OUR COVER

. . . an advanced-development model of the new transistorized TK-42 color TV camera, which has a monochrome channel added to the conventional red, green, and blue color channels. This four-channel approach provides both top-quality monochrome pictures and improved fidelity of color pictures. (See article by Sadashige and Kozanowski.) At top are the new electrostatically-focussed, magnetically deflected vidicons (see article by Neuhauser) used in the three color channels, and the image orthicon for the monochrome channel. Shown in the camera monitor are (left) Dr. H. N. Kozanowski, Mgr., TV Advanced Development, Broadcast and Communications Products Division, Camden, N.J., where this camera was developed, and R. G. Neuhauser, Engineering Leader, Image Orthicon Development, Electronic Components and Devices, Lancaster, Pa., where the vidicons and image orthicon were engineered. (Cover art direction, Jack Parvin. Photographs, Rodman Allen.)

With Science and Skill

A favorite expression of one of RCA's very competent engineering managers is "*The problem was solved with science and skill.*" The phrase *science and skill* is one that I like because it shows the need for both knowledge and common sense, or training and individual ingenuity. Although science and skill are very important, RCA engineers need more than this; they need a *secret ingredient.*

You are well aware that RCA sells engineering. In much of our business with military agencies, engineering capability is marketed quite directly. With products such as phonograph records, television sets, tubes, transistors, and various communication equipment the sale is indirect. If it were not for competition, we engineers might anticipate a very relaxing life. The mental image of a technical *Utopia* with unlimited funds, time, and support quickly vanishes with the realization that in our every field of interest some competitor has a capable engineering force intensively trying to be the best in the industry. This is why good engineering *with science and skill* is not enough. It is the norm against which we compete on all fronts.

Within the Broadcast and Communications Products Division, the broadcasting equipment engineers each year face an important deadline. It is the annual convention of the National Association of Broadcasters. At the convention this year we displayed an unprecedented number of new items ranging from a small audio amplifier to a 30-kw UHF transmitter. Each represented a significant investment of engineering and each required something more than good engineering by the individuals involved. These new products represented a *personal dedication* by each engineer toward the common goal. *This* is the secret ingredient.

I am proud to be associated with engineers who give so willingly of their time and ability, and I invite you to read about a few of their accomplishments on the following pages. I also challenge you to make *all* of your capability part of the team effort within RCA.

W. C. Morrison

Wendell C. Morrison
Chief Engineer
Broadcast and Communications Products Division
Radio Corporation of America

RCA ENGINEER

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AUG.-SEPT. 1964

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A TECHNICAL JOURNAL PUBLISHED BY **RADIO CORPORATION OF AMERICA,** PRODUCT ENGINEERING 2-8, CAMDEN, N. J.

● *To disseminate to RCA engineers technical information of professional value.* ● *To publish in an appropriate manner important technical developments at RCA, and the role of the engineer.* ● *To serve as a medium of interchange of technical information between various groups at RCA.* ● *To create a community of engineering interest within the company by stressing the interrelated nature of all technical contributions.* ● *To help publicize engineering achievements in a manner that will promote the interests and reputation of RCA in the engineering field.* ● *To provide a convenient means by which the RCA engineer may review his professional work before associates and engineering management.* ● *To announce outstanding and unusual achievements of RCA engineers in a manner most likely to enhance their prestige and professional status.*

An index to RCA ENGINEER articles appears annually in the April-May issue.

MANY RCA engineers may desire to contribute to the general body of technical knowledge by placing some of their general or specialized technical experience on paper—not just in an article or report, but in the larger, more comprehensive form of a technical book. The reasons for so doing may range from one of simple professional pride, through gaining prestige for RCA and for the author by documenting major advances in his particular field, to a perfectly natural desire for a monetary return.

Whatever the reason, the engineer-author may face many questions he can't readily answer: *1) To what level should the book be written? 2) Is the material really important enough to be published? 3) Which publisher(s) would want the material? 4) How do I go about contacting the publishers? 5) Should I take a flat fee, or get an advance on royalties? 6) Do I need an agent or a lawyer? 7) What's the story on copyrights? 8) Do I do my own artwork, or shall I supply sketches only?*

The Engineer and the Corporation

HOW TO WRITE A TECHNICAL BOOK AND GET IT PUBLISHED

M. P. ROSENTHAL
Systems Laboratory
Communications Systems Division
DEP, New York City, N.Y.

The author's own trials and tribulations described herein may help other RCA engineer-authors to get over the bothersome initial obstacles—and start writing. The suggestions included may also help in completing the writing job itself and (hopefully) in dealing effectively with the people associated with the writing and publishing effort.

CHECK YOUR RCA LAW DEPARTMENT

Before you do so much as put a pencil in hand, contact the responsible RCA Law or Patent Department personnel serving your Division. (It is assumed, of course, that you have already received your supervisor's endorsement of the writing project.) *Why do this?* Most companies (RCA included) have a procedure whereby every article, paper, and book must receive official company approval before publication. Such procedures protect both the author and the company from hassles over proprietary data, copyright laws, and questions about signing contracts between the publisher and you, an RCA author. My own experience has shown that no restrictions arise as long as your RCA affiliation is clearly stated and when the RCA reviewers agree that the company's best interests are being served by having your text appear in print. Your RCA Technical Publications Administrator will advise and assist you in obtaining reviews and approvals later on when you reach that stage of completion.

Final manuscript received April 10, 1964

DECIDING THE LEVEL

Once you've straightened out all your legal problems, the first thing to do is sit back and decide just about what level of reader you want the book to reach. For example, *do you want to write it so that the layman can understand it? Or would you prefer to keep it at the level of a recent college graduate's understanding? Or, the level of a professional already partly familiar with your work?* Your basic reason for writing the book should help you determine the level. For the author whose sole purpose is to document professional knowledge—without too much thought for monetary gain—the level will probably be at least that of the college graduate. On the other hand, the market for laymen or inexperienced professionals is much larger. Finally, to combine both profit *and* prestige there's the possibility of writing it as a textbook for a high school or college curriculum—perhaps a smaller initial market, *but*, think of the *steady* income should one or more schools decide to use the book as a basic text.

PREPARATION OF OUTLINE AND SAMPLE CHAPTERS

Having decided the level, you can then prepare an outline. Make it a good one; one in which idea follows idea in a logical order. If you have an editor handy, say, someone in your division's engineering publications department, have him go over it.

With the outline a finished, polished piece of copy, *write at least one chapter, preferably two or three.* A sample portion of the book accompanying the outline often means the difference between acceptance and rejection by a publisher. (Some publishers require it.) In writing the sample chapter, follow the outline as closely as possible. You'll find it difficult, as thoughts wholly necessary to the chapter(s) but not thought of during outline makeup, enter your mind. But don't let this bother you; most publishers know that some deviations from preliminary outlines are inevitable, and may make for a better book.

Fig. 1 illustrates a useful typing format for the manuscript. Note the special characteristics therein for *book manuscripts* (wide margins, author's name on each page, word count, etc.).

WHAT ABOUT ARTWORK?

Now, what about the artwork that accompanies your samples? On the whole, this will comprise some sketches you've drawn as you went along. Redraw them neatly, using straight-edges and a dark pencil. Keep them as neat and clean as possible. In fact, draw them as if you had to use them as is, without benefit of having a draftsman redo them. The use of a few triangles and circuit-symbol templates will be repaid by the professional look they give your work. Another thing, try to do the drawings on translucent paper, preferably graph paper with guide lines of nonreproducible blue; the blue lines drop out in almost any reproduction process leaving you with a clear drawing on a clean background. Any of the usual office-copier or drafting-room reproduction processes is good enough for submittal of acceptable artwork; however, Xerox is best for first contact, since it's clean and neat, and fairly cheap, about $0.05 a copy. You may also include a few sample photos that you propose to use. (More on artwork later.)

COMPANY APPROVAL

Now, you are ready to obtain a formal review and approval through your RCA divisional TPA. First, submit multiple copies of the outline and sample chapter. Then, in accordance with the procedures worked out personally with your TPA, continue to submit the book, chapter-by-chapter, as you complete it. In addition to gaining the necessary formal approvals, you'll be pleasantly surprised at some of the helpful comments that can result; things you may well have overlooked in your writing.

SELECTING THE PUBLISHER

Your motivation for writing may be genuinely professional, but you must become an *entrepeneur* when seeking a publisher. First of all, a publisher is interested mainly in *money*. Secondly, it's not "Who shall I trust with my labor of love?"; it may be more like this, "I wonder who'll be willing to take a chance on a new author?"

With this last thought firmly in mind, let's explore the possibilities. First, let's use both level and monetary reward as determining factors. Say, for example, you've aimed at a senior in an engineering curriculum. This connotes a textbook, and a hard-cover one, at that. This automatically leads you to a publisher on the order of McGraw-Hill, or D. VanNostrand, Inc. On the other hand, suppose you want to appeal to the mind of a high-school science student or a college engineering major. This, too, connotes a textbook, but with a difference: it can be either hard of soft cover. One of the largest publishers in this field is John F. Rider Publisher, Inc. Another is Prentice-Hall, and McGraw-Hill on occasion.

Next, which publisher has the greatest prestige in your particular field? Which publisher specializes in the type of book you're planning: reference book, textbook, or "how-to" book? The answers to these questions tie in directly with the factors of level and financial reward.

Usually, greater professional prestige obtains with higher levels of readership. (For example, the McGraw-Hill College Textbook Series). Such texts connote a smaller, although steadier market. On the other hand, Rider's prestige in laymen and high-school student texts is tremendous, and the market is huge; sort of paradoxical, but there it is. As for measuring the greatest prestige, your own readings at school and work can tell you which publishers had the best books; that is, which ones did you find most helpful? One further item on personal and professional prestige—the greater that of the publisher, the greater yours. This can mean a lot in the future, both in terms of your employer and your gaining the acceptance to write another book, or even short articles. In fact, it could lead to publishers seeking you out, instead of the reverse.

HOW DO PUBLISHERS PAY YOU?

What are the payment setups of the various publishers? Again, you must make a choice, between prestige and reward. It may happen that your choice of publisher offers greater professional prestige but less monetary reward; my advice is to stick with your first choice, since you may apply to your number two choice later, if you are rejected.

Publishers rarely offer a flat fee for a book-length work. Payments are almost always a cash advance against future royalties. Publishers who offer a greater percentage of the book's potential gross or net profits as royalties usually offer a smaller advance, and vice versa. Remember, the cash advance is taken out of the potential royalties.

One thing to help you in your decision is a consideration of the tax laws. Usually, the bigger the advance, the bigger the tax bite for the year in which the advance was made. The publisher doesn't take out withholding, so the Internal Revenue Service (IRS) hits you all at once. The publisher is supposed to send you a printed statement of cash payments made by him to you. This usually arrives just before the tax deadline. Once you get it, simply follow the instructions on rents and royalties in the tax data furnished every year by the IRS.

Whatever the case, you earn more in the long run by taking a smaller advance and getting more in royalties which are spread out over a longer interval. Remember though, that as a beginner author, you will probably have to take whatever is offered; once you're established it's another story.

One last item. Your company library, any good public library, or your own intimate knowledge of your field can tell you whether a similar book has already been published. If one such does exist, the answer is obvious: Just don't contact that publisher. A rival publisher would be more likely to want your book, especially if the other book is selling well and you can convince him yours is superior.

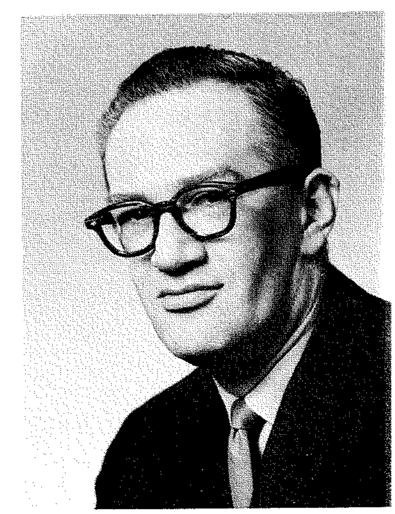
CONTACTING THE PUBLISHER

The outline is written, as are the sample chapters, and sample artwork is complete. Now you're ready to contact your choice of publishers, but how do you go about it? A good source for this information is a book entitled *Writer's Market '63*, which lists all significant publishers together with their requirements, basic policies, etc.[1,7] After selecting an appropriate one, send the outline and sample chapters, together with a short covering letter; the letter should contain a listing of anything you've written and already had published, and where it has been published. You might also mention where you think the book will sell, and give the reasons for your belief. Better make these good, though; remember, the publisher has sold many, many books, and is apt to know more about this than you do.

Maybe you are thinking, "perhaps an agent could do all this." My experience is that competent agents in the technical book field are scarce, the job takes longer this way—and it costs you more in money and patience in the long run.

So, you've shipped off the outline, sample chapters, and covering letter. Now just sit back and wait—don't expect any answer in less than a month, unless the publisher is especially interested. Of course, you may get your material back, and you can start all over again with your second choice.

MURRAY P. ROSENTHAL received the BS in Physics at Brooklyn College in 1959, and is currently taking graduate courses in English leading to an MA. His education also includes Diplomas of Electronic, Advanced Radar, and Airframe Technician from various civilian and military schools. Mr. Rosenthal has been in the field of electronics since 1944, when he was a USAAF technician. He then spent several years as a Radio-TV Technician, then switched to publications. Starting as a writer with the Espey Mfg. Co., N.Y., 1953, he progressed to technical writer at Consultants & Designers, N.Y., then to Electric Boat Div., General Dynamics Corp., Groton, Conn., in 1955 as senior writer and group leader. He then joined Renwar, Inc., N.Y., in 1956, as senior writer and group leader. He joined RCA in the DEP Communications Systems Div. in 1960, as a Member, Technical Staff, of the New York Systems Laboratory. He has since become Senior Member, Technical Staff, supervising the Engineering Publications and Repro Departments, and serving as an RCA ENGINEER Editorial Representative. He is a Member, IEEE (PTGEWS, PTGA), and Senior Member, STWP. In addition to articles, his writings include two books, "Basics of Fractional HP Motors," John F. Rider, Publisher, 1962, and "Fundamentals of Radio," scheduled for June 1964 release by Rider, as well as many contributions to EIA and government manuals. His current extracurricular work is a book on hi-fi, scheduled for release in 1965.



