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The IMPORTANCE OF RELIABILITY and MAINTAINABILITY of ELECTRONIC DEVICES

S. R. Calabro

THE RADIO CLUB OF AMERICA, INC.
11 West 42nd Street ★ ★ ★ New York City

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The Radio Club of America

ORGANIZED FOR INTERCHANGE OF KNOWLEDGE OF THE RADIO ART, THE PROMOTION OF GOOD FELLOWSHIP AMONG THE MEMBERS THEREOF, AND THE ADVANCEMENT OF PUBLIC INTEREST IN RADIO

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PROCEEDINGS OF THE RADIO CLUB OF AMERICA

Volume 39 July 1963 No. 2

THE IMPORTANCE OF RELIABILITY AND MAINTAINABILITY OF ELECTRONIC DEVICES

by S. R. CALABRO

Your RADIO CLUB has an enviable heritage of which you should be truly proud. Proud - because you have contributed so much to the economic, scientific, cultural and social development of our great nation by helping bring to it the miracle of what we once called "Radio" but is now the broader field of electronics. As we all realize, its benefits have permeated every field of endeavor, be it medical, defense, educational, industrial, etc. -you name it ! - and electronics is there to serve all.

Although I cannot boast of being one of you in membership, I can honestly say that I have been your associate in spirit, since as a boy, I felt the impelling urge and the intense pleasure to build a wireless set. When I completed my first crystal set, the feeling of accomplishment was overwhelming and exhilarating. From the winding of the coils, the assembly of the detector and the playing with the catwhisker to receive the stations, I became an early radio addict. My interest continued until I received my EE degree, a career which I do not believe I would have chosen had it not been for my early interest in Radio. This small facet of my life created in me an affinity of belonging here among you.

My subject tonight is the science of RELIABILITY and MAINTAINABILITY. *

"Reliability is the probability of a device performing its purpose adequately for the period of time intended under the operating conditions encountered."[1]

Maintainability is defined as:

"Maintainability is the probability that a device will be restored to operational effectiveness within a given period of time when the maintenance action is performed in accordance with prescribed procedures."[2]

From these definitions, it is obvious that Reliability is concerned with the probability of survival of a device for a given period of time; while maintainability is a measure of the time it takes to maintain or repair a device which has either failed or is in the process of a preventative maintainance action.

As of this date, reliability has received most of the attention, but because of the high maintenance cost of our complex military system, maintainability is now coming into its own. Various costs of maintaining our military equipment have been quoted in the past. One most prevalent figure is that some of our military equipment costs more than ten times its original procurement price to maintain during its useful life. Another, and most illuminating figure, is that it costs the government about ten billions of dollars a year (i.e. in excess of 25 million per day) for maintenance. Therefore it should be obvious that the ideal situation is to design devices that are less susceptible to failure, but having once failed can be repaired in a minimum of time and cost.

Those of us who have studied engineering under past curricula, will agree, I believe that most of the stress was placed on the pure engineering sciences, i.e. - mathematics, physics, chemistry, laboratory work and basic electrical theory, and some electronics. Very little, if any thought was given to statistics and its application. Therefore, when it was realized that Reliability and Maintainability were parameters that had to be considered in the design of complex equipment, many of our best circuit designers found themselves ill equipped to tackle the new problems which confronted them.

ABOUT THE SPEAKER

Mr. S. R. Calabro, President of the Aerospace Technology Corp., is a graduate of the Univ. of the City of New York, (BSEE - 1939) and is a licensed Professional Engineer. He is the author of the recognized textbook on the " Reliability Principles and Practices" McGraw-Hill, 1962. Previously to founding ATC, he has held positions of Director of Product Assurance at International Electric Corp., and Manager of Quality Control and Test Engineering at ITT- Federal Division. ATC is engaged in providing all fields of service to industry and government in the matters discussed in this paper.

Most of us realized our shortcomings and decided to do something to improve the situation. This culminated in the development of the science of reliability, which will reach its fruition as soon as Maintainability has reached the same level. Some argue that there is nothing new about the principles involved in these parameters and that they have long recognized the essentials, and therefore the discussion is "old hat". This may be true - but it is equally true that unless the factors involved are recognized and tabulated in an orderly and authorative manner they will not receive the attention they deserve . Some of these factors will now be discussed.

For example, the design objectives mentioned can be realized only if several factors are considered which individually and collectively affect each of them. The initial design concept should stress simplification without sacrifice of specification and contractural requirements. It should also weigh the relative merit of manual versus automatic operation or control, as well as speed of operation, programming, and other factors as they affect reliability, interchangeability, replaceability, and maintainability. Moreover, sound reliability engineering must consider the aptitudes of individuals as well as the capabilities of machines, in order to ensure the greatest over-all reliability of the combination. Thus, as human engineering takes its place besides design engineering, the human machine becomes an integral part of system reliability.

Therefore, the engineer must consider whether by virtue of his design, the human is capable of performing the things demanded of him. Is the human going to be required to exceed his limits of physical strength, perform too many functions simultaneously, or perceive and handle information at faster rates than his capabilities will permit ? Is he going to be asked to maintain monitoring vigils without adequate informational feedback, or to perform meticulous tasks under difficult environmental conditions and for longer periods than he can function at a reliable level of performance ?

Or is he going to be required to perform at peak performance, yet make judgements that are beyond the range of human capability without adequate illumination ? Is he going to be required to perform visual motor functions as efficiently as any other person or work with tools in surroundings which are not compatible with his physical dimensions, or is he expected to have the same physical stature, motivational level, training, experience and intellectual background and be of the same size and have same physical characteristics as any other person ?

