely redesigned in case of war before those "excluded" production men can build them in quantity.

At this point let us try to pin down this elusive "producibility" factor. The sketches on these pages are taken from a "running gag" which constantly circulates through the engineering departments of nearly all aircraft companies. Although obviously exaggerated, they do help to accentuate the design engineer's initial dilemma, even before the problem of producibility is considered. So many things must go into the airplane, and yet it must still fly better than any comparable airplane. Once the aerodynamics and the configuration are determined and the weight of equipment plus load is set, about the only variable left which can affect performance is the weight of the **airframe** itself. When **performance** is essentially the only basis for evaluation of a company's (and therefore its design engineers') ability, every possible weight-saving device is used.



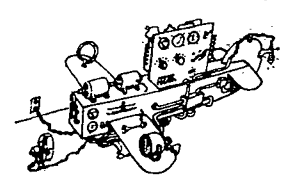
**Production Group
Dream Airplane**

For example: The fuselage of a reciprocating-engine fighter plane includes the tail surfaces, the pilot's seat, the flight and engine controls, and radio and other equipment. Structurally it is roughly a hollow tapered cylinder with fins on one end, and the stress requirements can be met by designing the whole assembly as one unit, with stringers running the whole length of the ship without splices, and with the circumferential ribs and skins being as free of joints and splices as possible.



**Armament Group
Dream Airplane**

Now consider the effect of such a design on the production organization. Because of the "unit" design the entire assembly must take place in one large "jig" which can locate and hold all the individual pieces exactly in place until they can be riveted together. Only a very limited number of men can work efficiently on one such jig at a given time, and the total elapsed time required to complete a cycle through the jig is very long. This problem becomes even more acute after the structural work is complete and the thousands of equipment items and controls must be installed in the cramped quarters of the fuselage.



**Electrical Group
Dream Airplane**

At low production rates, of one or two per week, such a situation is not critical, but a rate of 100 per week with semi-skilled labor has been shown to be impossible under such conditions. In other words, there just wouldn't be enough tool and die makers to make the elaborate jigs, nor enough floor space to house them, nor enough skilled labor to use them, if it became necessary to increase production 100 times while still using the "unit" design and the corresponding production methods necessitated thereby.

What, then, does producibility really involve? On our fuselage example, if producibility were to be introduced into an existing "unit" design inherited from the "performance only" experimental stage, the following **major design changes** would be **necessary** before high production rates would be possible.

1. The splitting off of a tail cone which could be bolted to the main fuselage **after** separate horizontal and vertical stabilizers had been bolted to the cone and after all of the internal rigging and wiring had been easily installed in this empennage "sub-unit".

2. The splitting of the fuselage into at least two side panels (and possibly a top and bottom), each of which could be easily assembled by itself in a sub-assembly jig, and most of the wiring and equipment easily installed while completely accessible.

3. The breakdown of wiring and plumbing design drawings into units which correspond to the structural sub-assemblies mentioned above.

4. The inclusion of bolt angles or other suitable means for quickly and accurately joining the sub-assemblies together in a "mating" or master jig.

The volume of engineering work and elapsed time involved in such a redesign for producibility is only part of the story. Tooling must be redesigned and rebuilt to the new drawings and the manufacturing process almost completely replanned. This takes **time**, a priceless commodity during a war.

Without producibility, the desired quantities of fighting air power simply cannot be produced. Does it, then, make sense to wait for the astronomical production demands of war before starting after one of the major prerequisites of such production?

It is apparent that a basic change of military engineering division policy will have to take place before the bulk of the airplane companies will voluntarily do away with the "Iron Curtain" which now exists between their advance design and production staffs. Specifically, the military engineering divisions will have to be given the direct responsibility of seeing to it that producibility actually receives equal weight with performance in design proposal evaluation, and making sure that any experimental airplanes incorporate as much of the producibility concept as possible. After all, an experimental airplane (not a basic research project) is supposed to be a prototype of a usable air weapon. To the extent that producibility is sacrificed in an experimental model to gain performance, the

(continued on page 9)

MODERN RECORDING--*A Summary of Methods*

By BEVERLY F. FREDENDALL

Author's Note: This article is designed to acquaint the technical man not actively engaged in recording with some of the more pertinent aspects of this interesting industry.

IT IS A LONG WAY back to the point in history when Edison invented the phonograph in 1877. However, it would be unfair not to pay tribute to this great man whose genius and the outgrowth of whose developments are responsible for the gigantic recording business of today.

The original recorder as conceived by Edison utilized sound waves to actuate a diaphragm and needle. As sound reached the diaphragm, the needle caused an indentation (recording) on tinfoil, which could then be used in reverse to recreate the original sound waves. Since that day, many changes, innovations, and improvements have been added to produce modern methods of recording. (Notable contributions to the art of recording are shown in Fig. 1.)

Early recording systems were severely limited, as to both frequency response and dynamic intensity range of reproduction. Such limitations in phonographs did not detract at first from their universal acceptance, because people as yet had not become accustomed to the superior reproduction of music and speech on the radio and the sound motion picture.

Most of the early acceptance of the phonograph was based upon novelty and a wide choice of recorded music. Subsequent to the introduction of the vacuum tube amplifier, which also produced broadcasting, the early acoustical phonograph appeared doomed on two counts: quality was lacking in comparison with radio, and the quantity of recorded material appeared inadequate. In an attempt to improve quality, the Orthophonic Victrola was marketed. Although the quality of music reproduction was noticeably improved, as the result of a more efficient design of the acoustical horn, it could not compare with that of electrical recording and reproduction, and, therefore, soon gave way to present-day systems.

As an aid to understanding the wide choice of present-day recording methods, it is well to keep in mind that the early machines were powered by acoustical energy and that only after the important invention of the vacuum tube amplifier could the most worth-while improvements take place.

SOUND STORAGE METHODS

Basically speaking, sound may be stored in one of three ways: by employing either a **mechanical,** an **optical,** or a **magnetic** sound track. Let us examine in some detail definitions of these three forms of storage.