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(No. of Words)

(TITLE)

(AUTHOR'S NAME OR PEN-NAME)

On the first page, begin text about halfway down; on subsequent pages, start text at top margin. Typing must be double-spaced on one side of white bond paper, with minimum erasures. Use a standard elite typewriter (conventional office variety) with a fresh black ribbon. Do not use a typewriter with an "arty" typeface (gothic, script, etc.) or with proportional spacing (IBM Executive or Varitype). Leave liberal margins; from 1 1/2" to 2" top, bottom, and left, and 1" on right.

Put the number of words in book in the upper right-hand corner of the first page. To estimate this, count the exact number of words on 10% of the pages, and then multiply by ten.

On all succeeding pages, put page number in top right corner and your surname in top left corner.

Make at least one copy for your retention.

Fig. 1—Book manuscript format. Use for both sample chapters and final manuscript. In sample chapter, word count should be the planned length of the whole book. In final manuscript, it should be the actual length, counted as noted in the above sample. Careful manuscript preparation counts heavily in gaining a publisher's favor.

June 5, 1964

Radio Corporation of America
Electronic Components and Devices
Somerville, N.J.

Attention: Public Relations Dept.

Gentlemen:

I am presently engaged in the preparation, for the ____________ Publishing Co., of a book for retail and educational sales, entitled "____________________________."

I would greatly appreciate any help you could furnish, in the form of technicalliterature, illustrations (photos, cutaways, etc.), charts, and graphs, which is pertinent to your power transistor product line. In addition, similar data on tunnel diodes would be appreciated.

Any such data used would carry full acknowledgement as to the source, including the "courtesy" line for each illustration.

Thank you for any help you can give me.

Sincerely yours,

M.P. Rosenthal
2534 E. 66 Street
Brooklyn 34, N.Y.

Fig. 2—A data request letter. If sent to an RCA activity, add mention that you are an RCA employee, and give your activity. Be as specific as possible in your request. Most firms will readily supply a variety of material in return for an appropriate "courtesy of" line in your book.

One little *important item! Don't* send other copies of the outline and chapter(s) to any other publisher *until* you've heard one way or the other about your first submittal. Spraying the field may be your idea of a better chance of success, but it isn't. Competitive though all publishers are, they compare notes. If you submit to more than one at a time, *all* of them get wind of it, and you're dead. On the other hand, suppose two publishers want it; the one you turn down may never again even look at any other material you or RCA submits.

YOUR BOOK HAS BEEN ACCEPTED

Hurrah! A publisher has accepted your proposal; you're on your way. He has told you to go ahead and write the book and a contract will be forthcoming. Go ahead and start writing, but don't rush it. Wait for the contract to show up before you go too far. The publisher may have decided to revise your outline, or decided in his own mind that you'll only need four months to complete the book, when you know very well that such a deadline is impossible. Later on, if you have unavoidable delays, most publishers will be reasonable in their demands. Whatever the outlook, don't commit yourself too firmly until you've received and digested the contract very thoroughly.

WRITING AND ILLUSTRATING THE BOOK

You've cleared up the details on the contract to your satisfaction, signed it, returned it to the publisher, and you're ready to get to work.

Where and how to get your source material? Do you have it all in your head? I doubt it. You have the main idea, of course, upon which you based your outline. But how about reference material, upon which you base your conclusions, or from which you've taken data to support your thesis? And, do you intend doing all of your own diagrams, graphs, etc.?

If your book describes products or technical processes with which RCA is involved—e.g., computers, antennas, radar sets—the appropriate RCA marketing, public relations, or sales departments can supply a wealth of photos, technical literature, and descriptive data. (The same holds true for other companies.) Get all of it you can, and use whatever you can to illustrate the book without making it appear that you're going overboard in plugging specific products (publishers frown on this). (Remember that the captions for such photos must each contain a "credit line" mentioning the company that supplied it.)

Before sitting down to write the main text, gather together a list of all the individuals, groups, RCA activities, and other companies that are involved with your topic. (The *IEEE Annual Directory* and the *Electronics Buyer's Guide* are useful sources for this if your book is design or equipment oriented.) Now make up an information-request form letter, such as the one shown in Fig. 2, and spray the field. The more letters sent out the better: you have to figure on some no-answers and some answers which don't give you exactly what you ask for.

With these out of the way, list all the possible books, magazines, articles, and reports, you think you're going to need to read for source material. If possible, try to use material produced by the publisher with whom you have your contract: he'll be more than willing to lend it to you, freeing you from the burden of buying it or searching libraries for it. Whatever he doesn't have you may get in your RCA or public library, or by means of free reprints of the articles you desire; most technical companies, including all divisions of RCA, publish reprints as a regular practice.

One of your best possible sources is the U.S. Government Printing Office. They have a wealth of published information for sale, ranging from $0.05 for a pamphlet to $3.50 for a Technical Manual; write for their catalog or catalogs in the field(s) in which your interest lies.[2]

Government publications permit you to "lift" pertinent data and drawings, with no official permission required; however, flagrant use of Government source material is frowned upon. In fact, to be on the safe side, you should edit all material; in most cases you will want to edit to your own style and format.

Now you can start writing. You know what style you prefer to use, or about the use of grammar and punctuation, spelling, and continuity of thought. There is already a surfeit of books and papers on these topics.[6] However, I can point out a few time savers which can help.

Try to utilize the literary standards most accepted by the professional society concerned with the technical field involved. This includes such items as abbreviations, mathematical symbols, technical definitions, etc. For example, a book on electronics would use IEEE Standards; one on gears would use ASME Standards; one on chemistry would use ACS Standards; and so on. Conflicts may occur, of course, where your topic overlaps several technical fields. When this does happen, you must make compromises, especially where the technical terms have different meanings in the various disciplines. In *any* technical book it is always wise to prepare a *Glossary of Terms* to cover those that you have used in a specific way in the text. Add to it freely as the writing proceeds, and place it at the *beginning* of the book so that the reader knows immediately where to look for a particular symbol or term.

MATH, TYPING, FINAL ART, AND EDITING

Before you hand the material over for final manuscript typing, give some thought as to how you are going to put in the manuscript any mathematical symbols you might need. My advice is to do them yourself, with a good India Ink pen. There are several good reasons for doing this. First, very few typists have math (Greek) symbols on their typewriters. Unless the typist is a real whiz at it, the typing job will be much slower than you expected; you must proofread and close check the whole text when the typing is finished; since you're doing this anyway, it is just as easy to insert your equations and symbols as you go along.

So, have your typist *leave out all* math symbology, with sufficient space left for you to write it all in. As a help to you, she could indicate in the margin, by means of nonreproducible light-blue pencil, just where she has made her omissions. These, in addition to your own proofreading, are insurance that you won't omit anything.

Always keep up a running List of Illustrations, as you write; this is invaluable in keeping you abreast of your last reference number, and if properly maintained, facilitates compilation of the final artwork. Your outline can serve as the basic Table of Contents, filled in as you progress. Producing the final artwork can work both ways: in my case, one publisher did all final art, while another required me to do my own, i.e., have an artist or draftsman do the work at my expense. When the publisher does the final art from your sketches, the cash advance is usually lower, and vice versa.

Publishers do not take on the job of manuscript typing. *You* do it, or have it done. When you figure that any book manuscript runs to a minimum of 250 double-spaced-typed pages, typing could be an expensive item. I have found the cheapest and best method is to approach a friend or neighbor, one with a typewriter at home, and amenable to free-lance work. Done this way, my last typing job, about 280 pages, cost only $50.00, about $0.16 per page. Commercial rates run anywhere from $0.50 to $1.50 per page, depending upon complexity.

The number of final manuscript copies you must submit is a variable. The minimum is two, one for the publisher's technical editor, the other for a spare should the edited copy go astray. *Always* make a copy for yourself. It comes in handy in the event of disputes over content, if the editor has some questions that can be answered by phone, and when you're proofreading galleys and/or page proofs.

It usually takes about six to eight months from submittal of final manuscript to actual publication. The time elapsed in between is required for editing, incorporating changes and corrections, setting up the galleys, sizing of art, layout, checking galley proofs, and scheduling.

REFERENCES AND COPYRIGHTS

Should you use another work or magazine article for reference, and have occasion to quote from it, be sure to give credit to the author and/or magazine. If you have excerpted quite heavily, or are using a drawing as is, get written permission to do so from the source: Very often the material is copyrighted, and you stand a chance of being sued unless you have "permission to use" in black and white. Speaking of copyrights, familiarization with the requirements for and infringements of trademarks and of the copyright laws is a must; see the Bibliography for sources on this.[3,4,5] Also, your RCA Law Department can guide you in these respects, and your publisher may have specific requirements.

CONCLUSION

To write and get a technical book published can be a very challenging effort—yet a rewarding accomplishment in terms of personal, professional prestige, RCA's image as a competent technical company, and even in the return of a monetary reward. Obstacles arise, that's certain; but they can be overcome more readily than you think. At RCA there are technical associates willing to assist you—editors to advise you on the writing—a law and patent department to guide you—and a TPA to assist you with reviews and approvals. So, go ahead and write your book . . . and, Good Luck!

BIBLIOGRAPHY

1. *Writer's Market 63*, Writer's Digest, Cincinnati 10, Ohio; this lists everything from trade journals to poetry publishers and includes royalty rates, how to submit, amounts of royalties, etc. Should be available in most RCA Libraries.
2. "Price Lists of Government Publications," free from Superintendent of Documents, Gov't. Printing Office, Wash., D.C.; books and pamphlets (mention your field of interest) are described.
3. J. H. Nipp, "The Engineer—Writer and the Copyright Law," IEEE, *PTGEWS Newsletter*, Vol. 6, No. 2, April 1963.
4. J. A. Wortmann, "Trademarks—Basic Principles and Concepts," RCA Engineer, Vol. 9, No. 6, Apr.-May 1964.
5. C. E. Yates, "Legal Restraints on the Exportation of Technical Data," RCA Engineer, Vol. 9, No. 5, Feb.-Mar. 1964. Also see addendum to this published as an *Engineering and Research Note* in Vol. 10, No. 1.
6. E. M. McElwee, "How to Edit Your Own Writing," RCA Engineer, Vol. 6, No. 2, June-July 1960.
7. M. P. Rosenthal, "How to Write A Technical Book and Get It Published," to be published in *IEEE Trans. on EWS*, 7-2, 1964. (Similar to the present article, but with an *Appendix* added listing major technical book publishers and their requirements.)

REVIEWS OF RECENT TECHNICAL BOOKS BY RCA AUTHORS

If your book is omitted here or if you write a future one, send a review to your Editorial Representative. Reviews will be published periodically.

"FUNDAMENTALS OF TELEVISION"

W. H. Buchsbaum
Communications Systems Div.
DEP, New York, N.Y.

The basic principles and circuits of TV receivers, for use as reference text in trade schools and technical institutes. This book covers monochrome and color TV circuits, transistors, UHF and special features such as remote controls. *(Price, $7.95, approx., to be published by John F. Rider, Inc., New York City, N.Y.; 1964.)*

WALTER H. BUCHSBAUM received his BEE and MEE from Brooklyn Polytechnic Institute and designed TV receivers for Garod, Tech-Master and Olympic until he joined Kollsman Inst. in 1952. He joined RCA in 1962 as Technical Staff Leader where he has been associated with such digital switching systems as UNICOM and AUTODIN. He is the author of texts on *Television Servicing* (Prentice-Hall) and *Color TV Servicing* (Prentice-Hall) as well as numerous technical articles.

"ELECTRICAL INTERFERENCE"

R. F. Ficcki
Communications Systems Div.
DEP, Camden, N.J.

Gives the design and field engineer, program manager, and technician a broad view of the importance of interference in modern electronics systems. Interference control is introduced in the design of equipment. Theoretical and practical considerations of design are covered with tabular material summarizing the advantages of various materials that can be used. Full chapters cover principles and practices of filtering, interference related to cable connections, specific equipments and the problems they have with interference. Grounding is thoroughly discussed in four chapters. *($8.75; published by Hayden Book Co., Inc., New York, 1964.)*

ROCCO F. FICCKI received his BS from St. Joseph's College. Prior to joining RCA in 1958, he spent 15 years with various electrical engineering consulting firms. Mr. Ficcki gained considerable experience in the field while working on the interference problems involved with BMEWS and MINUTEMAN.

"DIGITAL MAGNETIC TAPE SYSTEMS"

B. B. Bycer
Communications Systems Div.
DEP, Camden, N.J.

The state-of-the-art of digital magnetic tape systems in terms of basic mechanical, magnetic, electronic, and computer techniques. The introduction establishes and compares analog and digital techniques. Then, the digital magnetic recording aspects are covered from the mechanical viewpoint of the tape deck through magnetism to the concept of a digital module representation of the magnetic tape device. Finally, computer applications are covered in areas such as data storage, input-output operations, program coding, communication links, tape format and translation. *(Price, $10.00; to be published by Hayden Book Co., N.Y. in January 1965.)*

BERNARD B. BYCER received his BSEE in 1945 and MSEE in 1959 from the University of Pennsylvania. He has several credit courses toward a PhD at the same University. He has written many professional papers and has several patents to his credit in the communication and data handling fields. Since joining RCA in 1956 his work has included investigations in digital data magnetic recording, incremental computers, and radar systems.

"PEROXIDASE: THE PROPERTIES AND USES OF A VERSATILE ENZYME AND RELATED CATALYST"

Dr. A. G. Holmes-Siedle*
Astro-Electronics Div.
DEP, Princeton, N.J.