In addition to the human engineering aspects, the design must consider all technical and environmental factors involved in the initial design concept. There must be a consideration of the limitations of weight, complexity and size on accessibility and replaceability of subassemblies. The advantage of using replaceable modules in lieu of unit construction must also be evaluated. The design should also consider the effects of heat dissipation, vibration, shock, and the mounting of parts, as well as to specify the proper mechanical structures which should be used.

The engineer should also weigh the practicality of the design with regard to standard factory production techniques, as well as weigh the probable effects of varying environmental conditions on heat dissipation, and deterioration of parts and devise means overcoming these effects. In this regard, he must evaluate whether the most appropriate techniques are being used in the most effective manner. Moreover, he must decide whether the required performance will be achieved under all specified conditions of imposed environmental stress power supply fluctuations, contaminents, tolerance accumulation of circuit elements, as well as temporary and permanent shifts in the value of any item imposed by variation of the operation conditions and by age. He should also evaluate whether the desired functioning is accomplished in the most effective manner from the viewpoint of reliability, with a minimum of "series" elements and proper and adequate application of redundancy techniques.

Another consideration is to determine if the interaction between electrical and mechanical functions is optimum. This involves all mechanical aspects necessary for proper structural support, control of electromagnetic pickup by physical orientation or isolation, heat source proximity, and lead dress.

The designer should also weigh the possible effects of heat and heat transfer on the operation of the equipment. Therefore he should study methods of conduction, insulation, radiation, convection, and cooling to overcome disasterous effects.

In order to cope with the design factors, the electronics engineer must be a capable, mature individual of wide experience and a thorough, sound technical training. He must be capable of balancing cost items, manufacture, and installation versus his desires for incorporating pet experiments or circuits which are still in an experimental stage. A good engineer who is interested in achieving reliability will select basic circuits which have been provenand tried. He will resist pressures of his own or of subordinates to experiment with the untried or purely hypothetical concepts.

This does not mean that engineers should not be encouraged to be creative. There is much room for creativity in any field. It is certain that nobody would be guilty of stagnation of progress in electronics, which is so crucial to the defense and development of the country.

However, we are suggesting that new circuit types be fully developed and tested in less critical or in commercial devices before being considered for incorporation in highly reliable gear, particularly if it is destined for military service. To sum it up - a good designer should use simple circuits of proven reliability in his designs. These circuits are usually available as a result of his own experiences, or, in some instances they may be offered to industry as pre-packaged modules of proven characteristics and reliability, by reputable vendors.

The designer should also be assured that the circuits he selects are stable without the necessity for excessive shielding or voltage regulation, or that they are not critical or marginal to the extent that special parts must be selected to assure the proper functioning. Such a condition is undesirable, because the replacement of a random spare part is not feasible unless the circuit in which it is to be used is retuned. It is not always possible to perform this retuning under field conditions, and therefore this type of unstable circuit should be strictly avoided. The foregoing is a good argument for designing or using circuits that will accomodate parts of wide tolerance without imparing their operation.

Moreover, as in the case of individuals who specialize in specific fields in order to attain a high degree of proficiency, so must we expect circuits to specialize. Dual-purpose circuits, although generally more economical because they use less parts, are usually less reliable. This is one of the major reasons why parts manufacturers' complaints that the alleged lack of reliability of their parts is not due to the parts at all but rather due to misapplication of the parts in the circuitry. Dual circuits are usually blamed for such a situation. In summary, as a general rule it is a good principle to avoid the use of dual-purpose circuits when high reliability is desired.

Another argument in favor of standard circuits is that they are usually familiar to maintenance men, who have seen them before in other equipments. Therefore, this type of circuit can be packaged in a module that is interchangeable and easily replaced, resulting in a high degree of maintainability

A reminder for the electronics engineer with respect to tolerances is that he must consider the products of all manufacturers for the same type of approved part if he is to achieve a high degree of interchangeability.

It is not unusual for a part of a particular manufacturer not to function in some circuit while a part from another manufacturer does, even though each of them complies with the applicable specifications. It is apparent that in this case the interaction between part and circuit is different for each manufacturer.

A good designer will try a cross-section of parts from various approved manufacturers in his circuits and check their response by simulating tolerances through marginal checking techniques. This means that specific or critical voltages will be varied and the outputs for specified inputs are studied, in order that all possible effects can be assessed. If this study reveals that the only method which will permit the use of parts from all manufacturers is to specify tight tolerances, (such as plus or minus 1% values) then the circuit should be redesigned, because any part cannot be expected to maintain such tight tolerances over extended periods, even though they have been so advertised.

Marginal checking may also be used on major subassemblies to determine their degradation characteristics and to pin-point the reason for the effect. This includes the use of programming techniques and automatic readout to plot subassembly degradation and thereby establish proper preventative maintenance cycles.

Another variation of the marginal checking idea is called "testing to destruction". In this case various loads are imposed on a part or device and the outputs are monitored. The loads are varied by gradual increments until failure occurs. After sufficient data are accumulated, a statistical analysis will determine the safe loads, and limits can be imposed. A deficiency of this method is that the data are not obtained under the conditions of actual usage. In other words, the immediate part environment for each application is not the same as that under which the part was tested, nor are the electrical applications the same.