The mechanical track is either a lateral cut or a vertical cut, depending upon whether or not the needle vibrates crosswise to the groove at a uniform depth, as in lateral recording, or vibrates up and down with varying depths, as in vertical recording. The grooves may be formed by either the engraving process or embossing. In engraving, a chip or thread is removed from the surface of the material, whereas in embossing, the groove is formed by an indentation of the record material, purposely caused by a sufficiently large needle force. The mechanical track method is largely used in present-day record players employing flat discs and in dictating machines using cylindrical records.

The optical track employs a light source made to vary in one of two ways: (a) by varying the area of the optical image; (b) by varying the light transmission of an optical track of constant width. Optical methods are used primarily in the motion picture industry.

The magnetic track stores sound by magnetizing the record material in either a lengthwise direction or a transverse direction with relation to the sound track. These variations may be thought of as applying to the magnetic recording process in the same way that the terms "lateral and vertical" apply to the mechanical track process. Two additional terms used in magnetic recording are **DC Bias** and **Supersonic Bias.** These designations deal with alternate methods of preparing the magnetic material to receive and magnetically store the variations of sound. The magnetic track method is commonly known as magnetic wire recording or magnetic tape recording. Although originated several decades ago, this method has become popularized only recently through further developmental work and modern publicity. It has been used quite extensively during and since World War II for commercial purposes, and an interesting application has been made in connection with furnishing entertainment on passenger trains. New uses are coming to the fore every day, and one of these which doubtless will enjoy a big future is in the development of the application of sound to home movies.

Although three basic systems of sound storage have been described separately, two of them already have been combined in the Phillips-Miller method of tape application. This utilizes a V-shaped needle which cuts vertically through a black-coated surface, thus producing both a mechanical and an optical sound track. When the recording is played back, only the optical track is used. The Phillips-Miller method has the advantage of constant track speed, resulting in fixed frequency response and long-time playability. This method has not become very popular to date, possibly because of the greater all-over expense involved. It has been used at radio station WOR in New York.

RECORDING MATERIALS

The three main processes of sound storage have been described with little or no mention of the form or the materials used in the record itself. The shape of the record may be, as in Edison's original device, a cylinder, or it may be a disc, a tape, or a wire, depending upon the process used and the application of the finished product. When discs are used for receiving and storing sound, they may be either metal, wax, shellac, modern plastics, or consist of coatings such as lacquer applied on metal, bristol board, or glass. Material for the optical process is the usual photographic emulsion, such as is used on motion picture film. Materials for the magnetic process are either steel tape or other types of tape coated with magnetic dust. This latter tape may be any one of several different kinds, among which are motion picture film and paper. For wire recording, ordinary small-gauge steel wire is used.

TRACK SPEED

The recording track speed may be either constant or variable, depending upon choice and execution of the mechanical drive. For example, Edison's original cylinder, plus the film, tape, and wire forms, is of the constant track speed variety, while the usual home phonograph has a variable track speed, resulting from a spiral groove on a constant **angular** speed turntable. Track speeds vary from 15 to 180 ft per minute. The higher the sound track speed, the better is the frequency response possible and the higher the cost of material. The use to which the finished record is put and the frequency response desired should determine the original recording speed.

CHOOSING A RECORDER

One might question the need for such a large diversification in the process, form, material, and speed used in the entire field of recording. Some of these differences were undoubtedly designed to circumvent patents, while others were worth-while contributions to the art of recording. The person concerned with choosing a suitable recording system should consider the following three groups of factors, the meaning of which will be described later:

PERFORMANCE FACTORS:

- **Frequency range**
- **Signal to noise ratio**
- **Distortion**
- **Uniformity of response**
- **Signal stability**

MACHINE FACTORS:

- **Initial cost**
- **Operating cost**
- **Size and weight**
- **Ease of operation and handling**
- **Recording time available**
- **Reliability of tracking**
- **Ease of spotting and editing**
- **Instantaneous speed accuracy**
- **Cumulative speed accuracy**
- **Life of machine**
- **Time interval between recording and playback**
- **Effect of temperature and humidity**
- **Ease of maintenance**
- **Adaptability to automatic operation**
- **Adaptability to field or mobile use**
- **Adaptability to synchronism**

RECORD FACTORS:

- **Cost per hour**
- **Size**
- **Weight**
- **Breakage**
- **Ease of handling**
- **Life and number of playbacks possible**
- **Re-use**
- **Editing**
- **Duplication**
- **Shipping**
- **Storage space**
- **Fire hazard**
- **Effect of temperature and humidity**

In view of the length of this list of factors dealing with the choice of a recording system, it is obvious why we have such a diversification of recording methods now in use. No one machine can completely satisfy all requirements, ranging from the minimum performance of a child's toy, to the demands of business and the large amusement industry. In making a choice, minimum requirements as to performance, and then specific machine and record factors, should be accorded