*(*Coauthors of this text are B. C. Saunders and P. Stark, former associates of Dr. Holmes-Siedle during his research work in England.)*

This is the first known book about the peroxidases, a class of peroxide-destroying enzymes widely distributed in nature. It is an attempt to place in perspective a class of haem compounds which have an important place in the evolution of biophysics and enzymology. The authors have jointly carried on research on the mechanism of this enzyme's action using organic chemical techniques. The book surveys a large amount of published work on the haem compounds and an attempt is made to relate the evidence to modern chemical theories in transition metal chemistry, oxidation mechanisms and the transport of energy in biological systems. For the first time, a collection of all relevant haemoprotein spectra information is made available. *(To be published and released by Butterworths, London, in mid-1964; price not yet known.)*

DR. HOLMES-SIEDLE received a BA Sc. Degree from Trinity College, Dublin, in 1954, and a PhD in Organic Chemistry from Cambridge University, England, in 1958. He joined the technical staff of the Physical Research Group of the Astro-Electronics Division in 1962. He is doing research on radiation damage and scientific instrumentation of satellites. Dr. Holmes-Siedle conducted post-doctoral chemical research at the Cambridge University Chemical Laboratories from 1958 to 1960, and from 1960 to 1962 was with Hawker-Siddeley Aviation as a project engineer.

"FUNDAMENTALS OF RADIO"

M. P. Rosenthal
Communications Systems Div.
DEP, New York

The fundamentals of radio and electronics for high-school seniors who intend either to pursue an engineering degree, or to utilize the information for hobby purposes. Thirteen chapters include basic radio mathematics (from algebra through vectors); fundamental theory of vacuum tubes, transistors, and semiconductor diodes; theory of resistance, capacitance, and inductance and the associated components (resistors, capacitors, coils, chokes, and transformers); theory of amplification, oscillation, rectification, mixing, automatic volume control, and heterodyning; discussions of actual amplifiers, oscillators, rectifiers, mixers (converters), and IF stages; theory of sound; AM and FM theory and operation, including discussions of actual receivers and tuners; theory and operation of tone compensation (bass, treble) circuits; antenna theory; and troubleshooting hints and procedures. *(Price, $4.50, published by John F. Rider, Inc., Division of Hayden Book Co., New York, 1964.)*

MURRAY P. ROSENTHAL received his BS in Physics from Brooklyn College in 1959, and is now taking graduate work. He has been involved with electronics since 1944, when he served as a radio technician with the USAAF. He has been concerned with technical writing since 1953, and from 1953 to 1960 worked in various technical publications capacities. He joined RCA in the DEP-CSD Systems Laboratory in New York in 1960, where he is a Member of the Technical Staff, now supervising Engineering Publications Department. He has written a previous book, *Basics of Fractional Horsepower Motors* (J. F. Rider, 1962), and is now working on a new book, on high fidelity, scheduled for publication in 1965.

"PARAMETRIC AND TUNNEL DIODES"

Dr. K. K. N. Chang
RCA Laboratories
Princeton, N.J.

Treats comprehensively parametric and tunnel diodes and discusses their circuit applications. Pertinent physical principles and phenomena of parametric and tunnel diodes are introduced with a complete coverage of the latest solid-state active devices using such diodes. The most recent results on a mm-wave detector and mixer emphasize the feasibility of new mm-wave active devices. A precise analysis of parametric-diode frequency multipliers, and a thorough explanation of the microwave devices and digital elements using parametric and tunnel diodes are included. Outstanding sections: 1) The Physics of Parametric and Tunnel Diodes, 2) Harmonic and Subharmonic Generation by Parametric Methods, 3) Tunnel Diodes and Digital Circuit Elements, 4) Recent Progress on Parametric and Tunnel Diode Devices and 5) Rigorous Analysis of Harmonic Generation with Parametric Diodes. *(Price, $10.95, published by Prentice-Hall, Englewood Cliffs, N.J., 1964.)*

DR. K. K. N. CHANG received the BS from National Central University, Nanking, China in 1940, the MSEE from the University of Michigan in 1948, and the DEE Degree in 1954 from the Polytechnic Institute of Brooklyn. A pioneer of microwave parametric and tunnel diode research, he has written this book after six years of extensive experience in this field. Since 1948, Dr. Chang has been a member of the technical staff at RCA Laboratories, Princeton.

"CONCEPTS IN PHOTOCONDUCTIVITY AND ALLIED PROBLEMS"

Dr. A. Rose
RCA Laboratories
Princeton, N.J.

Stresses primarily a compact treatment of the concepts and formalism found useful for understanding recombination processes, the interaction between space-charge-limited and photocurrents, the role of electrical contacts, and the noise properties of currents in solids. The contents formed part of a course on "Electronic Processes in Insulators" given in 1961-1962 at Princeton University. Sections include Gain-Bandwidth Product for Photoconductors—Part I, Recombination, Space Charge-Limited Current Flow, Gain-Bandwidth Product—Part II, Noise Currents, Capture Cross Sections, Electrical Contacts, and Energy Levels in Solids and Electrolytes. *(Price, $5.95, published by Interscience Publishers, a Division of John Wiley and Sons, N.Y. and London, 1963.)*

DR. ALBERT ROSE received an AB in 1931 and a PhD in physics from Cornell University in 1935. Dr. Rose joined RCA in 1935 and was first associated with electron tube research at Harrison, N.J.; he transferred to RCA Laboratories in 1942. His studies in the field of solids led to his widely recognized work on the mechanism of the photoconductive process and current-flow in insulators. Dr. Rose has made basic contributions to the development of the orthicon, image orthicon, and vidicon television tubes.

"MICROWAVE SOLID-STATE ENGINEERING"


Dr. L. S. Nergaard and Dr. M. Glicksman
RCA Laboratories Princeton, N.J.

At the request of the Microwave Engineering Education Committee of RCA Electronic Components and Devices, RCA specialists in various branches of solid-state technology provided material on both principles and applications, especially the newer developments. The physical approach has been followed throughout, beginning with discussions of the pertinent principles of quantum mechanics and the properties of solids, as applied specifically to their new technology. These principles are applied directly to semiconductor and microwave devices. Particular attention is paid to tunnel diodes, parametric devices, masers, lasers, ferrite devices, and plasmas. Frequent analogies are used with familiar engineering concepts and devices. *(Price $8.00, published by D. Van Nostrand Co., Inc., 1964.)*

DR. L. S. NERGAARD, Director, Microwave Research Laboratory, RCA Laboratories, a graduate of the University of Minnesota, he received his MSEE in 1930 from Union College and his PhD in Physics in 1935 from the University of Minnesota. Dr. Nergaard is a Fellow of the IEEE and of the APS, and the recipient of two recent *RCA Achievement Awards* and the *David Sarnoff Award for Outstanding Achievement in Science.* He has contributed to many professional journals.

DR. MAURICE GLICKSMAN is now Director, Laboratories RCA, Inc., Tokyo, Japan. A graduate of Queen's University in Canada, he received his MS in 1952 and his PhD in 1954, both from the University of Chicago. A Fellow of the APS, Dr. Glicksman has contributed to several books and numerous professional journals.

"INGENERIA de ANTENAS"

E. A. Laport
Research and Engineering
Princeton, N.J.

A Spanish-language translation of *Radio Antenna Engineering* (published originally by McGraw-Hill Book Co. 1952 and lately out of print in U.S.A.). It covers radiation, circuit and structural design of antennas made of towers, masts and wires from 15 kc to about 30,000 Mc. It also covers engineering design of RF transmission lines, synthesis of impedance matching networks, and has a chapter on logarithmic potential theory as applied to antennas and transmission lines. There are data appendices. The translation into Spanish is by Dr. Eng. Adolpho DiMarco, Professor of Electronic Engineering of University of Buenos Aires and University Nacional de LaPlata. *(Published by Editorial Hispano-Americanna, S.A. Buenos Aires, Argentina, November 1963, 551 pp.)*

EDMUND A. LAPORT attended Northeastern University, Massachusetts University Extension, and McGill University. In 1924 he joined the Westinghouse Electric and Manufacturing Company as a radio engineer. In 1936 he joined the RCA Victor Division, Camden, N.J.; in 1938, Chief Engineer of engineering products in the RCA Victor Company Limited, Montreal; and in 1944, Chief Engineer of the RCA International Division, New York. Since November 1954, he has been Director, Communications Engineering, for RCA Research and Engineering (staff).

"SIX STUDY GUIDES FOR 'ELECTRONICS AT WORK'"

J. W. Wentworth
Product Engineering,
Research and Engineering
Camden, N.J.

Six instructional study guides (100 or more pages each) have been released by Mr. Wentworth on the subject *Electronics at Work.* Ninety individual lessons are included in the following six study guides: 1) "Electrostatics and DC Circuit Principles", 2) "Electromagnetism and Its Applications", 3) "Power Supplies and Basic Electronic Components", 4) "Vacuum Tubes and Reactive Circuits", 5) "Audio Communication Systems", and 6) "Television Communication Systems". Mr. Wentworth has also prepared and published a companion series of 90 half-hour instructional television programs (available on 16-mm film), and the first three units of a projected series of seven teaching guides. The complete 90-lesson course is structured as a two-semester program to be completed within a conventional school year at a rate of 3 lessons per week. The course serves as a pre-engineering study for high-school seniors or as a general introduction to basic electronics for adults with at least a high-school background. A series of practical exercise manuals to supplement the course will be published later. The *Electronics at Work* television programs will be broadcast by WNDT, New York (Channel 13) commencing October 5, 1964. *(Price of Study Guides, $1.90 each book; published 1963-64 by Wentworth Corporation, West Columbia, S.C.; Quantity prices, teaching guide prices, and film prices available from Falcon Films, 475 5th Avenue, New York City.)*

JOHN W. WENTWORTH, in preparing "Electronics at Work", has drawn upon 14 years of experience at RCA in engineering, teaching, and management. Licensed as a professional engineer in the State of New Jersey, Mr. Wentworth holds a BSEE degree from the University of Maine. He is the author of *Color Television Engineering* (McGraw-Hill, 1955). He is now Manager of the Current Concepts in Science and Engineering Program for Product Engineering.

"STRUCTURAL EFFECTS OF IMPACT"

M. Kornhauser
Systems Engineering
Evaluation and Research
DEP, Moorestown, N.J.

A simplified approach to the prediction of structural failure in terms of the loading conditions of meteroids, entry into water, penetration into earth media, and air-blast loading. Emphasis is placed on *go* or *no-go* behavior, survivability or failure. Although response to loading is analyzed, the object has been to permit wherever possible, estimates of failure directly in terms of the loading conditions. The primary purpose has been to provide the practicing engineer with some relatively simple approaches to the prediction of failure, thus providing a working document for engineering estimates of impact effects. *(Price, $10.00, published by Spartan Books, Inc., Baltimore, Maryland.)*

MURRAY KORNHAUSER received the BSME degree from R.P.I. in 1944. Following military service in 1946, Mr. Kornhauser engaged in research and development for various turbine and rocket propulsion companies and at the U.S. Navy Bureau of Ships. He joined GE Missile and Space Division in 1956 where he was in charge of structural impact projects and Lunar Systems Development. In 1962, Mr. Kornhauser became Manager of the technical staff of RCA's Advanced Military Systems; he transferred to SEER in 1963, where he is now Staff Systems Manager.

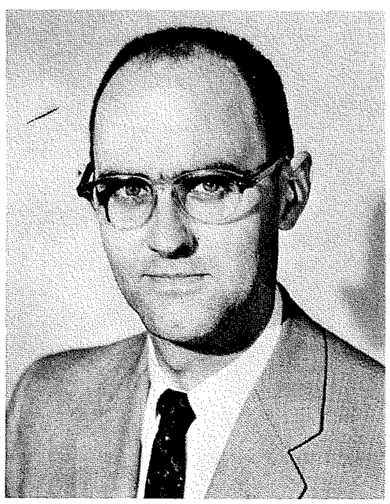
COLOR TELEVISION — THE FIRST TEN YEARS

J. W. WENTWORTH, Mgr.

Current Concepts in
Science and Engineering Program
Product Engineering
Research and Engineering
Camden, N. J.

Color television was of major interest to nearly all RCA engineers from about 1949 through 1953, during which period the Federal Communications Commission conducted rule-making proceedings to establish transmission standards for color broadcast service. A significant fraction of RCA's total research and development effort had been mobilized to complete the development of a color transmission system compatible with existing monochrome broadcast systems, and the color television signal specifications finally adopted by the FCC in December 1953 were based in large measure on concepts pioneered and developed by RCA. Color television has now been in actual service for more than ten years, and technical progress has continued as engineers in the Home Instruments Division, the Broadcast and Communications Products Division, Electronic Components and Devices, NBC, and the RCA Service Company have pressed the search for optimum designs in translating concepts into practical equipment and techniques. This paper summarizes the status of compatible color television after approximately a decade of authorized service in the United States. It is adapted from one prepared in 1963 for a committee of the European Broadcast Union, which is currently exploring alternative approaches to color television as a prelude to the establishment of color transmission standards for Europe—an activity that is also discussed briefly herein. The emphasis of this paper is essentially on problems related to transmission techniques. (The colorimetric principles of color television are relatively noncontroversial, and the design concepts embodied in cameras and display tubes do not significantly affect the choice of transmission standards.) The basic principles of compatible color television are well described in earlier literature, and highlights of the continuing work in color television have been published periodically since. A selected Bibliography to such literature is included herein.

JOHN W. WENTWORTH received his BSEE from the University of Maine in 1949. He joined RCA in 1949, and then concentrated for over a decade on engineering work connected with both monochrome and color television. He became Manager of TV Terminal Equipment Engineering and for a number of years taught courses in color television to RCA product-design and service engineers, and to NBC studio engineers. He has lectured and written widely on television and educational technology, publishing numerous papers and books. In early 1964, he was named to his present position of Manager of the Current Concepts in Science and Engineering Program, an RCA staff activity aimed at supporting engineering Managers and Leaders in their efforts to stay abreast of new and fast-changing technologies. Mr. Wentworth is a Fellow of the SMPTE, and a member of Tau Beta Pi and Phi Kappa Phi, an Associate of Sigma Xi, and a Member of the IEEE. He is a Registered Professional Engineer in New Jersey.



THREE significant indicators of the level of color TV activity in the United States are: 1) the number of color receivers sold and in use, 2) the number of broadcast stations equipped to transmit color signals, and 3) the total number of color program hours broadcast in typical American cities.