The only advantage, therefore, of the test-to-destruction technique is that it provides a "ball park" estimate of what stresses the part will withstand, and as long as the results are regarded in this light, they are useful to the designer. Another technique that is useful in improving reliability is called derating. In this application stresses are applied to the part which are less than those specified when reliab-

ility limits by the manufacturer. Various published derating data and curves are available to the designer who is interested in derating.

In those instances where the required degree of reliability is considered in excess of what is conceivably practical after study of all the techniques we have been discussing, the designer invariably resorts to redundancy. This is a technique that utilizes one or more additional parts, components or equipments which are intended to sustain the functions if the original fails.

Most of the time the use of redundancy is not justified, because of the additional costand space, but it is more than worthwhile if the advantages which accrue from the increased reliability are considered. However it should be used only when there are no other more-economical approaches possible, because it is usually the most costly method.

From the foregoing, it should be obvious that the man-machine interface is of paramount importance in current designs. No longer can we neglect this important aspect. Our aircraft travel too fast, and our equipment is too complex to neglect the effect of operators, not only from the reliability standpoint but also from the security and life considerations. An error in judgement by a fatigued operator could cost the lives of many, or could spell the difference between success and failure of a military engagement.

The techniques used to assure good reliable and maintainable designs are highly specialized in their technical aspects, but it was not my intention to get into these technical specifics. For example technical subjects of interest would have been considerations of various redundancy configurations, and an explanation of mission, time and equipment availability, new time sampling techniques, and the principle of the time constraint as applied to maintainable designs.

I have attempted to acquaint those of you who have not been exposed to the reliability and maintainability concepts with some of the underlying thoughts which compose this new science. If I have succeeded in doing this I have more than fulfilled my objective.

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*,1,2.

Reference: see "Reliability, Principles and Practice" by S. R. Calabro, Publ. 1962 by McGraw-Hill Company. Chapters 1 and 9.

STUDENTS SCIENCE AWARD

The 1963 recepient of the STUDENT SCIENCE HONOR AWARD given by the Radio Club, is Joseph Goodbread, a senior of the Jamaica (L. I.) High School. This award is given annually for out standing work in the Science Honors Program conducted by the Columbia University School of Engineering and Applied Science.

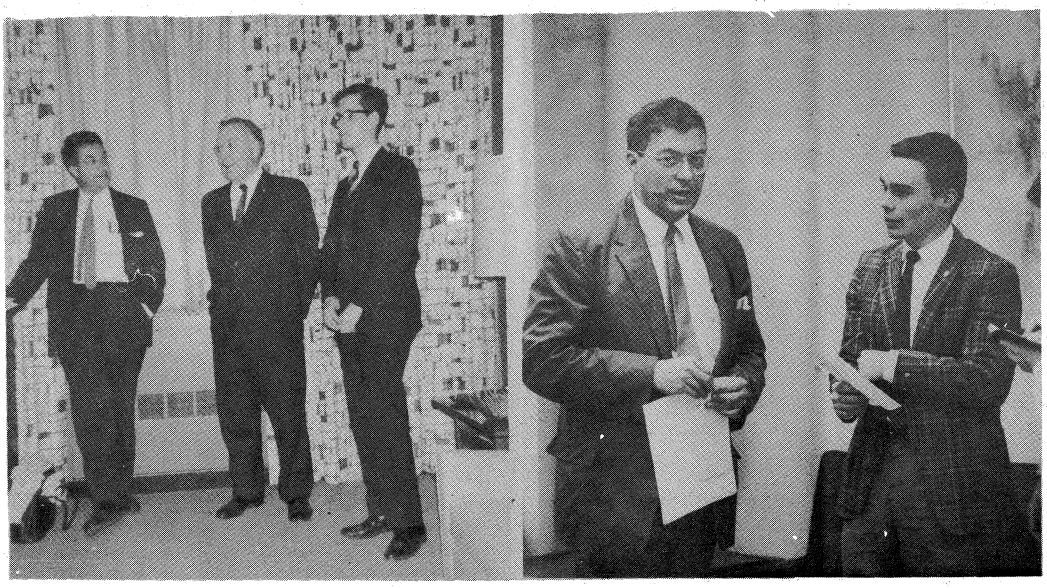
The AWARD, a cash gift, was delivered by club president Batcher, at a ceremony at the S. W. Mudd Engineering Building of the University, on April 22. The Columbia Science Honors Program was selected as the best media for selecting the most qualified student who shows unusual talents in scientific matters. It is granted each year by the Club to encourage research of the type that requires original thinking as well as individual efforts and ingenuity. Club Directors Bowes and Houck were also in attendance at these ceremonies.

The Science Honors Program, guided by Asst. Dean Donald Barr of Columbia, has the support of the National Science Foundation. Each year around 350 students are selected by competetive examinations from about 1800 nominees made by the science staffs in some two hundred and fifty junior and senior high schools in and around New York City. Thus the very privilege of participating in this program is quite an honor. The 350 students so selected spend 30 Saturdays a year in lectures, discussions and laboratory research programs in one of several fields of science, which range from anthropology and biology to astrophysics and advanced mathematics.

Joseph previously had completed several quite sophisticated projects of his own, at his own home, and was assigned to a group developing an electron microscope, under the direction of Professor L. D. Peachey and Mr. Joseph Thomas-Hazell. He soon thereafter became the group leader on this project. He will enter Princeton this fall and expects to specialize in bio-engineering.