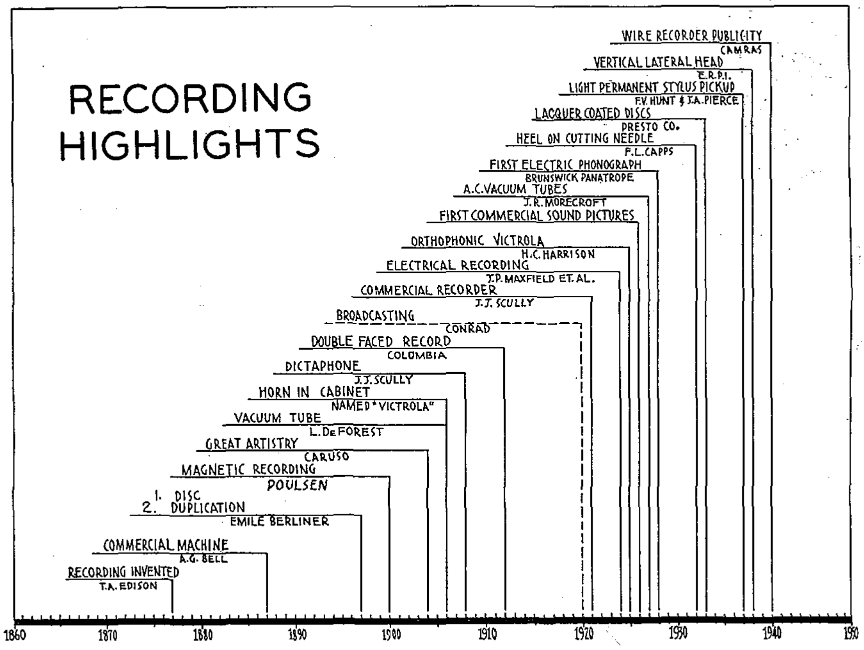


Figure 1

careful thought. While the primary concern is performance, it is quite possible that any one of the other factors may govern the choice of a recording machine in a specific instance. Since performance factors are of such importance, an explanation of each is now in order.

PERFORMANCE FACTORS

The sound spectrum is generally considered to be composed of ten octaves, ranging from 16 to 16,000 cycles per second. Edison's early cylinder probably utilized not more than three of these ten octaves. Its **frequency range,** therefore, can be thought of as limited to about 30 per cent of the total. However, although limited in range, the early acoustical phonograph was acceptable because the middle portion of the frequency band is of greater importance than either end. See Fig. 2.

The Signal to Noise Ratio is important because it defines the degree of sound intensity or dynamic range which can be accommodated. Noise tends to mask the desired signal when that signal is weak or of low intensity.

Distortion deals with the lack of faithful reproduction of the original sound; that is, whether the shape of the original wave is reproduced faithfully or disturbing harmonics are added to the original frequency components.

Uniformity of Response means freedom from any abnormal or extreme intensity peak or valley within the transmitted band. In this connection it is well to *remember that the loudspeaker is by far the most outstanding* example of apparatus having non-uniform response because of extreme variations in its efficiency or its ability to convert electrical energy into acoustical energy. Instead of producing a uniform sound wave at different frequencies, even the best loudspeaker contains intensity peaks and valleys throughout its frequency range.

Signal Stability applies to the constancy of reproduction of a steady input signal. For example, if a steady signal, such as a single frequency tone, were applied to the recording machine, the same steadiness or stability of the original wave should be obtained upon playback. Lack of signal stability may be termed amplitude modulation.

After the first requirements of performance have been met, other factors are important in the selection of a recording machine. The meaning of most of these factors is rather obvious. The **cost** of the initial installation, plus that of operation, is of great concern. Modern plastics fit in with the desire for low operating cost. In comparison with the cost of using home phonograph discs, amounting to approximately $4.00 an hour, film costs in embossed recording can be obtained at as low a rate as $1.00 an hour for comparable quality. In contrast with the usual five-minute disc recording, a continuous film will record without interruption for nearly two hours, or, if necessary longer. When records are not to be kept on file, magnetic materials are lowest in cost following the initial investment.

Size and weight of a unit mainly concern those who have use for a portable machine or for one adapted to dictation and general office work. Machines vary in size from permanent studio types somewhat resembling an average machine-shop lathe to those used for recording "on the spot" broadcast programs and communication recorders for aircraft flight tests, the latter about the size of a small suitcase. Toward the end of the war the Navy had contemplated the use of "pack" recorders which were similar to pack transmitters in portability and battery operation. They were a completely self-contained, lightweight unit. Weights of portable recorders vary from 25 pounds to about 150 pounds.

Ease of operation and handling is again mainly desirable in machines intended for the general public. In a professional studio, where technicians are specially trained to operate the intricate machine, numerous controls are available. These adjustments allow the operator to set for proper cutting angle, depth of groove, and throw of the engraved chip, plus numerous controls of the electrical system. Such adjustments are considered desirable for trained personnel in order that the highest signal to noise ratio may be maintained simultaneously with the least distortion and the least tendency to over-modulation. It is interesting to note that a well-known recording company, when first organizing its recording department, assigned members of its technical personnel unselectively to the work of making recordings. After numerous failures, it was realized that the job required considerable training and experience, and therefore, a special department was created so that each technician might gain the knowledge required to make nearly perfect recordings.

Length of recording time available varies with the purposes involved. Magnetic tape machines have been known to operate for a period as short as ten seconds. A machine of this kind might even be used to add reverberation to a program otherwise lacking in proper acoustics. Such a reverberation machine might operate with several playback heads so spaced along the tape that a controlled portion of energy from each succeeding head could be added to the original pickup, thus giving the illusion of repeated sound reflections occurring to the original sound. Other machines have been built for continuous 24-hour operation without reloading. These are mainly used for verbatim transcription work.

Reliability of tracking applies to mechanical recording where it is possible that the playback needle might jump out of the groove and repeat an adjacent groove, or even skip across the record at the least provocation. This may happen on ordinary disc phonograph machines either because of excessive motor vibration or because of a lateral thrust existing at the needle point, the effect of friction between needle and groove.

The needle in a home phonograph is mounted to rotate about a fixed pivot, rather than being held always tangential to the groove. A friction force acts in the direction tangential to the groove. A small component of this tangential force tends to cause the needle to jump out of the groove and swing about the arm pivot. For broadcast service this behavior of jumping cannot be tolerated. To the broadcaster this problem is more important than a correlated problem of tracking distortion caused by the head's being non-tangent to the groove. The relative merits of the so-called offset head with relation to the problem of groove-jumping are important to the designer, but beyond the scope of this article.

Ease of spotting and editing does not ordinarily concern those who use records for entertainment, as they usually play records from beginning to end. On the other hand, in movie work, conference recording, communication monitors, and occasionally in broadcasting it is desirable to be able to spot, delete, or rearrange portions of a continuous program. It is advantageous, therefore, to be able to identify and spot portions of a recording and to start and stop the sound track. Some machines are able to start and stop between syllables of a word, while others require several seconds to reach proper speed.