COLOR RECEIVER SALES

It is common knowledge that color receivers were not sold in large numbers during the early years of color broadcasting service in the United States, but the rate of sales jumped rather dramatically during 1962 and 1963, and the trend has continued in 1964. In early 1963, sixteen receiver manufacturers were marketing color receivers, and several more announced color models during 1963. While many competing manufacturers bought complete chassis from RCA as a means of minimizing the capital investments required to produce their early models, most of them had their own production lines in full operation by early 1964. Since Dec. 31, 1963, RCA has built only *RCA Victor* receiver chassis. A general indication of the growth of color receiver sales since 1954 (the first full year of FCC-approved color broadcasting) is shown in Fig. 1. The total number of color receivers in use reached the one million level in late 1962. The 1963 industry sales added an estimated 700,000 units to that total, and predictions are that 1964 color-set sales will exceed 1,200,000 units. In early 1963, some 3% of all the TV receivers in use in the United States were color, and the proportion may be expected to increase rapidly as the full impact of serious marketing efforts by many competing manufacturers becomes effective.

COLOR PROGRAM SERVICE

More than half of the 580 commercial TV broadcast stations in the United States are equipped to *transmit* compatible color signals, and roughly 20% of them are capable of *originating* either live or film programs in color. More than 98% of all TV homes in the U.S.A. are reached by at least one color TV broadcast station, and viewers in at least 29 cities have frequent opportunities to view color programs from two or more stations. RCA alone has delivered more

Final manuscript received June 19, 1964. Adapted and updated from a paper presented to the European Broadcast Union in 1963.

than 200 live color cameras and more than 150 color film chains to broadcast customers in the United States.

NBC has clearly led the way in providing network color programs. With but one exception (in 1958), the program hours devoted to color broadcasting by NBC have increased each year since 1954, and some three-quarters of the NBC nighttime schedule is devoted to color programs. The ABC network offers some regularly-scheduled color programs per week, while CBS offers occasional "special" programs in color. (The growth of color programming by the three networks combined is shown in Fig. 2.) In addition to network programs, American audiences in at least 60 market areas receive significant numbers of locally produced color programs; some non-network-owned local stations transmit color during as much as 40% of their total broadcast schedules.

PUBLIC ACCEPTANCE OF COLOR TELEVISION

Compatible color TV under the NTSC transmission standards has passed the test of broadcaster and public acceptance. It is self-evident that the rate of growth of color telecasting has been, to date, far slower than the corresponding growth of monochrome TV in the U.S.A. during the first few years of its serious use after World War II. Overseas observers of this slow growth of American color TV have occasionally suggested that this slow growth has been due, in large measure, to *technical* deficiencies in the medium under the NTSC standards, but few American authorities share this view.

While the apparatus available for the broadcast and reception of NTSC color TV signals is constantly being improved, technical difficulties have been one of the *least significant* factors accounting for the slow growth of the medium. There has never, throughout the entire history of American commercial color TV, been any substantial evidence of widespread customer dissatisfaction *among the actual owners of color receivers.* Furthermore, color TV receiver marketing has now become a clearly profitable activity even though the price level for color receivers is two to three times that of comparable monochrome receivers—a highly encouraging level of public acceptance. (The price level is determined primarily by the cost of the color picture tube and the related components; cost differentials between receivers designed for the various alternative methods of color signal transmission are relatively minor.)

Realistic explanations for the slow growth of color TV in the United States are to be found in the almost undefinable principles of consumer psychology and the free-enterprise marketing system, rather than in technical deficiencies in the system. The basic problem is that color TV represents more nearly a *refinement* of an existing service, rather than a totally *new* service. When monochrome TV was first introduced in the postwar period, it was immediately recognized as a *new* broadcast service of great significance, and it became commercially successful at a stage of technical development where the problems of technical complexity and price level (in terms of equivalent purchasing power) were fully comparable to those of color receivers today. In the case of compatible color TV, however, the viewing public is able to derive substantial enjoyment from color programs even without investing in color receivers, since the same program signals produce very satisfactory monochrome pictures. To justify the substantially greater investment in a color receiver, a consumer may properly demand some assurance that the *number of color programs available to him is great enough to increase his viewing enjoyment to a degree commensurate with the higher price.*

Color programs cost somewhat more to produce, however, and someone has to pay these higher costs. In the American system of privately controlled broadcasting, the basic financial support comes from advertisers, who must justify expenditures for broadcast programs in terms of results obtained in greater sales or greater interest in their products or services. It is quite understandable, therefore, that broadcast advertisers were very reluctant to pay the higher costs of *color* broadcasting during the early years of the medium when the number of color receivers in use was so small as to make no significant difference in the number of viewers who would tune in to their sponsored programs.

The impasse of consumers demanding more programs before they would buy color receivers and advertisers demanding more receivers in circulation before they would pay for color programs could only be broken by a major economic "pump-priming" action. *It is now a matter of historical record that this pump-priming role was played, almost single-handedly, by RCA—with major investments in facilities for producing both color kinescopes and color receivers, and aggressive promotion in the marketplace—all in the face of either indifference or active opposition by most of its competitors in the receiver manufacturing industry.* (The "negative selling" efforts of competitors who had no color products to sell in the early days of color broadcasting, and who were fearful of losing profitable monochrome sales, accounted for many of the false impressions of severe servicing problems and consumer dissatisfaction.) At the same time, RCA assumed responsibility for training the receiver service industry in color principles, and provided leadership in the production of color programs.

Fig. 1—Estimated sales of color receivers.

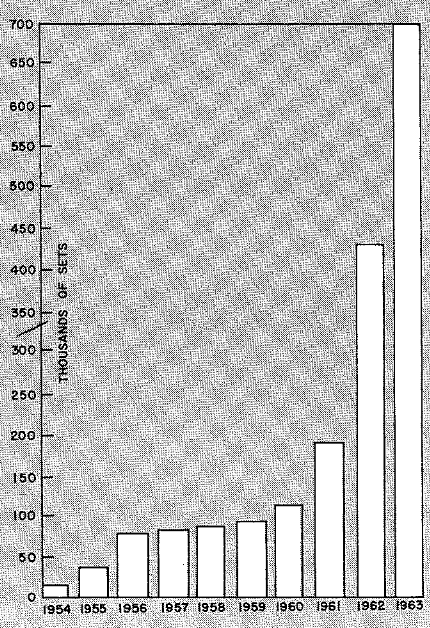
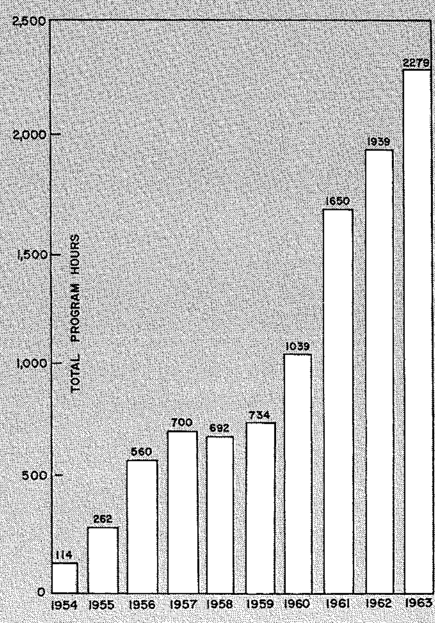


Fig. 2—Color broadcasting by U.S. television networks.



Color TV activity has now reached a point where very little additional pump-priming will be necessary. The public demand for receivers is real, most manufacturers have now taken a positive attitude to the promotion of color, and receiver circulation in many cities has reached a point where measurable differences in program and commercial ratings are beginning to convince advertisers that the added costs of color broadcasting are justifiable.

It is particularly significant that there is virtually no sentiment in the American TV broadcast industry that the NTSC transmission standards, as such, represent a significant limitation on the growth of color TV, or that they require revision in any significant respect.

COLOR TELEVISION PROGRAM PRODUCTION

Many of the challenging problems in the production of successful color TV programs have little or nothing to do with the transmission standards involved in the encoding and decoding of the color information for transmission between the camera chain and the picture display tube in the receiver. Such problems as studio lighting, selection and matching of camera tubes, spectral sensitivity in optical systems, color balance adjustments, image registration, gamma correction, and the matching of multiple cameras used in a given studio are all outside the context of this paper, although several of these are problems that require major attention in day-to-day color studio operations.

Most American broadcasters with color equipment use encoders (or *colorplexers*) that have remained essentially unchanged in design for several years; the encoding equipment is so stable and trouble-free that it requires far less attention than many other types of studio equipment. It has become standard practice in American color TV studios to include a colorplexer in each and every camera chain, both live and film, so that only a single-channel (fully encoded) signal need be handled through program-assembly switchers and studio distribution systems.

In spite of the tolerances that are required for distortion-free handling of NTSC color signals, American broadcast experience has shown that elaborate switching facilities for assembling color programs from multiple signal sources are fully practical. In most network studios, and in many of the larger locally owned color studios, the video switching facilities include both lap-dissolve amplifiers and special-effects equipment that may permit portions of as many as four camera signals (or other sources) to be combined in a single image. The electronic editing techniques used in assembling monochrome programs can also be used in color systems.

Routine *operation* of color switching facilities is no more difficult or restricted than in the case of comparable monochrome facilities, with the one possible exception that the fractions of the two color signals involved in a superimposition must be carefully controlled so that they always add up to unity. In the *design* of a color switching system, however, care must be taken to assure that all of the signals do arrive at a common point (normally the output of the final program bus) with the same relative timing, accurate within a few degrees at the color subcarrier frequency, regardless of the path followed by the signal through the switching facilities. Most switching systems for color TV include specific delay networks (usually in the form of short lengths of cable) to compensate for the intrinsic delays associated with lap dissolve amplifiers, special-effects amplifiers, and similar devices, as illustrated in Fig. 3.

To minimize timing problems, color synchronizing bursts to accompany each camera signal are generated within each colorplexer and accompany the related color picture signals through all switching facilities. Tests have shown that no serious subjective effects are noted on either "direct-cut" or lap-dissolve operations if the signals arrive at the switching or mixing point with relative timing in error by as much as about 20° at the subcarrier frequency. In a direct cut, the burst is switched along with the picture signal, and the recovery time of receiver burst-controlled oscillators for sudden errors of 20° or so is well within the psychological reaction-time of the viewer; he is aware only that a new picture has replaced the previous one, and could not detect the momentary error in color rendition. In the case of lap dissolves, the burst accompanying a mixed signal is at all times the vector sum of the two input signals, so if a change in the phase of a receiver oscillator is necessary in going from one signal to another, the required adjustment is made smoothly and almost invisibly. As a practical matter, it has been found relatively easy to maintain relative time stability within 2° to 3° at the color subcarrier frequency, making possible a variety of split-screen effects where part of a given camera signal may be accompanied by a burst developed in the colorplexer associated with an entirely different camera chain.

To facilitate the operational adjustment of color TV switching facilities, all colorplexers produced by RCA incorporate 360° phase shifters in the subcarrier input channel so that the relative phase of the subcarrier signals produced by each camera chain can be readily adjusted to match at the desired final mixing point. RCA colorplexers also have convenient means for substituting electronically generated color bar signals for the normal camera signals to permit rapid checks of the adjustments in individual colorplexers and the matching of several different colorplexers. The color bar signals are analyzed with both conventional waveform monitors and specialized instruments called *vectorscopes*.

In Fig. 3, dotted lines show facilities required for the *Chroma-key* process added to one camera chain. The chroma-key process, developed by NBC, is a means of obtaining a highly effective "traveling matte" or self-keyed video inset to combine separate foreground and background images, utilizing *color-difference* information to develop the keying signal. In the most common application of the process, the foreground action is played against a bright blue background and on a blue-painted floor, and the chroma-key matrix attached to the colorplexer for the foreground camera chain is adjusted to deliver a blue color-difference signal to the keying input of the special-effects amplifier. This color-difference signal turns *off* the background signal and turns *on* the foreground signal only in those picture areas where blue light was blocked by the foreground performer or objects. Blue is the most popular key-signal color for this process because it happens to be the color which is easiest to *avoid* in most foreground scenes, but other colors are occasionally used, and the chroma-key matrix networks can be adjusted to deliver any desired color-difference keying signal. The chroma-key technique has been found fully practical for NTSC color signals.

SYNCHRONIZATION OF MULTIPLE STUDIOS

In color network operations at NBC, it is common practice to employ *genlocking* facilities to assure that signals generated in remote locations remain tightly synchronized with those generated in the main studio plant. In the case of fixed remote locations, such as NBC's Brooklyn Studios, located several miles from the network origination center in the RCA Building on Manhatten Island in New York City, the genlock problem is normally solved by the use of a two-way video link, utilizing the facilities shown in simplified form in Fig. 4. In the main studio

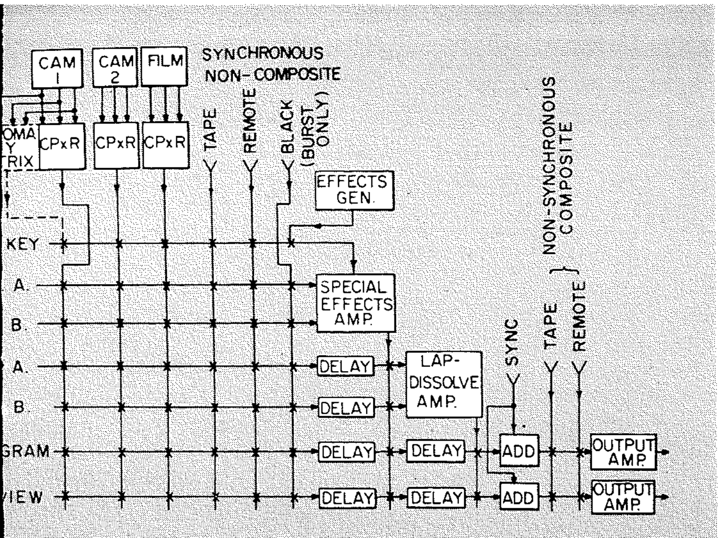


Fig. 3—Color television studio switching system.