The Club has made this Award for the second year. It may be of interest to report on a follow-up on the youth who received the honor last year, Mr. Paul Tukey of Hillside, N. J. It happened that about the same time that he received the Radio Club Award, he was also selected by the American Field Service as an exchange student to represent the U.S.A. in Italy and spent a year at the scientific High School in Naples. Paul will also enter Princeton this fall.

Your directors who attended the ceremony this year were greatly impressed with the scope of the work at the Columbia Science Honors Program and the talents and ingenuity shown by all of these budding scientists.



Left - Dean Donald Barr (Columbia University), Ralph R. Batcher, (Radio Club) and Joseph Goodbread (Jamaica, N. Y.) winner of the Club's Science Honors Award for 1963. Right - Dean Barr with Paul Tukey, Hillside N. J. who won the award 1962.

Newsbriefs

WIRELESS ANTIQUES

After an editorial that appeared in these pages last year, regarding the best method of disposing of interesting specimens of early types of wireless apparatus, we have received a number of comments. It seems that there is a growing interest in collecting "wireless" antiques, and that this hobby might become as important a hobby as that of old cars.

We have heard of many such pieces now at hand in the laboratories of some of our members, and that there are other interesting specimens among the effects of others now deceased. As an example the laboratory of the late Robert S. Kruse has a number of early General Radio and Grebe, etc., items. We are still looking for answers that we can pass on to anyone who has more equipment pieces on hand than they have storage space. It seems that good items of early gear often get thrown out when such collections are disposed of. It seems that most of our younger engineers generally look at all such items as junk - not having any salvagible transistors in them!

To bring things to a head, we decided to try out an experiment for just one issue of these Proceedings. In our Fall issue we will include a page of HAVE AND WANT ITEMS, listing only apparatus available or wanted, dating before the year 1925. To prevent this becoming a chore to the volunteers on our Publication Board, we ask that you just type out your own copy using a line length of about 65 characters per line in your typing. Send this with $1.00 for each four lines of your copy to the Club office. This fee for each four lines will about cover handling costs. Mark the copy APPARATUS. We cant take time to handle these small billing accounts, hence the advance payment.

Whether this experiment will be repeated will depend on the results of the response, but we will try anything once. Incidentally, Harry Houck, Chairman of our ARCHIVES COMMITTEE, is in charge of long range plans involving the CLUB's participation in preserving early radio apparatus items, and maybe interesting photos, manuscripts, and other good historical items. He will have comments about these plans in these columns later.

Incidentally, the Archives Committee would be interested in collecting current data on equipment museums of appreciable sizes, and on any values that are being placed on early equipment examples, that result from sales and transfers.

MEMBERS HEAR TALK ON BIO-MEDICAL ELECTRONICS

The last meeting of the 1963 Spring season was devoted to the ever-increasing need for improved measuring equipment and technical devices in the medical field. The paper was presented by Carl Berkeley, Editor of the magazine MEDICAL ELECTRONICS. It seems there is need for a diversity of electronic "gadgets" having serious import.

Carl, formerly Director of the Application Research studies at Du Mont, has had long experience in the uses of electronics in a number of fields, is also now Scientific Director of the Foundation for medical Technology. He is presently attending the International Federation for Medical Electronics Conference in Liege, which is concerned in the evaluation of bio-medical transducers this year, so his paper will not be ready for these pages for a while.

He mentioned a number of projects that could use the experience of electronic experts, so any Club members desiring specific information as to where he can do valuable service (as a volunteer) can drop a line to the Club and it will be forwarded.

Roster changes

A number of additions and deletions can be made to the membership listing contained in the Golden Yearbook. It has been our decision to publish a supplement to that section this Fall. The Yearbook Committee will contact all new members taken in after that Yearbook appeared, for personal data. By means of this notice we ask that all the others whose names do appear therein, to send us any information to up-date that information - changes in addresses, or in employment status, and any other personal information that should be included. The listings of members who have resigned, and those who have passed on since will be included.

A complete revision of the Yearbook will be considered at a later date. Therefore will all active members whose listing now appears in the Golden Yearbook please -

DROP US A POSTCARD INDICATING ALL CHANGES DESIRED IN THE INFORMATION CONTAINED THEREIN. IF WE DO NOT HEAR FROM YOU BEFORE OCTOBER 15th WE WILL ASSUME THAT NO CHANGES ARE NECESSARY.

EXPANDED COVERAGE

The pages of these Proceedings have always been open to all those having information of interest to our readers. In an effort to increase the total number of issues in a year, and the number of pages per issue we wish to emphasize a couple of features that were popular a few years back - a NEWS COLUMN with items of personal interest to and about members, and a CORRESPONDENCE PAGE.

The Club has always given special emphasis to developments resulting from individual efforts and personal initiative. Many of our most-read papers in past issues have been the contributions of individualists, like Armstrong and others, who carried out some basic research to an ultimate conclusion on their own initiative.

Contrary to much current opinions expressed in some quarters, not all useful research comes out of well equipped laboratories, with the most sophisticated facilities and whole "stables" of noted scientists that one can go to for help when he is stuck.

We are thus quite eager to get reports on interesting projects from our readers who are using their own facilities and talents (and Yankee ingenuity) on experiments of interest, whether just hobbies or of some commercial value. If the report is final and runs to a couple of pages in an issue it will be printed as a distinct article even if not delivered at a meeting.