Maintenance of constant **speed** is most important in recording machines intended for music rather than speech. Such speed changes as do occur can be classified as either instantaneous speed variations, amounting to momentary speed fluctuations, or cumulative speed variations, indicative of the average speed. Cumulative speed accuracy should be maintained to within one half of one per cent. This will keep the music on pitch and insure that in re-broadcasting a previously recorded fifteen-minute program the reproduction will properly fall within the time allotted. . The allowable time variation equalling one half of one per cent means four and one-half seconds in a fifteen-minute period. Instantaneous speed fluctuations produce wows or flutter, depending upon the rapidity of fluctuation. Naturally, the more rapid the speed of fluctuation, the more noticeable is the change in pitch of a sustained musical note. To date, the recording industry has not recognized the more desirable method of rating machines according to rate of change of speed (acceleration), but continues to rate them according to the maximum per cent change of speed.

Perhaps one of the reasons for laxity in rating a machine according to acceleration is the difficulty in measuring a transient phenomenon having such small instantaneous inaccuracies in the driving mechanism, such as occur because of normal manufacturing tolerances of gears, sprocket teeth, and variable friction of moving parts. In short, any change in load offered to the drive motor will be reflected as a change in speed of the recording. In particular, drive belts which are not absolutely uniform tend to whip or vibrate. Such vibration, in turn, causes a speed fluctuation.

For home use, the **life** of a machine should be comparable to that of other technical apparatus. Thus far, technical advances in design have caused machines to be superseded rather than discarded because of wear.

Time interval between recording and playback may be important to commercial concerns in order to determine immediately whether or not a recording is technically acceptable. If a particular recording is not acceptable, it may be repeated during the same recording session; otherwise added expense is required to

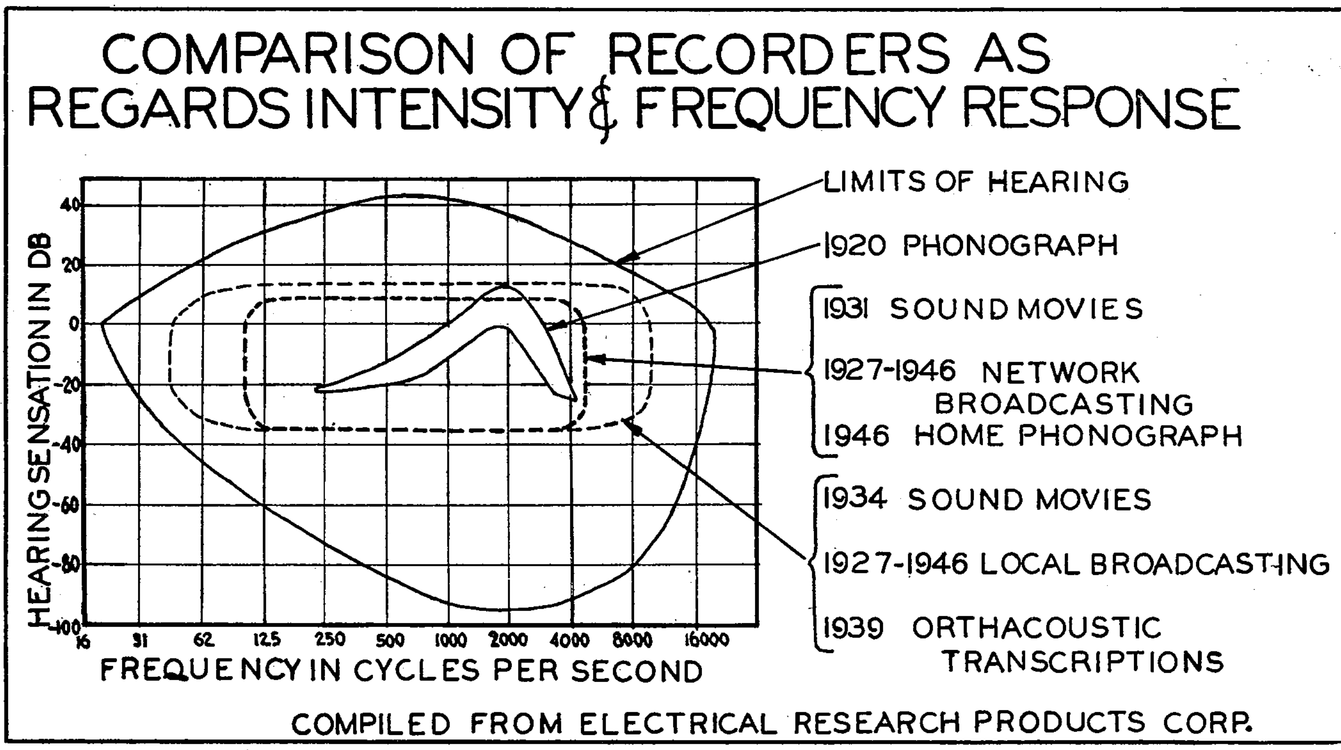


Figure 2

re-assemble the artists at a later date for a repeat recording.

The harmful effect of **temperature and humidity** upon technical apparatus has been emphasized by recent war experiences. In the United States only the southern central part of the country need be watched for harmful effects.

Ease of **maintenance** is more important in recording than the average person realizes. Dust, dry bearings, and worn friction drives all contribute their share of unwanted speed variations. An occasional check of the frequency response of the system, plus the necessary adjustments, rightly falls within the field of maintenance.

Adaptability to **automatic operation** is especially important to the large and thunderous juke box industry.

Adaptability to **field or mobile use** is one way of saying that the equipment is light-weight and may be used under conditions of shock. Some recorders have successively operated in airplanes and tanks under active battle conditions. In the field of **mobile use**, the usual disc machine is not suitable, because of vibration affecting the playback tracking. That is to say, when mechanically shocked, the needle may be thrown out of the groove. On the other hand, it is possible to provide both recording and playback on a wire, tape, or film machine by using mechanically fixed or guided heads.