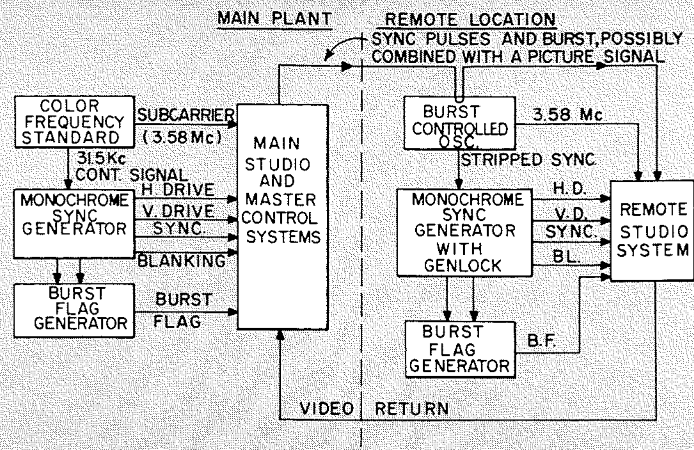


Fig. 4—Color genlock facilities employed by NBC.

plant, the master sync generator is kept locked to the proper subharmonic of the color subcarrier frequency by electronic counter stages in the color frequency standard. A signal from the main studio plant is transmitted via microwave or coaxial cable out to the remote location to serve as a synchronizing signal. This signal *always* includes standard deflection synchronizing pulses and color synchronizing bursts, and may sometimes include a picture signal needed at the remote location for cueing purposes or as part of the remote program.

At the remote location, a burst-controlled oscillator is used to derive a CW subcarrier signal locked to the incoming burst signals; the same equipment also delivers stripped sync pulses suitable for control of the remote sync generator through conventional AFC or genlock circuits (such circuits are standard equipment in most sync generators). Thus, the remote sources of color subcarrier signals and synchronizing pulses are kept in synchronism with the master sources by two separate AFC systems, but this type of operation has been found fully satisfactory. In cases where it is not practical to provide a two-way link with a remote location, it is necessary to make the sync generator at the main plant a slave to the one at the remote location. In no case, however, have the NTSC color standards prevented genlock operation fully comparable to normal practices in monochrome systems.

TRANSMISSION OF COLOR TELEVISION SIGNALS

One of the areas of greatest concern to the scientists and engineers associated with the development of the NTSC color standards was the requirement for close tolerances on the performance characteristics of all of the equipment used for the transmission or handling of the encoded signal. The very presence of the subcarrier signal in the upper portion of the video band requires greater attention to the flatness of frequency response than was ever necessary for monochrome service, and the nature of the two-phase-modulation technique employed for the subcarrier demands highly linear transfer characteristics if intermodulation effects are to be avoided. While many of the monochrome transmission facilities in existence at the time color was first introduced were, indeed, found to be inadequate for color service, the early fears that problems in this area might be found insurmountable have been proved to be groundless. The tightening up of design tolerances and operating practices required for the successful transmission of NTSC color signals has not been unreasonably expensive, and has clearly resulted in *improved monochrome service* as well as satisfactory color service.

Color TV has greatly stimulated the sale and use of video test instruments. With proper test facilities, maintenance of properly designed signal transmission equipment to the tight performance specifications required for color is *not* particularly difficult. In typical NBC studios, color signals pass through at least six amplifiers (including isolation amplifiers, lap-dissolve amplifiers, special-effects amplifiers, and line-driving amplifiers) between the encoder at each camera chain output and the output of the studio plant, but experience has shown that it is possible to maintain differential gain and phase specifications of less than 2% and 2°, respectively, for such complete studio systems. Microwave links between studio and transmitter sites are normally operated with a deemphasis of the low video frequencies of either 8 db or 12 db; this deemphasis greatly reduces the deviation for the low frequencies (where signal-to-noise ratio is not a problem), and holds differential gain and phase errors to almost negligibly small values. RCA links using 12-db deemphasis networks have successfully transmitted NTSC color signals through as many as eight hops in cascade, the signal being demodulated and remodulated at each relay point.

Although difficulties were experienced in early efforts to transmit NTSC color signals over common-carrier intercity circuits totaling several thousands of miles, the Bell Telephone System has made remarkable progress in solving the many problems involved. The so-called L-3 coaxial cable equipment (widely used for monochrome intercity service) was found troublesome for color, partly because of an exceptionally sharp cutoff characteristic which leads to excessive ringing at the upper end of the video band in long circuits. Hence, the long-line video service of the Bell System is now based almost entirely on microwave facilities. (The coaxial equipment has not been discarded, since it still has excellent characteristics for ordinary message service.) The Bell System is normally able to maintain overall differential gain and phase specifications on transcontinental circuits (nominally 3,000 miles) of 1 db and 4° respectively. This very satisfactory performance is made practical not so much by extreme precision in each individual link in the long microwave circuits as by deliberate staggering of the errors introduced by successive links so as to achieve effective cancellation. Fortunately, differential gain and phase characteristics are determined by ordinary amplitude-versus-frequency and phase-versus-frequency characteristics in FM systems, and judicious tuning of IF amplifiers permits attainment of almost any desired equalization characteristic in long circuits.

It has been found possible to adapt

the great majority of all TV transmitters ever produced in the United States for satisfactory transmission of color signals by the addition of relatively simple equalizers or precompensation devices. The RCA transmitters placed on the market since the advent of color have either been designed with intrinsically adequate bandwidth and linearity, or have had the required precompensation circuits built in at the factory. As might be expected, a transmitter requires somewhat closer attention from the technical staff to assure operation within *color* specifications than is required to maintain acceptable *monochrome* performance. As might also be expected, transmitter problems have been found to be somewhat more serious in the UHF band than at VHF, simply because of the technical facts of life—including the higher Q's required for comparable selectivity. Present UHF transmission problems have been dealt with effectively, however, as evidenced by the fact that at least 39 UHF stations in the United States are currently offering regular program service in color, and some do local color.

COLOR VIDEO RECORDING

Probably the most difficult problem which remained unsolved at the time the NTSC color signal specifications were approved by the FCC in 1953 was that of recording color programs for either short-term or long-term storage. Although color recording equipment is still far from perfected, good results can now be achieved with either magnetic tape or photographic film. At the present time, magnetic tape recording is generally more satisfactory than color film recording, primarily because a tape recorder handles only the electronic color *signal*, while a film recorder requires the development of color *images* (which almost invariably introduce some degradation in color fidelity and other aspects of picture quality).

Until quite recently, one of the most serious problems in color TV tape recording was that of assuring adequate time-base stability to avoid spurious phase modulation of the color subcarrier, resulting in *banding effects*—variations in hue as each video head scans across the tape. This particular problem has been virtually eliminated by the development of a color ATC (automatic timing control). One noteworthy benefit of ATC equipment is that it succeeds in stabilizing the *entire* video signal, not just the color subcarrier, so that a tape playback signal becomes very difficult to distinguish from a locally generated signal as far as time-base stability is concerned. In this respect, ATC equipment represents a major improvement over the previously developed stabilization equipment of the double-heterodyne type, which operated only on the color subcarrier portion of the signal.

Probably the most serious problems still remaining in color tape recording are those of differential phase and moiré patterns. Engineers are by no means discouraged about finding eventual solutions to these problems without requiring basic changes in the color transmission standards. Serious attention is being given to the development of optimizing the FM deviation characteristics in color television tape recorders so as to place the signal in a more favorable spectrum position that will help to eliminate or reduce both moiré effects and differential phase problems.

Color film recording received a great deal of attention during the mid-1950's, just before the advent of practical TV tape recorders, and NBC used a lenticular color film recording process at one time to handle the time-zone delay problem for color programs. To be quite frank, results with this process were never very good, and interest in color film recording was greatly reduced when color tape recording was found practical and far superior in results. Development of color film recording equipment has continued, however, and at least two organizations in the United States are now prepared to do work of commercially acceptable quality, both using three-tube monitors and conventional subtractive color film materials. One of these is NBC, which recently decided that its developmental equipment for color film recording had been refined to the point where it can be considered operational.

COLOR TELEVISION RECEIVERS

Not all aspects of color TV receiver designs fall within the context of this paper. Such factors as the design of the color kinescope itself, the design and adjustment of convergence or registration circuits, deflection and high-voltage systems, and gray-scale tracking adjustments will not be discussed here; rather the emphasis is on requirements for tuners, IF amplifiers, and decoder circuits.

Although NTSC color signals impose requirements on tuners and IF amplifiers that are somewhat more stringent than for monochrome receivers, the relatively great differences in design techniques that were anticipated in the early days of NTSC color have been found to be unnecessary. It is no longer considered necessary, for example, to design IF amplifiers that provide truly flat response for the upper sideband up to and beyond the color subcarrier frequency.

Tuners for NTSC color receivers are not highly critical in design. Because the accuracy of tuning affects color rendition, stability is somewhat more important than for strictly monochrome service, and intermodulation effects with high-level signals deserve careful attention, but these problems have not required the development of radically new design techniques. As might be expected, antenna installations for color receivers have been found to be somewhat more critical than for monochrome receivers, but the added problems result primarily from the presence of the subcarrier in the upper portion of the video channel; there is little reason to expect significant differences in propagation problems and antenna requirements between the NTSC system and other possible systems employing subcarriers.

Experience has shown that decoder circuits for NTSC color signals can be constructed in relatively simple form. Recent RCA color receivers employ only eight tubes for all video functions required between the second detector and the kinescope guns, including three stages of video amplification, delay compensation, subcarrier regeneration, chrominance demodulation and matrixing.

The *tint* and *color* controls (hue and saturation, respectively) associated with the decoders used in RCA color receivers have not proved at all difficult for the viewing public to understand and operate. (These controls actually vary the relative phase and amplitude of the color subcarrier signal.) As steady progress is made in improving the initial quality of program signals and in eliminating distortions in transmission processes, these receiver controls are actually used less and less frequently. They make possible appreciable variations to accommodate individual tastes. Color is, after all, a subjective effect, and not all observers are satisfied with what a scientist may claim is optimum color reproduction.

Most current color receivers do not make *maximum* use of the information transmitted to NTSC color signals, in that they do not utilize the full bandwidth of the I signal component. As a practical matter, most receiver manufacturers have found that the added benefits in color resolution derived from full use of the I signal do not justify the greater complexity of additional filters, delay compensation networks, and more complex matrix circuits, although it is quite conceivable that a fraction of the public may eventually develop an appreciation (and a willingness to pay) for such added refinements in a maximum-fidelity receiver.

With respect to reliability and ease of servicing, RCA receivers designed for the American NTSC standards have proved to be thoroughly practical and adequately reliable. The RCA Service Company has Service Contracts for approximately 40% to 50% of the recent color receivers now in use, and handles service calls on still more color receivers on a demand basis.

Among the interesting data derived from the records of the RCA Service Company are the following:

1) Owners of color receivers with full-coverage service contracts call for a serviceman between four and five times per year compared to an average of between two and four calls per year by monochrome set-owners with comparable service contracts. Customers without full-coverage contracts (who must pay for every service call) request somewhat fewer calls.
2) During the past four years, the average number of service calls per color receiver has dropped approximately 40%, due primarily to a combination of improved product quality and improved quality of field service.
3) The average worktime in the home on a color receiver service call is only 11% greater than for a monochrome receiver service call.
4) In cases where it is necessary to take a receiver to a shop, the average service time for a color receiver is only 14% greater than the average service time for black-and-white receivers.
5) The proportion of service problems that can be handled in the customer's home (without transporting the receiver to a shop) is approximately the same for color as for monochrome.

COLOR TELEVISION FIELD TESTS IN EUROPE

Broadcast engineers throughout Europe are currently engaged in field tests of color TV systems, and the European Broadcast Union has organized a series of committees to study various aspects of color television. (These committees are quite comparable to those organized in this country in the early 1950's under the National Television Systems Committee.) While European engineers are fully aware of the progress made in color TV in the U.S.A., they have shown little inclination to adopt the principles of the NTSC color signal specifications without thorough exploration of alternative approaches. As noted above, there has been some feeling that the relatively slow public acceptance of color TV may have been due to technical deficiencies, and that some of the new technological developments of the past decade may provide opportunities for developing still more effective color television transmission techniques.

At the present time, three competing systems are being studied by the European Broadcast Union. One of these is identical in principle to the so-called "NTSC System" used in this country, although certain of the constants in the system have been "scaled" to conform to the different scanning patterns and transmission channel spectra used in Europe. Another of the systems, designated the PAL system (for *P*hase *A*lternation, *L*ine rate) is actually a relatively minor variant of the NTSC system in which the phase sequence of the color subcarrier signal is reversed after each line to minimize the effects of differential phase distortion in the encoded signal. (The price paid for this advantage is somewhat greater complexity in both the studio and receiving equipment). The third system is a French development known as SECAM (a word coined from the French phrase meaning "sequential with memory"). In this system, the two-phase modulation technique embodied in the NTSC signal specifications is abandoned in favor of an arrangement whereby the two independent signals required to convey chrominance information are transmitted in line-sequential fashion on a single frequency-modulated subcarrier. The encoded signal in a SECAM system can tolerate a higher level of distortion without degrading picture quality, but the system requires a relatively expensive line-period delay line in every receiver and requires a number of compromises in other performance characteristics.

A full report of the European color TV fields tests is beyond the scope of this paper, and the final decision on color TV standards for Europe is still in the future. Personal observations of the European tests by the author and by other American broadcast engineers indicate, however, that this country's National Television Systems Committee (in which RCA was a major participant) succeeded in developing transmission standards for color TV which are very difficult to improve upon even with the more advanced technological concepts which have been discovered or refined during the past 10 years. It is highly unlikely that the current work in Europe or elsewhere in the world will significantly alter the technical foundation of American color TV.

CONCLUSION

It has obviously not been possible to cover herein all of the technical aspects of color TV. To remedy this, the selected *Bibliography* following directs the interested reader to some of more readily available current and historical literature of color television. Many of the papers cited in this *Bibliography* in turn contain bibliographies or references to yet other literature, thereby providing access to additional or more-detailed information on specific topics.