However most of these communications will we assume, relate to notes of projects under way, or where assistance of other like-minded individuals is desired, who might like to participate in some out-of-the-ordinary hobby: new processes or an application for an old one; in fields of sports, games, education, the helping of young future scientists, development of electro-medical items, and the like. Elsewhere in this issue the matter of the collecting of wireless antiques is under discussion. Such matters will also get into the proposed CORRESPONDENCE PAGE.

As a result of a previous editorial, that appeared two years ago, we have heard of several hobbies being worked on by some of our retired members. To encourage the publication of such items we are working out details of a plan to give citations for the most interesting accomplishments sent in. Full details soon, so start your planning.

STYLES AND FORMAT

Editorial work preparing these issues is quite a chore, and always is just a labor of love on the part of a very few members. To save time for ye Editor and his staff we ask that all manuscripts be carefully studied by the authors, bearing in mind-completeness, clarity and accuracy. We will not make revisions and in only rare cases will suggestions be made to authors calling for additional information where we believe essential data is missing.

All photographs should be clear and sharp and on glossy paper. Sketches should be neat and clear, Lettering size should be consistent with the total size of the drawing, so than when reduced to a size suitable for our pages will remain large enough to be clearly understood. We will handle all retyping necessary to get more conformity between pages, but do not have any facilities for reworking any art work, or for handling complex formulas. However this should not discourage the use of any mathematical approaches, if they are of importance in the handling of the subject.

You all know what constitutes a good technical article, and if authors will analyze the material he is ready to submit, in the light of providing a text that he would enjoy reading if it were prepared by someone else, every one will be happy. We do not want to make the mechanics of submitting a paper just as easy as we can.

As for presented papers, arrangements are usually made with each speaker at the time of the meeting or before. We prefer to get a written copy of a lecture in hand three weks ahead of the meeting, so that we can have copies of the issue containing it at hand for distribution at the meeting. This permits the speaker to cover many additional items during his discussion.

CORRESPONDENCE NOTES, as discussed above follow the same rules where applicable. A major paper may contain from say ten to a couple of dozen typewritten, double-spaced pages. All symbols and mathematical signs should be clearly indicated. It may take about three typewritten pages to make one printed page.

Manuscripts may be mailed into the office of the CLUB, or given to a member of the Publication Board, as you prefer. The augmented Publication Board this year will expedite publication matters more rapidly than in the past.

EXTRA COPIES TO AUTHORS

It may be of interest to writers who are in the mood for writing an article for these pages, to know of a recent Board action which upped the number of " Author's Copies" from 25 to 50 copies, so that the author, or speaker, can supply their associates with copies.

If still more copies, in addition to these fifty, are wanted for commercial uses, they can be obtained at our publication cost, if the order is placed at the time the copy is sent in. This offer of free copies, however applies only for printed papers that are at least a couple of magazine pages long.

MEMBERSHIP APPLICATIONS

The Radio Club of America is one of the few membership organizations in the country that has not increased its membership dues during its career. While costs have increased many fold during this period of fifty five years membership dues are still only $3. You may know of several associates who might like to consider joining. The application blank in this issue is a step you can start. If you want a sample copy of Proceedings for him drop a line to Club office.

FELIX BECOMES EDITOR

Edgar H. Felix has consented to fill that most-important job - the Editor of these PROCEEDINGS, starting with the next issue. Ed, a long-time member of the CLUB, recently retired as the Manager - Planning Co-ordination, of the Defense Electronics Products, at RCA in Camden. After service in WW-1 in the Signal Corps, Ed was instrumental in helping establish that first Broadcasting Station in New York City, at Ft. Wood on Bedloe's Island.

As head of an augmented Publication Board recruited from our members, these pages will be more newsy and their appearance more frequent - IF all members remember to forward news items, comments and any other interesting paragraphs.

HISTORICAL EQUIPMENT CONCLAVE

We note that an amateur historical exhibit is scheduled on August 17th at Holcomb New York (in Rochester area). Here many equipment classics will be displayed and an interesting program will take place, including a dinner, that evening. Reservations ($4.25 per person) can be made with Lincoln Cundall, 69 Boulevard Pkwy. Rochester (12) New York.

ROBERT S. KRUSE DIES.

We regret to report the passing, on April 17, of Bob Kruse, an early pioneer in that 'new' art of "wireless", operating station SK in Kansas for many years before calls were systematized by Department of Commerce activities. During WW-1 Bob was a designer at the Western Electric Compamy on radio equipment, and later was an instructor at a Signal Corps radio training school. He later was associated with the National Bureau of Standards on radio communication matters, and then joined the staff at ARRL as Editor of QST, and for his work on the first editions of the ARRL Handbook. The author of several books and hundreds of technical articles, usually not signed, mainly dealing with that newly-opened field "below five meters" - that range of frequencies discarded by most of the commercial interests in the late-twenties.

For many years he has been a Consultant in many projects, and with many companies. He rejoined the Radio Club shortly before his death.

De FOREST AUDION AWARD

Benjamin F. Miessner has been awarded the De Forest Audion Award medal granted by the V. W. O. A. at its meeting in Florida. As our members know, Ben has always been a prolific inventor since his introduction to wireless while in the Navy in 1908. After this stint he served with John Hays Hammond (after 1911) and with E. J. Simon during WW 1. His early inventions included the cat-whisker detector, guidance control systems, single control receivers, He has been long known for his pioneer work in the field of electronic music. He has long been a strong advocate of the importance of original thinking in stimulating progress. and has been foremost in searching for ways whereby inventors can be adequately compensated. The Club expects to hear him discuss these matters in a forthcoming meeting.