Adaptability to **synchronism** applies primarily to the motion picture industry and its little brother, television, where picture and sound are synchronized.

While the discussion given above applies to machine factors, many of the same principles apply to the medium supporting the sound track, that is, to the record. **Cost of operation** per hour has been discussed. **Size and weight** of the record govern the storage problem for those who must retain copies of recorded material for long periods of time. **Breakage of record material** will be a governing factor where either shipment or preservation is contemplated. **Ease of handling** ties in closely with the operation of the machine. Certainly the ease of handling disc records has been one of the determining factors in their popularity. Other record types adapt themselves to magazine loading, where threading or loading by hand has been reduced to a minimum. **Life of the sound track** and the number of playbacks possible, prior to deterioration and final discard, are important to the advertising industry, which makes repeated use of recorded sales material. Consider also the constant repetition offered to popular records which are subjected to an accelerated life test by the corner juke box.

Re-use of the record material is an advantage which can be claimed by systems using the magnetic process. This is possible by demagnitizing a previously recorded sound track prior to re-use.

Editing of recorded material is primarily accomplished by design of a good spotting device and start-stop mechanism. The **form** of record material also contributes to ease in editing. For example, a tape record with but a single sound track may be edited by cutting and joining at desired intervals.

Duplication of records is imperative for certain commercial applications. It can be recalled that Edison's invention lay comparatively dormant until Emile Berliner produced a successful duplication process, using flat disc records. **Shipping** of records ties in closely with the subject of breakage, and need not be discussed in this article.

Storage space required for old records may be a problem to a communication company that must keep a record of all communications for a certain period of time. In such a case, not only is the cost of operation extremely important, but also the amount of space required for storage.

The fire hazard of a particular material may require special precautions in both handling and storage. We are all familiar with the fire hazard which nitrate film represents, but tend to overlook the same fire hazard which exists when nitrate material is used to coat discs. Unfortunately, when early manufacturers first sold nitrate records, they called them acetate in order to further their sale. Actually, the chip or thread removed during the engraving of lacquer-coated records is highly inflammable. Abnormal temperatures and humid atmospheres may affect record materials to some extent. If one lives where abnormal conditions exist, these factors should be checked.

Naturally, one might wonder which of the three systems of recording is the best; that is, whether the mechanical, the optical, or the magnetic system inherently is best. Or perhaps, whether lateral is better than vertical. It is the writer's judgment that the capabilities of all systems are "about equal", but that the skills acquired by the proponents of each of the systems vary somewhat from time to time. This phase of the matter leads to conflicting opinions. At the moment the highest quality seems to have been obtained under carefully controlled conditions while the record was being played back at the outside edge from an original, lateral-cut, lacquer-coated disc. This effect does not eliminate the possibility that the future may produce a different system with striking results, or that the performance may be readily duplicated on a commercial basis. It is interesting to note that in 1929 the ambitious California Institute of Technology glee club produced a recording of its alma mater song. Those of us who bought a copy of that record were sadly startled to learn that all record concerns had not acquired the art of recording with equal skill. This record quickly found the junk pile. It contained far too much distortion.

Optical methods are particularly well adapted to the cinema, since its primary problem is one of synchronizing sound and picture. Further, photographic techniques are known by the movie industry and it is but a step from such techniques to their application for sound recording. However, these methods are cumbersome and expensive for the use of non-technical personnel. The layman wants a simple machine requiring very little technical skill for operation—possibly only an on-off switch.

A glance at the history of recording will show the very important part which electrical amplification has played in its development. The importance of electrical amplification lies mainly in its ability to handle all frequencies in the audible spectrum and to offer a means for correcting a deficiency in any part of the system by the use of simple electrical correcting networks. Just as the invention of the vacuum tube and the vacuum tube amplifier has played an important part in the development of radio, it has influenced the development of recording more than any other single contribution.

An Airplane is Not a Rabbit

(continued from page 4)

Air Staff and the entire nation are actually being misled, as they **can never get such an airplane in large quantities.** The many individual experimental superweapons found in Germany gave added proof to an often quoted but all too seldom recognized truism: "No nation has ever won a war with a handful of laboratory samples, even though the samples individually surpass any other weapon in the world."

It would appear that nothing can be done until the military engineering divisions are properly set up to handle their full responsibility. However, at least a start has been made within the aircraft industry toward breaking down the "Iron Curtain" which excludes production men from the inner sanctum usually reserved for the advance design engineers. Several models now in the experimental stage have actually been designed from the beginning with the basic structural needs of producibility given full consideration.

How is it possible to incorporate producibility without adding so much weight that all design competitions are lost? Although a strong, farsighted management is essential for their successful combination, the understanding and broadmindedness of individual engineers can go a long way toward achieving the same effect.

It was found that when the production men were fighting with the engineers to get the experimental design **revised** to incorporate some producibility in the production version, most of the changes resulted in a weight increase. The production men had their hands full trying to protect their own interests, and "never mind what it does to the weight". However, when the production men **worked with the designers** at the time the original design was **created,** the production men came up with as many weight-saving ideas as weight-increasing ideas. The result was a high-performance airplane that could be produced in quantity in case of an emergency, with no major redesign or retooling problems.

The best solution is a change of military engineering and procurement policy which will encourage the top management of all companies to follow through in this manner. In the meantime it is suggested that the designer let this one thought come to mind each time he sets pencil to paper: "You have to draw it only once, or maybe twice. Somebody else may have to duplicate it in metal a thousand times in a hell of a hurry, and your life and his may well depend on how fast it can be done."

ALUMNI NEWS

ALUMNI ASSOCIATION OFFICERS

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E. R. Hoge '18	W. B. Miller '37
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The San Francisco Chapter meets weekly for lunch at the Fraternity Club, 345 Bush Street, on Thursdays.