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A BRIEF REVIEW OF COLOR TV CAMERA DEVELOPMENT

Reviewed briefly is the history and development of the four-channel color TV camera concept—from Dr. A. N. Goldsmith's early patent in 1944 to the new TK-42 model. The developmental model of the TK-42 camera (Fig. 1) was introduced at the NAB Convention in April 1964. The luminance concept adds a monochrome channel to the conventional red, green, and blue color-channels—and results in monochrome pictures equal to those produced by the best monochrome studio camera, and a corresponding improvement in color fidelity. Other technical advances include smaller size, a built-in zoom lens to avoid color-matching problems, and the use of interchangeable, plug-in transistorized modules to conform with design patterns of companion equipment.

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TRADITIONALLY, color TV cameras for direct studio pick-up of live subjects have been three-tube cameras, starting with the introduction of the NTSC system of color television on an experimental basis in 1952. In the three-tube system, the red, green, and blue video signals are generated simultaneously by three image orthicons and registered optically and electrically on a given scene input. In fact, the earliest cameras could be considered as three monochrome image-orthicon chains having common horizontal and vertical deflection, and coupled together optically by a color-discriminating, beam-splitting optical-relay arrangement.

Final manuscript received May 14, 1964.

EARLY MISREGISTRY PROBLEMS

Early color cameras had the drift and instability problems of three monochrome cameras compounded into a single operating unit. With a sufficiently long warm-up interval, the early cameras would stabilize to a point where satisfactory results could be produced. However, a "sufficiently long interval" meant three or more hours of preparation time, often exceeding the actual length of the broadcaster's color TV program.

The main problems of the early color camera could be attributed to misregistry of the three images; such misregistry ranged from violent color fringes in its most aggravated form, to a "soft" monochrome picture when conditions were only slightly askew. Since the monochrome signal is produced by the addition of the red, green, and blue signals, the picture sharpness is determined by the degree of registry of the three signal components over the whole raster.

The importance of controlling misregistry in practice was recognized and led to many parallel efforts; some were aimed at developing novel color camera concepts, and others concentrated on the stabilization of the circuits and components in the three-tube camera.

ADVANCES IN STABILIZATION OF THREE-TUBE CAMERAS

Advances in the stabilization of monochrome cameras, based on high-precision control of image-orthicon magnetic-focus fields and image-orthicon focus voltages, were extended to the special case of color cameras. Substantial improvements in warm-up time and long-term stability made the three-tube image-orthicon color camera performance attractive and technically adequate.

So far, the successful three-tube approaches in color cameras have used image orthicons for live studio pick-up and vidicons for reproduction of color film. Nevertheless, the intriguing possibility of making a radical and fundamental advance in color cameras had

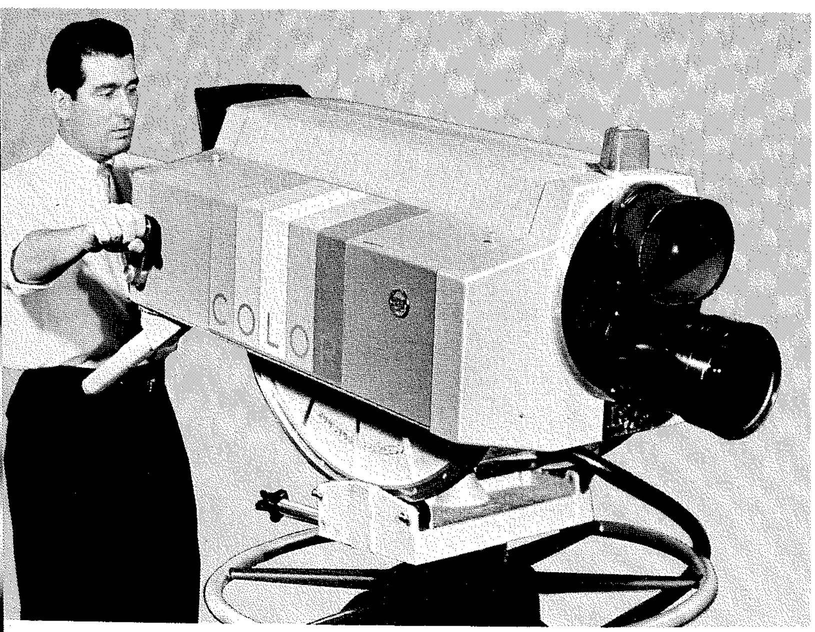


Fig. 1—The 1964 advanced development model of the TK-42 color camera, here operated by D. Mignone.

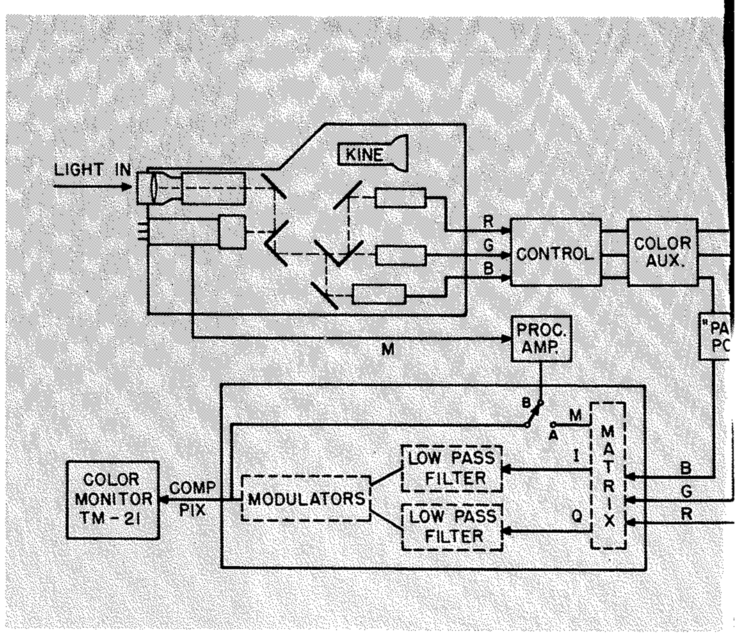


Fig. 2—The basic block diagram of the 4-tube color camera (1962 developmental version).

continued to engage our interest and efforts.

MODERN DEVELOPMENT GOALS

Before investigating further the various design and development possibilities, the following goals were established:

1) Obtain the best possible monochrome picture
2) Make no sacrifice in color performance
3) Provide competitive sensitivity
4) Allow latitude in operating conditions
5) Provide greater ease of operation
6) Provide greater economy in pick-up tube life

Selection of these goals was influenced greatly by the wide acceptance of high-performance monochrome cameras during the last few years; such successful everyday operation dictates that no degradation in monochrome quality can be tolerated when using the color camera for both monochrome and color operation. The monochrome viewer must be unaware that the program is also in color, while the viewer at the color receiver enjoys the picture fully.

THE 1944 FOUR-TUBE CAMERA APPROACH

Historically, the luminance-channel concept for color cameras is quite old. In fact, a patent filed on October 12, 1944 by Dr. A. N. Goldsmith makes him the Columbus of the new world of luminance-channel color cameras. The four tubes shown in the patent description are Iconoscopes. It is frightening to consider the light intensity required on the scene. The monochrome Iconoscope started to show "a flicker of interest" in a scene at 1,000 foot-candles incident.

Unfortunately, it seems that most engineers deliberately veered from this suggested direction into paths which offered a degree of simplification by cutting down the number of pick-up tubes required. Study has later shown that such approaches introduce practical problems which tend to complicate the design or limit the operating conditions of the device.

NEW APPROACHES INVESTIGATED

The most fruitful concept so far advanced for color cameras has been the use of a single tube for the luminance channel to supply the brightness of "monochrome" portion of the color signal, leaving the production of the chroma signal to the ingenuity of the engineer.

Many approaches have been made by RCA and by our competitors with varying degrees of success and failure. These investigations include two-tube systems involving storage of color information, three-tube systems in which the "missing" color is obtained by subtraction of two color signals from the luminance-channel signal, and finally, the four-tube systems. In the four-channel arrangement, the luminance signal is generated by a single high-definition tube; the red, green, and blue components of the chroma signal produced by independent tubes are almost completely divorced from the luminance channel.

DEVELOPMENT OF THE PRESENT FOUR-CHANNEL CAMERA

The choice of pick-up tubes in a four-tube camera is governed by many inter-related factors; the most important of these considerations are:

1) Sensitivity, or light required on scene
2) Signal-to-noise ratio required
3) Lag characteristics
4) Black-level behaviour
5) Cost-per-hour for tube operation

Experience indicated that the image-orthicon tube would hold the most promise for use in the luminance channel, since it produces high-quality signals with minimal scene illumination. In fact, one can select a specific type of image orthicon so as to trade sensitivity for signal-to-noise ratio as the occasion demands.

Thus, an image orthicon with a close-spaced target can be used for live-studio pickups where the signal-to-noise ratio must be excellent, even though the close-spaced tube requires more light than does the wide-spaced-target type of image orthicon. Wide-spaced-target tubes are used ordinarily where lighting conditions approach the low threshold light-levels encountered in TV outdoor or sporting events; here, signal-to-noise ratio becomes a secondary factor compared to sensitivity. The choice of a 3-inch or 4½-inch image-orthicon tube for the luminance signal follows the well-known rules developed for monochrome television. In fact, one can consider the four-tube concept as providing a highest quality monochrome signal, with chroma response determined by the over-all response of the color-encoding system.

Although any "ideal" tubes can in principle be used for the chroma signals, our choice of vidicons for this service is

Fig. 3—Optical layout of the four-tube color camera (1962 developmental version).

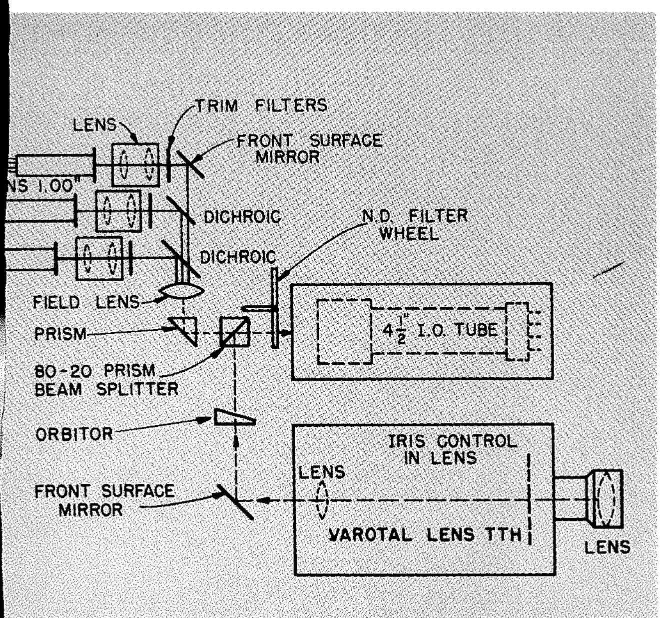
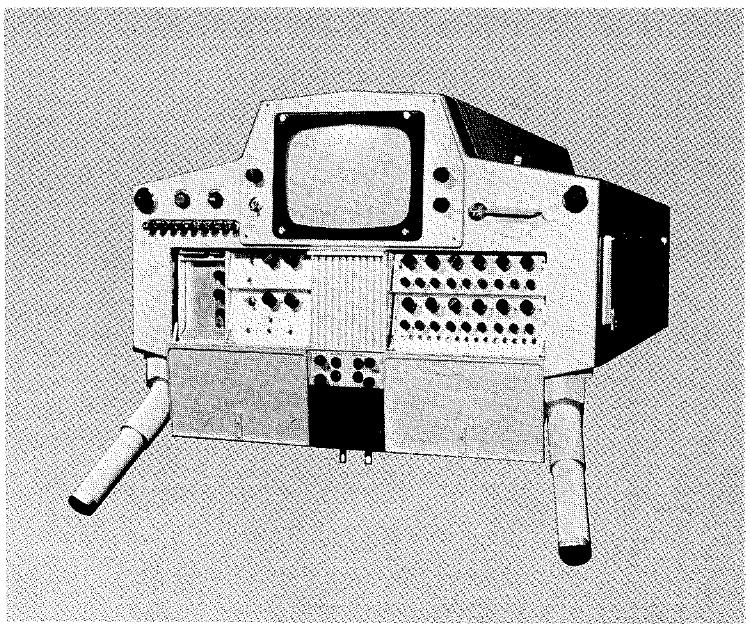


Fig. 4—View of the rear of the camera showing set-up controls, zoom range selector, view-finder-monitor, and controls.



based on several factors. Most importantly, vidicons are very well-behaved under black or no-light conditions. Therefore, it is possible to use them effectively as a basis for producing excellent flat-field rasters in the red, green, and blue channels. If the dark current in vidicons is kept small, the output signal is zero for a no-light condition on the tube. By contrast, for the "no-light" condition an image orthicon produces a maximum DC signal containing shading and multiplier error components which can vary from tube to tube.

Even under such adverse conditions, one could build a four-tube camera with image orthicons for the chroma channels and select tubes with a minimum dark signal.

However, vidicons, when properly operated, with the life expectations indicated by past experience, represent very significant decreases in the operating cost per hour and in the size of the camera. Up to now, vidicons in conventional live cameras for broadcast service exhibit a *lag*, or *trailing smear,* with moving objects which limits their usefulness. However, with the present luminance concept, the vidicons generate only the color difference signals and the brightness component comes almost entirely from the image-orthicon (luminance) channel; the resultant picture is practically lag-free.

THE FIRST LUMINANCE-CHANNEL CAMERA—1962 VERSION

The first developmental camera model using the luminance-channel camera concept was introduced at NAB in Chicago in 1962; this camera used a 4½-inch image orthicon for the luminance channel and three electrostatic-focus and -deflection vidicons for the chroma information (Fig. 2). The optical system uses the Rank-Taylor Hobson Varotal lens, having a focal length range of 1.6 to 40 inches when used with an auxiliary wide-angle adaptor element. The back-focal distance of 290 mm or 11.6 inches made it possible to locate all beam-splitting and dichroic elements in this available space; a functional optical layout is shown in Fig. 3. The electronic circuitry was a hybrid combination of solid-state devices and vacuum tubes, determined by the state-of-the art, and by performance goals.