Notes: regarding the Science safari comments in an editorial last year, would anyone be interested in exchanging ideas about setting up and using lasers? or in certain medical equipment items that might prove of interest? We will help similarly-minded amateurs in some of these non-communication fields to get together if you drop us a line.

FOUNDED 1909

The Radio Club of America, Inc.

11 West 42nd Street

New York 36, N. Y.

APPLICATION FOR MEMBERSHIP

TO THE BOARD OF DIRECTORS: .....19.....

I hereby make application for membership in THE RADIO CLUB OF AMERICA, and agree, if elected, that I will be governed by the Constitution as long as I continue a member, and refer to the sponsors named who are personally known to me.

(Please type or letter all information and read extracts from the Constitution on the back of this blank.)

FULL NAME (Family Name First) (Given Names)

BIRTHPLACE (State or Country) DATE OF BIRTH AGE YEARS

NATIONALITY (Of what country is applicant a citizen?)

Address—

* Home ☐

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** Indicate by X address to which notices should be sent.*

EDUCATION

SECONDARY SCHOOL DATES

to

COLLEGE OR UNIVERSITY (1) ATTENDED

DEGREES RECEIVED DATE

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DEGREES RECEIVED DATE

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Do not fill in below this line (see other side)

Receipt acknowledged..... Letters to Sponsors 1..... Sponsors Letters 1.....

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What particular branch of the radio art are you most interested in? .....

.....

DETAILS OF PRESENT OCCUPATION

(General Nature of Work Done by Your Firm [or Department] and Nature of Your Own Duties)

DATES	
From	.....
	.....
To Present Date	.....
	.....

PREVIOUS EXPERIENCE

(Prior to Present Occupation—Most Recent First)

DATE	TYPE OF WORK
.....	.....
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EXTRACTS FROM THE CONSTITUTION

ART. I SEC. 2. Its object shall be the promotion of co-operation among those interested in scientific investigation and amateur operation in the art of radio communication.

ART. II SEC. 1. The membership shall consist of:

(a) Members
(b) Fellows
(c) Honorary Members

Members, Fellows, or Honorary Members shall be entitled to all privilges of the Club except that Fellows only may hold office or be elected to the Board of Directors.

SEC. 2. A Member shall be a male or female person, not less than seventeen years of age, who has been interested in the investigation of the principles of radio communication and in radio operation, either in its commercial or amateur aspects, for a period of at least one year.

SEC. 3. An Honorary Member shall be a person of high professional standing who is interested in the activities of the Club.

SEC. 4. A Fellow shall have been a member in the Club for five years or one whose contributions to the Radio Art are of such a nature as to qualify him.

ART. III ADMISSIONS, EXPULSIONS AND RESIGNATIONS

SEC. 1. An applicant for admission to membership shall present the prescribed application, properly filled out, to the Corresponding Secretary. The application shall contain the names of three Fellows or Members to whom the applicant is personally known.

SEC. 2. Applications for membership shall be acted upon at the discretion of the Board of Directors.

SEC. 3. The Corresponding Secretary shall notify an elected candidate of his election and forward to him a statement of entrance fee and initial dues.

SEC. 4. Members found delinquent in their duties may be tried by the Board of Directors, and upon decision of the Board their names shall be submitted to the Club to determine their suspension or expulsion. A three-quarters vote of the Club will be necessary to ratify such action of the Board.

SEC. 5. A member may resign his membership by a written communication to the Corresponding Secretary, who shall present the same to the Board of Directors; when, if all his dues have been paid, his resignation shall be accepted.

ART. IV ENTRANCE FEE AND DUES

SEC. 1. The annual dues payable by Members shall be Three Dollars; for Fellows, Five Dollars. The entrance fee payable by Members on election to membership shall be One Dollar. Honorary Members shall be exempt from payment of any dues or fees.

SEC. 2. The annual dues shall be payable on the first day of each calendar year, in advance of the ensuing year. It shall be the duty of the Treasurer to notify each Member or Fellow of the amount due.

SEC. 3. Every Member or Fellow, upon payment of his annual dues, shall be furnished with a membership card bearing the signature of the Treasurer.

SEC. 4. Persons elected to membership after July 1st of any year shall pay only one-half of the dues for that year.

SEC. 5. Any Member or Fellow whose dues become two months in arrears shall be notified by the Treasurer. Should his dues then become four months in arrears, he shall again be notified by the Treasurer. Should his dues then become six months in arrears he shall forfeit his connection with the Club. The Board of Directors may, however, for sufficient cause temporarily excuse from payment of annual dues any Member or Fellow or extend the time for payment.

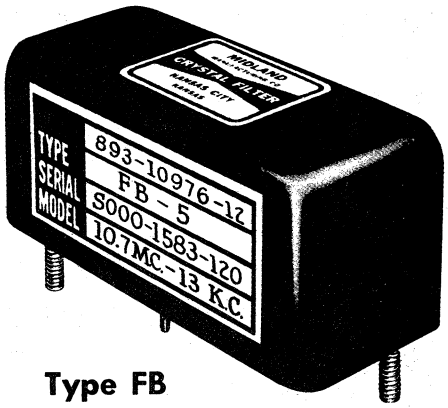
SEC. 6. Every person admitted to the Club shall be considered as belonging thereto and liable for the payment of all dues (except as per Sec. 7 of this Article) until he shall have resigned, been expelled or have been relieved therefrom by the Board of Directors.