E. E. GRADUATE HEADS STANFORD'S RESEARCH INSTITUTE

NEW DIRECTOR of the Stanford Research Institute is Dr. J. E. Hobson '35, who came to this post March 1 from the Armour Research Foundation, where he has been since 1944. The Stanford Research Institute is the first industrial research institute in the West, offering research in engineering, chemistry, biology, physics, and mathematics, and industrial and social sciences.

Dr. Hobson came to C.I.T. after receiving his B.S. and M.S. degrees from Purdue University in 1932 and 1933. His Ph.D. in 1935 was conferred Magna Cum Laude.

Following his doctoral work at the Institute, Hobson spent two years as an instructor in electrical engineering at Armour Institute of Technology, then became central station engineer with Westinghouse. During four years with Westinghouse, he was also lecturer in electrical engineering at the University of Pittsburgh, from which institution he joined the Illinois Institute of Technology faculty as director of the department of electrical engineering.

In 1940, during his employment with Westinghouse, Dr. Hobson received the Eta Kappa Nu award as "the outstanding young electrical engineer in the United States".

YOUR 1948 NOMINATIONS

In accordance with Section 3.04 of the By-Laws of the Association, the Directors met as a nominating committee on February 16, 1948. Five vacancies will occur on the Board at the end of the current fiscal year, one vacancy to be filled from the present Board and four to be elected by the Association. The present members of the Board and the year in which their term of office expires, follow:

J. R. Bradburn '32	1948	J. W. Lewis '41	1949
E. R. Hoge '18	1949	W. B. Miller '37	1949
W. M. Jacobs '28	1948	F. T. Schell '27	1948
A. L. Laws '26	1948	W. D. Sellers '25	1949
H. B. Lewis '23	1948		

The four members of the Association nominated by the Directors are:

Nicholas A. D'Arcy Jr. '28	Ruben F. Mettler '44
Robert M. Lehman '31	George K. Whitworth '20

In accordance with Section 3.04 of the By-Laws of the Association: ". . . Additional nominations may be made by petitions signed by at least ten (10) regular members in good standing, provided that the petitions must be received by the Secretary not later than April fifteenth."

Statements about the nominees of the Directors are presented in this issue of **Engineering and Science.**

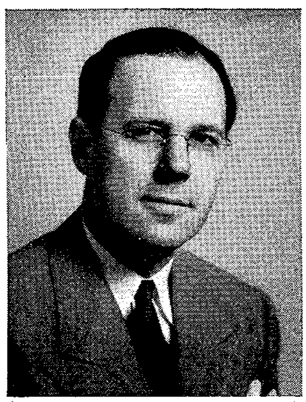
D. S. CLARK, Secretary

Nicholas A. D'Arcy Jr.

Nicholas A. D'Arcy Jr. '28, headed the committee which arranged the 1947 Alumni Seminar. As an undergraduate, D'Arcy was editor of the Big T, president of the Student Chapter of A.S.C.E., and a member of the varsity football team. Since 1928 he has been in engineering sales work, starting, in February 1947, his own organization which represents Fawick Airflex Company, Inc., Torcon Corporation, Foster Cathead Company, and Hercules Filter Company.

D'Arcy has contributed two articles to **Engineering & Science,** and is also a frequent contributor to national petroleum trade periodicals. A member of A.P.I., A.I.M.E., and A.S.M.E., he has presented several papers before these organizations on oil field equipment and his specialties of hydraulic drives and friction clutches. D'Arcy has also served for the past two years as chairman of the Student Awards and Student Relations Committee of A.I.M.E.

Robert M. Lehman



Robert M. Lehman '31, served, as an undergraduate, as Freshman Basketball manager, Sophomore Class president, Junior Board of Control member, and Student Body president during his senior year. He was also chairman of the committee which made an extensive study of student housing and living conditions on other campuses and which in turn made recommendations that were accepted as a basis for use in CalTech's student houses. After graduation, Lehman spent two years as resident manager of the Old Dorm.

Last fall, he was successful in obtaining a zoning variance from the City so that the Earhart Laboratory could be built. Lehman, and assistants whom he paid out of his own pocket, obtained approval of property owners in the general area of the laboratory location by securing signatures on a petition. These petitions formed the basis upon which the entire Institute presentation was made to the Zoning Committee.

Lehman has been engaged in the wholesale bakery business since graduation, producing packaged merchandise under the trade-name, Cake Box Products.

Ruben F. Mettler

Ruben F. Mettler entered CalTech with the Navy in 1943 after two years at Stanford University, and graduated in 1944 with a B.S. in Electrical Engineering. After graduation, Mettler attended Midshipman's School at the Prairie State, Columbia University, and was commissioned at the top of a class of 400. He also won the New York Yacht Club award as "Outstanding Midshipman". Mettler next went to the M.I.T. Radar School and later served on destroyers in the Pacific area as a trouble-shooter for the Naval Research Laboratory, also working on target ship instrumentation for both Bikini tests.

After his discharge, Mettler returned to CalTech and received an M.S. in Electrical Engineering. Subsequently, he worked on electronic logging problems for the Halliburton Oil Well Cementing Company, and on missile guidance problems for North American Aviation, Inc.

Mettler is now back at the Institute working toward his Ph.D. in Electrical Engineering, and is teaching assistant in Applied Mechanics, resident associate of Ricketts House, and consultant to North American Aviation, Inc., on missile guidance problems. He is also actively participating in the current Alumni Fund drive.

George K. Whitworth

GEORGE K. WHITWORTH '20, is known to more recent alumni through last December's meeting of the Association in Pasadena, for which he handled all arrangements. A 1922 graduate in Electrical Engineering from the University of California at Berkeley, Whitworth attended the Institute (then Throop College) in 1916, but left in 1917 to enlist in the Army. Following World War I, he completed his college work at U.C. and took up the study of law, receiving the degree of Doctor of Jurisprudence from the University in 1924.