The performance of the 1962 version camera both at NAB and experimentally under action broadcasting studio conditions generated enthusiasm for the results obtained. Such tests showed where additional effort was required for improvements and where a fresh point-of-view might be rewarding. Thus reoriented, development and refinement continued for two more years.

THE 1964 FOUR-CHANNEL CAMERA

A critical re-examination of the four-tube approach to a luminance-channel camera indicated that the use of three separate vidicons to obtain direct red, green, and blue chroma information would keep the color circuits straightforward and the operational flexibility high; other advantages of compactness, greater stability and better color fidelity are apparent.

The version of the color TV camera shown at the 1964 NAB Exhibition (Figs. 1, 4-8) is based on the use of an image orthicon for luminance signal and three electrostatic-focus, magnetic-deflection vidicons for the chroma channels.

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The optical system is now centrally placed so that the image orthicon and the vidicons are located on opposite sides of the main lens (Fig. 5). This allows the use, experimentally, of either the 3-inch or 4-inch image-orthicon assembly for the luminance channel.

New High-Stability Vidicons

The three electrostatically-focused, magnetic-deflection vidicons[1] used in the camera are easy to drive, and when equipped with precision yokes, easy to register. Certain annoying registry problems associated with the charging of the deflection plates of the early electrostatic-focus and deflection vidicons are now completely eliminated.

Transistorization

The rapid advances in reliability and power capability of transistors and solid-state devices during the past two years have made it possible to transistorize the camera. With the obvious exception of image orthicon, vidicons and viewfinder kinescope the camera and control circuits are completely solid-state at no sacrifices in performance and with attractive reductions in power input and over-all camera size.

Standard Modules and High Reliability

The packaging of the transistorized electrical circuits conforms with the pattern established by Product Design Engineering for use in all film and studio cameras and ancillary equipment. This design philosophy[2] is based on the use of a standard-sized and interchangeable module board readily plugged into a master frame. The use of standard-size plug-in modules for the electronic circuits holds a potential for high reliability, ease of maintenance and a high degree of interchangeability; a typical module is shown in Fig. 8.

High Stability

All of the known precision registry and stabilizing techniques and circuits have been incorporated in this development model. The goal of an inherently stable camera requiring only minor trimming adjustments over long periods of time has been achieved.

Following the philosophy developed in monochrome camera design, the circuits and controls provided in the camera head allow registration and alignment using the transistorized viewfinder as a monitor. Stabilization circuits and stable components assure that the alignment will be maintained for long periods of time. Paralleled registry controls at the control position allow for precision registry checks using a color-picture display. Beam current adjustment for the

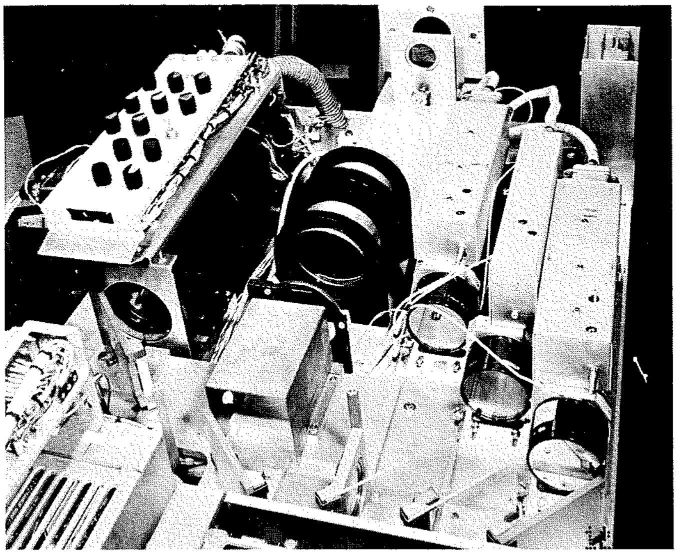

Fig. 5

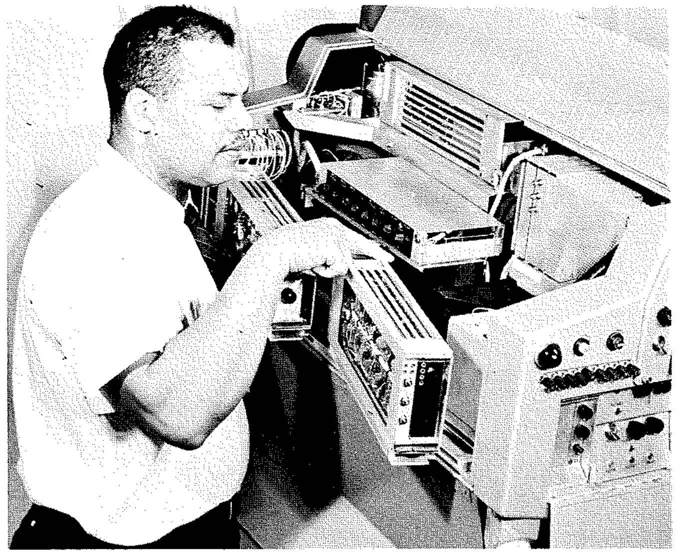

Fig. 6

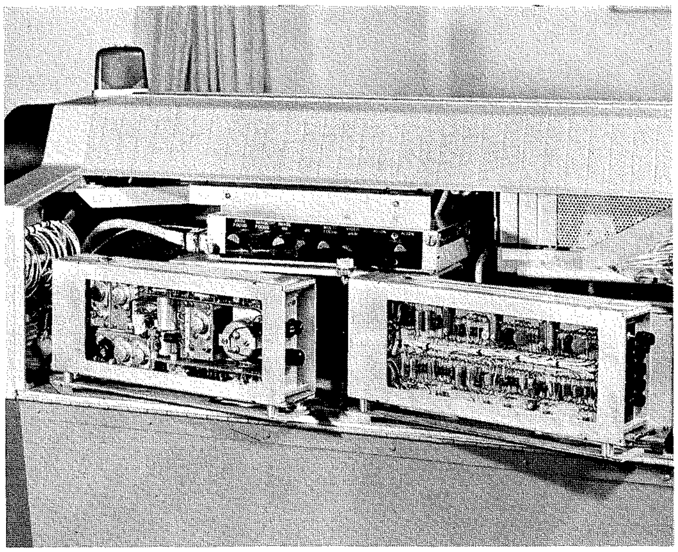

Fig. 7

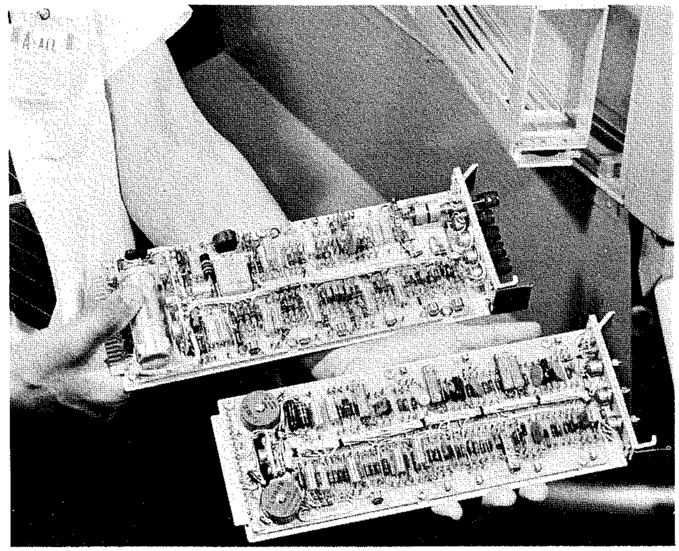

Fig. 8

image orthicon is also provided to obtain optimum signal-to-noise, even under difficult or unusual lighting conditions.

CONCLUSION

The 1964 four-channel TV color camera represents our fourth example of the Advanced Development phase of the luminance-channel concept. As set forth in the development goals, it contains the features required to produce high-quality color TV pictures. Our tests and measurements show that it has met the standards set for performance, and contains the elements required for exploitation of advances in pick-up tubes, circuits, and operating techniques which will come in the future.

Critical tests of colorimetry using calibrated Munsell Charts, and the new color swatches developed in England show that the color fidelity is at least equal to the fidelity of the TK-41 three-image-orthicon camera now in general use. It is possible, by simple switching techniques, to compare the colorimetry of the four-tube camera with that of the three-vidicon section alone.

Experience with the camera both in set-up and operation makes us very optimistic about its future reception in broadcast color pick-up. It represents an easy-to-handle color camera that produces an excellent monochrome picture, an equally excellent color picture, and provides a welcome increase in the ability to reproduce dramatically lit scenes.

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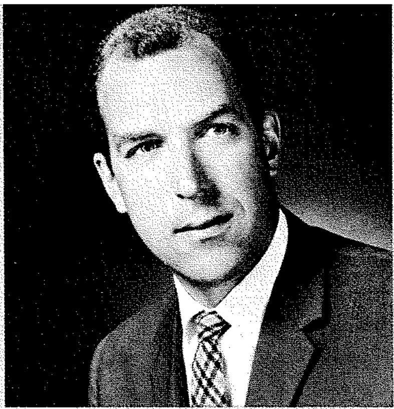
Fig. 5—Optical arrangements at right are the three vidicons, and at left the image orthicon. The lens system is in the center, and this mirror system is at the bottom of the photo. (See also Fig. 3.)

Fig. 6—Internal arrangement, showing the "swingout" module frames, and controls; J. Hardy is pointing at the position of the image orthicon.

Fig. 7—Horizontal and vertical deflection modules and controls.

Fig. 8—Camera plug-in module.



ROBERT G. NEUHAUSER joined RCA at Lancaster as a co-op engineering student, alternating work with study from 1946 to 1949. He received the BSEE from Drexel Institute of Technology in 1949 and joined the cathode-ray tube development group at Lancaster. In 1950 he was assigned to the camera, oscillograph and storage tube development activity. Since 1953 he has been Engineering Leader in charge of camera tube design.

DEVELOPMENTS IN ELECTRON OPTICS PRODUCE TWO NEW LINES OF VIDICON TUBES

A major development program at Lancaster was aimed at revising the electron optical system of the magnetically deflected, magnetically focused vidicons. That program has led to two new series of vidicons: 1) magnetically focused, magnetically deflected, with an internal electrostatic collimating lens, and 2) electrostatically focused, magnetically deflected.

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Image Orthicon Advanced Development
Electronic Components and Devices, Lancaster, Pa.

ADVANCES in the electron-optical design factors of vidicon camera tubes have resulted in the creation of two completely new lines of vidicon tubes: 1) the magnetically focused, magnetically deflected tubes with an internal electrostatic collimating lens, and 2) the electrostatically focused, magnetically deflected family of vidicons. These developments are the outgrowth of an earlier program to revise the electron-optical system of the magnetically deflected, magnetically focused vidicons—developments that involve not only the design of the tube but also the design and interrelationship between the tube and its associated deflecting or focusing coils.

The magnetically focused tube with the internal collimating lens results in a four-fold improvement in picture quality, specifically in resolution, signal uniformity, and uniformity of focus. In addition, the tubes maintain good resolution over a wide range of beam-current adjustment.

The electrostatically focused tube produces pictures comparable in quality to the improved magnetically focused tube and in addition this family of tubes also affords the advantages of requiring less space, less deflecting power, and no focusing coil. Particular advantages of this family of tubes are the nearly perfect geometry obtainable and the excellent uniformity of resolution over the scanned area, features that are extremely important in the multitube color-camera designs.[1] This electrostatically focused tube family is being used extensively in many new camera designs because of these system design features and because of the simplified circuitry-stability requirements afforded by the electrostatic-focus concept.

MAGNETIC FOCUSING AND DEFLECTION

Fig. 1 shows the locus of the electron trajectories in the undeflected beam of the basic magnetically focused tube system. Magnetically focused vidicon tubes are usually operated with one loop of focus between the gun and the target. This mode of operation restricts the individual electrons that are emerging from the minute grid No. 2 aperture to a single spiral around the magnetic field lines before the electrons converge at a common point somewhere along the axis of the tube. These traverses are illustrated in Fig. 2, an end view of the tube showing the trajectories taken by three typical electrons after they emerge from the grid No. 2 aperture and progress toward the target. All of the electrons have the same orbit time and, therefore, all converge at approximately the same time, forming a focused beam.

The purpose of the grid No. 3 (sometimes called the *focusing electrode*) in this vidicon is not to focus the beam in the usual sense, but to adjust the beam velocity so that the transit time of the electrons traveling between the grid No. 2 aperture and the target will be equal to the orbit time of the electrons in the magnetic focusing field.

The orbit time T, in seconds, is:

$$T = \frac{3.56 \times 10^{-7}}{B}$$

Where: B is the magnetic-focus field flux in gauss.

The single loop of focus between grid No. 2 and the target aids in maintaining resolution. There are some aberrations in the system because each of the electrons has a slightly different velocity and therefore all the electrons do not arrive at exactly the same point along the axis at exactly the same time. If the tube were designed for multiple-loop focusing, this error would be cumulative. However, the fact that only one loop of focus is used, presents some other problems when the beam is deflected as in an operating vidicon. Any change in direction of the beam due to deflection

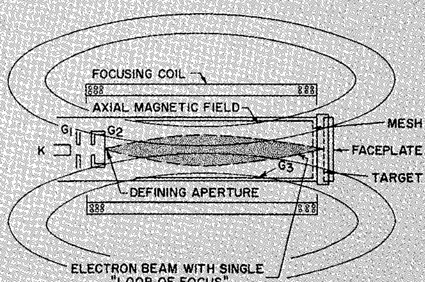

Fig. 1—Magnetically focused vidicon, basic tube system.

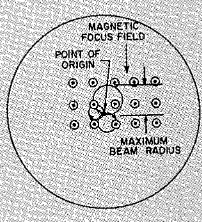

Fig. 2 — Electron trajectories within an undeflected beam of a magnetically focused vidicon.