SEC. 7. Any Member or Fellow not in arrears, upon payment of One Hundred Dollars shall be exempt for life from the payment of Annual Dues.

Delivered In Quantity...

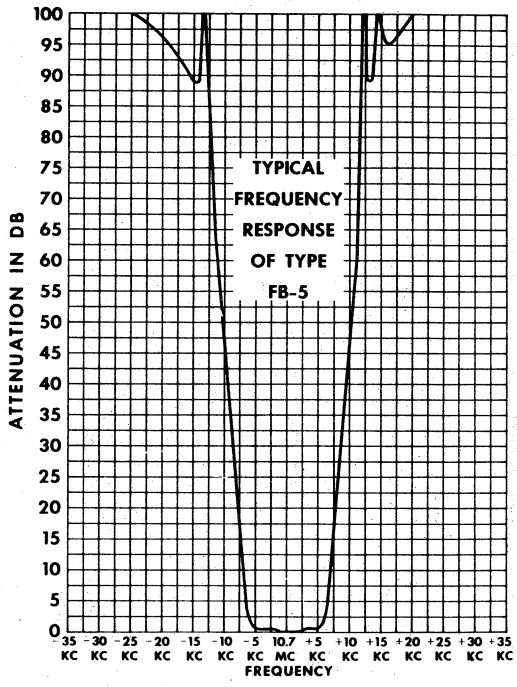
MINIATURE

Narrow Band-Pass Crystal Filters



Type FB

The Midland Type FB Series is a group of hermetically sealed, eight-crystal, narrow-band filters that provide bandwidths in the range of 2 KC to 30 KC @ 6 db, with a center frequency of 10.7 MC. They are designed to operate in the environmental temperature range of −55°C to +90°C with an insertion loss of 4 db max. and an inband ripple of .8 db max. The Type FB narrow-band crystal filter is ideally suited for design in two-way communication systems, telemetry systems, electronic instrumentation equipment and other 10.7 megacycle applications where small fractional bandwidth filtering plus a high degree of selectivity and temperature stability is required. It can be used to best advantage in designing single-signal RF stages to give greater adjacent channel separation and performance reliability, in addition to conserving space and reducing material and manufacturing costs. Midland invites inquiries in assisting with any engineering problem where the use of crystals and crystal filters is proposed.



Specifications

	FB-5
Center Freq.*	10.7±375 CPS
BW @ 6 db Min.	13 KC
BW @ 60 db Max.	23 KC
60 db/6 db BWR Max.	1.8
BW @ 80 db Max.	26 KC
Ultimate Rejection Min.	105 db
Req. Source/Load Resistance (R_o)	1 K ohms
Inband Ripple Max.	.8 db
Insertion Loss Max.	4 db
BW @ 1 db Min.	10 KC

*Center freq is the arithmetic mean of the frequencies at 6 db.

Operating Temp. Range: −55°C to +90°C
Shock: 200 g
Vibration: 15 g to 2 KC
Max. Input Level: +10 dbm

Midland MANUFACTURING COMPANY, Kansas City 15, Kansas

WORLD'S LARGEST PRODUCERS OF QUARTZ CRYSTALS

DIVISION PACIFIC INDUSTRIES INCORPORATED

Robert Finlay SALES COMPANY
MANUFACTURERS REPRESENTATIVE
RIDGEWOOD NEW JERSEY

MEASUREMENTS' — "FAMOUS FIRSTS"

1939

MODEL 54 STANDARD SIGNAL GENERATOR — Frequency range of 100 Kc. to 20 Mc. The first commercial signal generator with built-in tuning motor.

MODEL 65-B STANDARD SIGNAL GENERATOR — This instrument replaced the Model 54 and incorporated many new features including an extended frequency range of 75 Kc. to 30 Mc.

1940

MODEL 58 UHF RADIO NOISE AND FIELD STRENGTH METER — With a frequency coverage from 15 Mc. to 150 Mc. This instrument filled a long wanted need for a field strength meter usable above 20 Mc.

MODEL 79-B PULSE GENERATOR — The first commercially-built pulse generator.

1941

MODEL 75 STANDARD SIGNAL GENERATOR — The first generator to meet the need for an instrument covering the I.F. and carrier ranges of high frequency receivers. Frequency range, 50 Mc. to 400 Mc.

1942

SPECIALIZED TEST EQUIPMENT FOR THE ARMED FORCES. WORLD WAR II.

1943

MODEL 84 STANDARD SIGNAL GENERATOR — A precision instrument in the frequency range from 300 Mc. to 1000 Mc. The first UHF signal generator to include a self-contained pulse modulator.

1944

MODEL 80 STANDARD SIGNAL GENERATOR — With an output metering system that was an innovation in the field of measuring equipment. This signal generator, with a frequency range of 2 Mc. to 400 Mc. replaced the Model 75 and has become a standard test instrument for many manufacturers of electronic equipment.

1945

MODEL 78-FM STANDARD SIGNAL GENERATOR — The first instrument to meet the demand for a moderately priced frequency modulated signal generator to cover the range of 86 Mc. to 108 Mc.

1946

MODEL 67 PEAK VOLTMETER — The first electronic peak voltmeter to be produced commercially. This new voltmeter overcame the limitations of copper oxide meters and electronic voltmeters of the r.m.s. type.

1947

MODEL 90 TELEVISION SIGNAL GENERATOR — The first commercial wide-band, wide-range standard signal generator ever developed to meet the most exacting standards required for high definition television use.