Whitworth practiced law in San Francisco from 1925 to 1940, serving for a time as deputy clerk of the State Supreme Court, and as city attorney of Menlo Park from 1927 to 1934. In 1940 he returned to Southern California and since that time has been a deputy city attorney of the City of Los Angeles with the Department of Water and Power. In 1940-41 he assisted in the renegotiation and drafting of contracts with the government relating to the generation and distribution of Boulder Dam power.

During World War II, he served as a member of the Selective Service Board of Appeals for the Southern California area, also as chairman of the Los Angeles Bar Association's Committee on War Council Induction Program and as chairman of the State Bar's Southern Advisory Committee on War Work.

THE FUND PROGRAM IS NOW YOURS

AS THIS IS being written, letters are going forward, as rapidly as the class chairmen can handle them, to all alumni, announcing the Fund Program and appealing for contributions. The CalTech Alumni Fund Program is now a reality!

Actually, work on this Program has been under way for nearly two years. Director Howard Lewis '23, was chairman of a Fund Study Committee during the '46-'47 Association year. Their investigation was thorough; their proposals sound. You have heard their progress reports at Association meetings, and you have read previous fund articles in this publication. Then at the Annual Banquet last June the first group of contributions was handed to Dr. DuBridge, even though the Program was still in a formulative stage.

This Association year, Howard Lewis, now vice-president as well as director, has continued to head the organization of "The Fund". Working with him has been Director Joe Lewis '41 (no relation to Howard), who was chosen chairman of the Fund Committee following an important Fund organization meeting last fall, attended by Institute Trustee and Faculty representatives, class secretaries, and Association officers and directors. That Committee has prepared the appeal which is now being mailed.

This much is history. Now, the Program officially begins to live. The letters which will reach you will include an excellent illustrated statement on the Fund: its nature, purpose, and the reasons why every alumnus should support it. Little would be served by an attempt to restate portions of that here. I can do no less, however, than to urge serious study of the letter and statement, and immediate action by each alumnus. Our Association is now mature, and this is its biggest project. It must succeed.

The time and effort invested in the development of this program by the two Lewises and their committeemen is prodigious; and their work will continue. The Association will long be in their debt. But the success of this well-conceived plan, having a new gymnasium as a goal, is up to the individual alumni. The Fund Program is now yours!

W. M. Jacobs '28
President, CalTech Alumni Association

PERSONALS

1922

ALFRED W. KNIGHT and V. WAYNE RODGERS '27, registered patent attorneys in Los Angeles, have recently formed a partnership, Knight Rodgers.

1923

BERNARD G. EVANS has met the prescribed requirements of the American Institute of Real Estate Appraisers and has been awarded the professional designation, M.A.I. He is now working in San Bernardino.

1924

KENNTH B. ANDERSON, who is working with the Pacific Public Service Company, a subsidiary of Standard Oil, has just been transferred from Santa Cruz to the main office in San Francisco.

1926

THEODORE C. COLEMAN, back from a two year stay at Sao Paulo, Brazil, where he was engaged in importing and exporting, has recently been appointed assistant treasurer of the Standard Oil Company of California and is working in their main office in San Francisco. From 1940 to 1945, Ted was a director and vice-president of Northrop Aircraft, Inc. and previously was in the investment business in Pasadena and Los Angeles as vice-president of Banks, Huntley Company.

1927

THEODORE C. COMBS, working with the Trinker Structures Inc., has been promoted to resident manager in San Francisco.

1931

FRANCIS W. HUTCHINSON, professor of mechanical engineering at the University of California, Berkeley, was recently elected to the Committee on Research of the American Society of Heating and Ventilating Engineers. Prior to his present professorship, Hutchinson was a member of the Purdue University faculty, and before that an associate professor at U.C.

FRANK M. MASON has just been appointed vice-president in charge of the new, enlarged Atlantic plant of U. S. Electrical Motors, Inc. at Milford, Connecticut. With this company since 1930, Frank has held many positions; in charge of the Test Department, Service Department; then assistant chief engineer, Chicago District manager, and manager of the Brooklyn Assembly Plant.

1932

LAWRENCE D. SCHRODER, M.S., was appointed assistant superintendent of Salt Lake City public schools last December. He will be in charge of personnel and school organization. Schroeder has completed all classwork necessary for a doctorate in education from Stanford. He served as principal of Jackson school, Salt Lake City, after teaching in elementary and secondary schools in that city.

1933

In December, JOHN R. BOWMAN, a senior research fellow at the Mellon Institute, Pennsylvania, was named head of a new research department at the Institute which will do fundamental research in physical chemistry. John has been working at the Mellow Institute since 1935 on a fellowship established by the Gulf Research and Development Company.

1937

RALPH S. BENTON JR. is sales engineer with Ingersoll Rand Ltd. in Bombay, India.

1939

EDWIN I. SULLIVAN, who is working with the Bureau of Reclamation in Sacramento, has been elected vice-president of the local section of the ASCE.

1940

GILBERT W. HOFELLER, working in the Flight Test and Research Department of Consolidated Vultee's plant in San Diego, will be flight test engineer on the XC-99, world's largest land-based airplane, during the company's six-months-long flight-testing program. Gil joined Consolidated Vultee's San Diego Division as an engineer in 1940, shortly after his graduation. In 1941-42 he was an instructor in the ground school of the Ryan School of Aeronautics in San Diego, and then returned to Consolidated to take the position he now holds.

1941

ALEX E. S. GREEN, M.S., who is studying toward a doctor's degree in science and also instructing at the University of Cincinnati, has been awarded the Medal of Freedom for outstanding work performed when he was with the 20th Air Force in India, China and the Marianas Islands.

1942

CHARLES M. SEIBEL, Wichita, Kansas, has just designed, patented, and flown a simplified helicopter which he believes will sell for $3000 to $4000. Charles built his "flying windmill" in his spare time. The plane weighs 540 pounds empty and is designed to cruise at 75 miles per hour, although in testing, the experimental model has not flown over 30 miles an hour. Charles plans to sell his patents outright or form a corporation and build the helicopters in Kansas.