1948

MODEL 59 MEGACYCLE METER — The familiar grid-dip meter, but its new design, wide frequency coverage of 2.2 Mc. to 420 Mc. and many other important features make it the first commercial instrument of its type to be suitable for laboratory use.

1949

MODEL 82 STANDARD SIGNAL GENERATOR — Providing the extremely wide frequency coverage of 20 cycles to 50 megacycles. An improved mutual inductance type attenuator used in conjunction with the 80 Kc. to 50 Mc. oscillator is one of the many new features.

1950

MODEL 111 CRYSTAL CALIBATOR — A calibrator that not only provides a test signal of crystal-controlled frequency but also has a self-contained receiver of 2 microwatts sensitivity.

1951

MODEL 31 INTERMODULATION METER — With completely self-contained test signal generator, analyzer, voltmeter and power supply. Model 31 aids in obtaining peak performance from audio systems, AM and FM receivers and transmitters.

1952

MODEL 84 TV STANDARD SIGNAL GENERATOR — With a frequency range of 300-1000 Mc., this versatile new instrument is the first of its kind designed for the UHF television field.

1953

MODEL 59-UHF MEGACYCLE METER — With a frequency range of 420 to 940 megacycles, the first grid-dip meter to cover this range in a single band and to provide laboratory instrument performance.

1954

FM STANDARD SIGNAL GENERATOR. Designed originally for Military service, the commercial Model 95 is engineered to meet the rigid test requirements imposed on modern, high quality electronic instruments. It provides frequency coverage between 50 Mc. and 400 Mc.

1955

RADIO INTERFERENCE MEASURING SET. An aperiodic noise meter useful to 1000 Mc.

1956

MODEL 505 STANDARD TEST SET FOR TRANSISTORS. A versatile transistor test set which facilitates the measurement of static and dynamic transistor parameters.

1957

RADIO FIELD STRENGTH AND INTERFERENCE MEASURING SET. A tuned radio interference and field strength set covering the frequency range of 150 Mc. to 1000 Mc.

1958

MODEL 560 STANDARD FM SIGNAL GENERATOR — First successful FM Signal Generator using solid state modulator.

1959

MODEL 700 FREQUENCY METER — A completely new concept of frequency measurement. An instrument capable of direct and continuous reading to one cycle in 25-1000 Mc. range.

1960

MODEL 139 TEST OSCILLATOR — A compact, versatile, and portable instrument for rapid and accurate alignment of I.F. circuits in all types of radio receivers.

1961

MODEL 760 STANDARD FREQUENCY METER — An accurate, simple to operate, direct read-out, portable instrument designed for servicing two-way mobile radio equipment.

1962

MODEL 140 STANDARD DEVIATION METER — A portable, self-contained instrument designed to accurately measure the peak deviation of F.M. transmitters. Frequency coverage from 25 to 1000 Mcs.

MEASUREMENTS
A McGRAW-EDISON DIVISION
BOONTON • NEW JERSEY • U.S.A.

Another *hallicrafters* FIRST ----

with SSB !

New kind of information center brings you all the things you don't want to get away from

If you need a portable only for an occasional picnic, then frankly this one is out of the ball park. But if you are a man of action whose interests demand important and reliable information wherever you go . . . read on.

This precision communications instrument utilizes the same type of high performance hand-wired circuitry and features employed in Hallicrafters' finest professional and military receivers.

Four separate short wave bands bring you news of important world events, direct by short wave (in English) from Moscow, Berlin, Havana, London — with as many different viewpoints. And you can monitor radio amateurs, military, aviation, government and disaster frequencies at will.

The low-frequency band brings you reliable aviation data and government weather reports from hundreds of miles around, 24 hours a day . . . plus Consolan marine navigation . . . and you'll hear home-town stations from hundreds of miles away on the extreme-sensitivity AM band.

- ★ **Six bands — four short wave (foreign, amateur, government, military, disaster frequencies) plus extended-range AM plus long wave band for aviation weather and marine navigation.**
- ★ **BFO for code, single sideband and Consolan (marine navigation system) reception.**
- ★ **Weighs only 12 lbs.; plays up to 500 hours on ordinary flashlight batteries.**
- ★ **Illuminated, rotating dial shows band in use.**
- ★ **Three-position tone control.**
- ★ **Vernier fine-tuning knob for far-away stations.**

hallicrafters

WR-3000 Portable

6-band, communications-type
SHORT WAVE/LONG WAVE
plus AM RECEIVER

This is no "ordinary" portable, but a six band, precision communication instrument utilizing the same type of high-performance, hand-wired circuitry and features found in Hallicrafters finest professional and military receivers. Completely transistorized. **Priced under $200.00.**

In 1860, with war impending, need became acute for communications between the East and California. The Government established the Pony Express to carry the mails. Horses were kept at "stages" every ten or fifteen miles between St. Joseph (Mo.) and the Pacific.

Each rider covered some seventy-five miles. Neither snow nor rain, mountain nor desert, nor the attacks of hostile Indians stopped them. They traversed in eight days the distance a stagecoach required twenty-four days to travel.

After eighteen short months, the telegraph replaced them. But the heroic hoofbeats of their horses have thundered down a hundred years of history.

Messages today travel at the ultimate velocity: the speed of light. Via REL tropo scatter radio, a part of so many military and civilian systems, they also leap lightly over obstacles. In Herculean strides of up to 500 miles, they by-pass old barriers – vast stretches of snow, desert, and mountain.

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