1943

DAVID R. ARNOLD is now employed as a gas engineer for The Superior Oil Company, Los Angeles. In December 1947, he received the M.B.A. degree from Stanford.

JAMES H. LEONARD is employed by Western Geophysical Co. as chief computer. The Company does oil exploration work in California.

1944

JOHN FREDERICK NICHOLS married Miss Jeanne Lytle of Arcadia. Since 1944, John has been doing graduate work at U.S.C.

1946

FREDERICK C. ESSIG has accepted a position in the Instrumentation Laboratory at the Naval Air Missile Testing Center, Point Mugu, California. He is working with electronics at the Laboratory.

1947

ALBERT H. J. MUELLER is now working for General Electric as test engineer on the GE Test Course, in Schenectady, New York. Albert informs us that five per cent of the class of '47 are now working for the GE—BURTON CRUMLY and CARTER SINCLAIR and AL are at the Schenectady Works; ROBERT BELYEA and GEORGE LYON are at the Fort Wayne Works; JOHN HOLMGREN is at the Erie Works; and MERWYN HODGES is at the Pittsfield Works.

1948

DAVID K. CARLISLE, president of his freshman class at Tech in 1944, left the Institute to attend the U. S. Military Academy at West Point. Dave stood in the top five per cent in the Fourth Class and now has the best over-all record of any negro cadet ever attending the Academy.

ANNUAL ALUMNI SEMINAR

Saturday 17 April 1948 — C.I.T. Campus

FEATURING: TWO SEPARATE PROGRAMS

For Alumni . . . . .
Talks on Topics of General and Scientific Interest
Luncheon: Student Houses

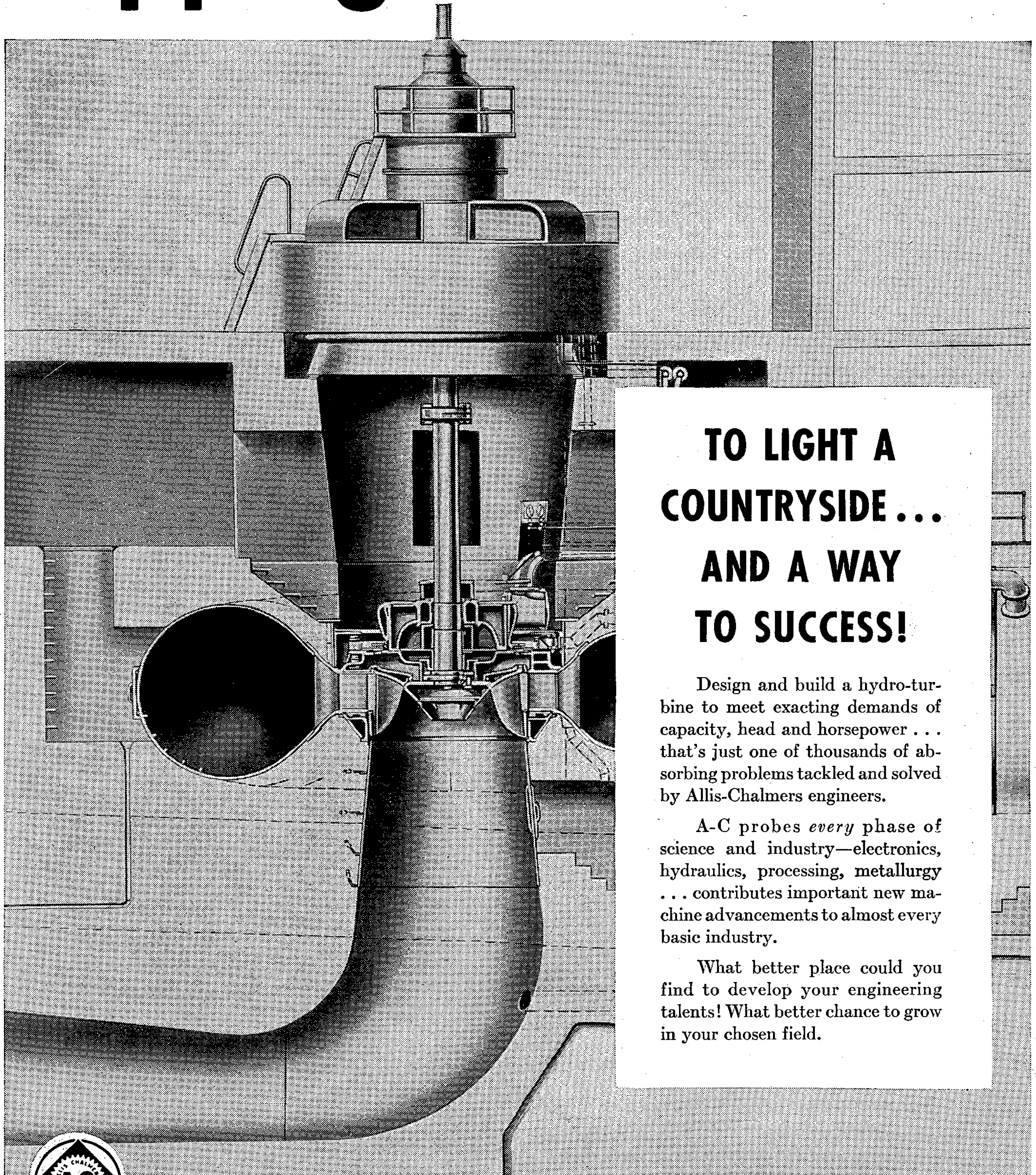
For Alumni Wives . . . . .
A Varied Program, including:
Lectures, Demonstrations, Tour of Campus
Luncheon: Athenaeum

BANQUET at the Shakespeare Club

President DuBridge will speak on Atomic Fission

COMPLETE PROGRAM WILL FOLLOW BY MAIL

Tapping a Waterfall...



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