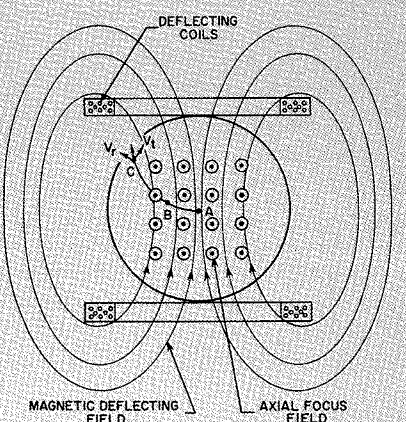

Fig. 3—Front view of deflected beam trajectory in a magnetically focused, magnetically deflected vidicon.

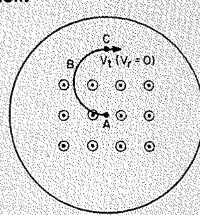

Fig. 4—Beam trajectory showing a situation wherein the beam has zero radial component of velocity error.

Final manuscript received June 4, 1964

resulting in a spiraling motion of the entire beam, will allow only a portion of a new spiral to be completed because the time of the spiral is dependent only on the strength of the magnetic field.

This effect is illustrated by Fig. 3, a front end view of a vidicon showing the axial magnetic-focus field and one of the magnetic-deflection fields. The trajectory of the beam after it enters the deflection field is illustrated by the line *A-B-C*. As the beam enters the magnetic deflection field, it is traveling perpendicular to this magnetic field and begins to make a spiral in a direction perpendicular to the deflecting magnetic field. This action causes the beam to have a velocity component perpendicular to the magnetic focus field, which in turn causes the beam to curve in the arc shown by *A-B-C*. The resulting deflection is, therefore, not at right angles to the magnetic deflection field, and the beam arrives at the target, point *C*, with two unwanted components of velocity, one radial (V_r) and the other, tangential (V_c). These components of velocity are unwanted because they cause a loss of energy in the axial direction of the beam that results in a nonuniform signal output.[2]

The earliest concern with the design of the magnetically focused, magnetically deflected vidicon was to minimize or eliminate these unwanted components of beam velocity so that the photoconductor-target would be stabilized at the same voltage at every point. The original magnetically focused tube system made no provisions for this correction, and because the vidicon photoconductor is highly sensitive to voltage variations, the result was a nonuniform signal output. The beam not arriving at the target perpendicularly is also a probable cause of poor corner resolution.

EARLY DESIGN MODIFICATIONS

A review of the previous advances in electron-optical design will illustrate the principles involved in the new tube-yoke-focus-coil electron-optical systems.[3]

In the first design revision of the magnetically focused, magnetically deflected vidicon electron-opitcal system, the trajectory error was corrected solely by means of magnetic fields. The deflection coil was positioned far enough back along the tube so that the beam, in the process of deflection, spiraled as shown in Fig. 4. At point *C*, as the beam approached the target it had only a tangential component of velocity error. Proper design of the magnetic focus coil resulted in a focus field which had a radial component near the target that caused the beam to spiral in such a way that it arrived perpendicular to the target, as illustrated in Fig. 5.

TABLE I — New Family of Magnetic-Electrostatic Vidicons

New Magnetically Focused Tubes with Internal Collimating Lens	Size, Inches		Magnetically Deflected Counterpart Tube
	Diam.	Length	
8507	1	6.25	7735A
8572	1	6.25	7038
8573	1	5.12	7262A
8051	1½	7.75	—
8521	1½	7.75	—

TABLE II — Electrostatically Focused Vidicons

Type	Size, Inches		Uses
	Diam.	Length	
8134	1	6.25	Industrial TV; film pickup, B&W and color
8480	1½	10.25	Film pickup, B&W and color; high-definition industrial TV
8567	1	6.25	Ruggedized version of 8134 for military and space applications

ALTERNATE CORRECTION METHODS

An alternate correction method was to impress a modulation voltage on the cathode of the vidicon tube. This method did not cause the beam to land perpendicular to the target, but it achieved a similar effect by the cathode being made more negative as the beam was deflected further away from the center. As a result, the beam accelerated to a greater velocity and obtained a higher component of velocity in the axial direction and in this way compensation for the loss of energy to the unwanted radial and tangential components was achieved. This system has its limitations. The unwanted errors are proportional to the grid No. 3 voltage, and when stronger magnetic focus fields and higher grid No. 3 accelerating voltages are used with the vidicon to produce better resolution, the requirements for high cathode modulation voltage become rather severe and cause excessive modulation of the beam current.

COMBINATION OF MAGNETIC AND ELECTROSTATIC TRAJECTORY CORRECTION METHODS

The 1½-inch vidicon tube, 8051, was the first vidicon to utilize a new principle of design which combined the use of radial components of the magnetic focus field at the target to compensate for the tangential errors and an electrostatic collimating lens, formed by the mesh and the wall electrode, as illustrated in Fig. 6, to compensate for the radial errors.[4]

In this system, a collimating lens is formed by isolation of the mesh from the wall electrode and the application of the higher of the two voltages to the mesh. This electrostatic field tends to deflect the radial component of velocity of the beam towards the axis of the tube as illustrated by the trajectory in Fig. 5. In this electron-optical system the deflection coil is placed closer to the faceplate of the tube which results in an improvement in picture geometry. This method effectively reduces the *S* distortion that is present in the all-magnetic system where a straight line across the center of the picture takes on a slight *S* shape.

This same electron-optical system has recently been designed for the 1-inch vidicon tubes and has produced the entire new family of vidicon tubes listed in Table I. Only minor changes need be made to most existing cameras to accommodate these particular tubes. The 1-inch tube requires either a shorter

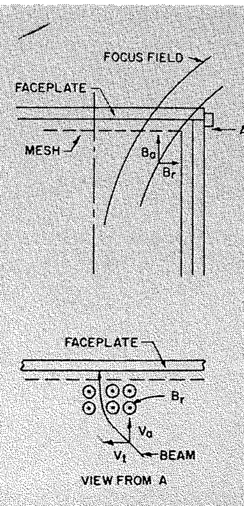

Fig. 5—V_r compensation using radial component of magnetic-focusing field.

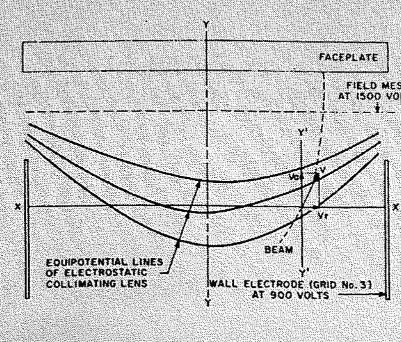

Fig. 6—Compensation of V_r with electrostatic collimating lens.

focus coil than the original magnetically deflected tube focus coil or that the tube protrude approximately ¼ inch in front of the normal position in the focus coil, in order that an adequate radial component of the magnetic focus field can be obtained near the target. The tube's internal construction is different from its predecessors *only* in that the mesh is isolated electrically from the wall electrode and is designed to be operated at a higher voltage than the wall electrode. Another adjustment in the system is the relocation of the magnetic deflection coil to a position closer to the faceplate of the tube. The net result of this change in the electron-optical system of the 1-inch vidicon tube has been an increase in the center resolution without the necessity for increases in the magnetic-focus field and the required deflection power. Fig. 7 shows the amplitude response of the 1-inch vidicons. In addition, the corner focus has been improved considerably and the tube produces excellent geometry free from the typical *S* distortion peculiar to the all-magnetic system.

Another feature of the magnetically focused vidicon tubes with the "isolated" mesh is their ability to operate with a higher beam current. In the magnetically deflected tubes very-low-energy secondary electrons are emitted from the field mesh in a direction towards the gun. Because these electrons, for the most part, have very low energy, they progress very slowly through the tube and the magnetic-focus field causes them to spiral around the lines of force as shown in Fig. 8. This trapped space charge deflects and defocuses the beam, the effect becoming greater and the resolution poorer as the beam currents and resulting secondary electron currents increase. Even in an electron-optical system that is not designed to utilize the collimating lens effect as used in the new line of one-inch tubes, an improvement in resolution and the ability to handle an excessive beam current can be obtained by biasing the field mesh only slightly more positive than the wall electrode, thus providing an electric field that pulls the secondary electrons back to the mesh and prevents them from developing a space charge which interferes with the scanning beam.

THE ELECTROSTATICALLY FOCUSED TUBES

A second complete new line of tubes has been developed in which the beam is electrostatically focused and magnectically deflected.[5] Fig. 9 illustrates an undeflected beam as it travels through a typical electrostatically focused tube which uses the low-voltage Einzel lens system. Fig. 10 illustrates the front view of the beam trajectory as the beam enters the magnetic deflection field. The beam is deflected at right angles to the magnetic-deflection field lines, and, therefore, at point *C*, as it arrives at the target, it has only a radial component of velocity which is readily compensated for by a collimating lens.

One advantage of the electrostatically focused, magnetically deflected tube is that with one fifth the deflection power of the magnetically focused tubes its performance is comparable to any of the all-magnetic tubes when operated with similar voltages on the electrodes. This advantage is an important camera design factor for two reasons: 1) the resolution in any vidicon is a function of the accelerating electrode voltages, within certain limits; and 2) the deflection system accounts for a major portion of the total camera power requirements.

The electrostatically focused tubes require more precise alignment and adjustment in a camera, require effective shielding from external magnetic fields, and are more costly because of the more complicated gun design. However, where space, weight, picture geometry, resolution, uniformity, and size or deflection power are major criteria these tubes are fulfilling a very important function.

The electrostatically focused tubes have an additional performance advantage in that focus is independent of the tube electrode supply voltage if all electrode voltages are supplied from a common voltage source. Such an arrangement maintains the same voltage ratios on all electrodes in spite of power supply voltage variations. This feature provides built-in focus stability and simplifies the design and reduces the cost of the camera.

Table II lists the line of new electrostatically focused tubes which have been commercially introduced. Tubes of this type are used in the new four-tube studio and film pickup color cameras because of their excellent geometry and signal uniformity, low deflection-power requirements, and the built-in focus stability. Because these tubes do not require a magnetic focus coil geometric inaccuracies from channel to channel, that might occur if a coil were necessary, are eliminated.

ACKNOWLEDGEMENTS

I would like to acknowledge the very valuable contributions made to the electron-optical design of these families of vidicon tubes by B. H. Vine, W. H. Hackman, J. E. Kuehne, G. A. Robinson, and R. E. Johnson.

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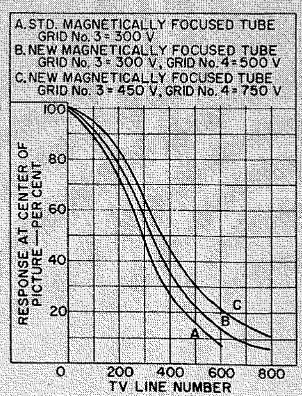


Fig. 7—Amplitude response of 1-inch vidicons.

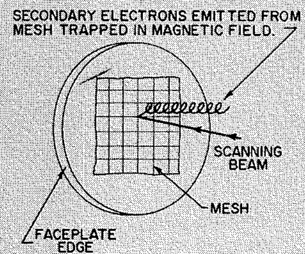
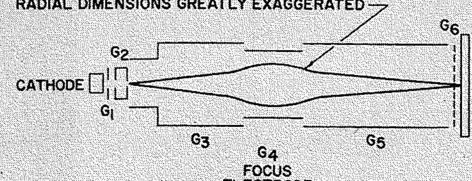


Fig. 8 — Effect of secondary emission from the mesh in vidicons.

Fig. 9 — Shape of undeflected beam in an electrostatically focused vidicon.



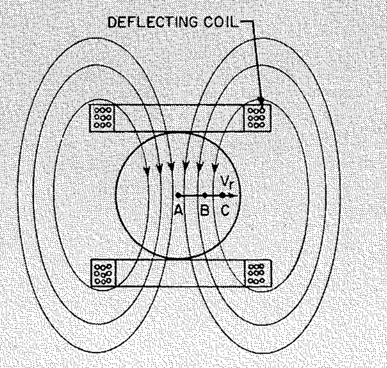


Fig. 10—Beam trajectory in a magnetically deflected electrostatically focused vidicon.

PRODUCT DESIGN PHILOSOPHY FOR NEW BROADCAST TV CAMERA EQUIPMENT

New RCA broadcast TV equipment is being created with a consistent design philosophy centered about a common-module approach utilizing solid-state components. As this paper discusses, this product design approach provides significant improvements in many of the product characteristics of greatest concern to the broadcaster—such as reliability, ease of maintenance, simplified setup, better stability, automatic operation, compactness, and reduced power consumption.

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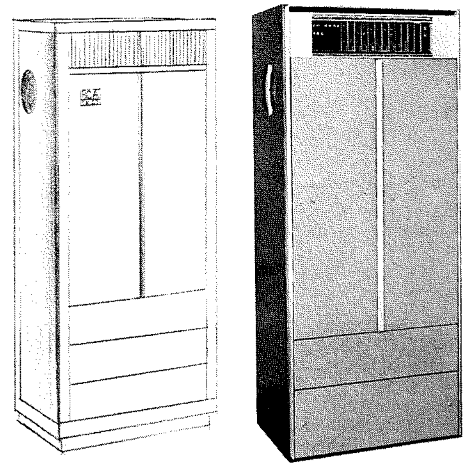
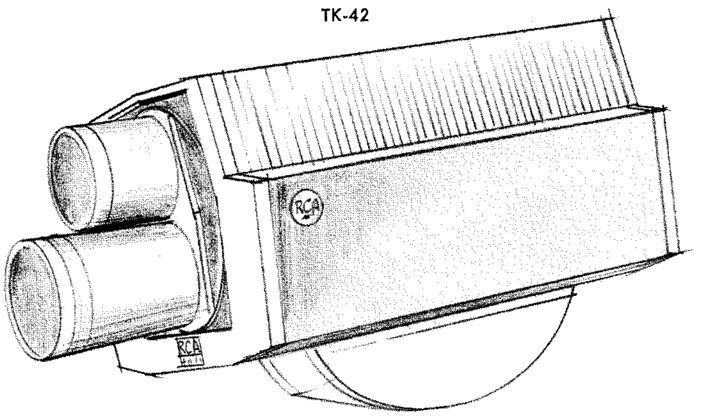
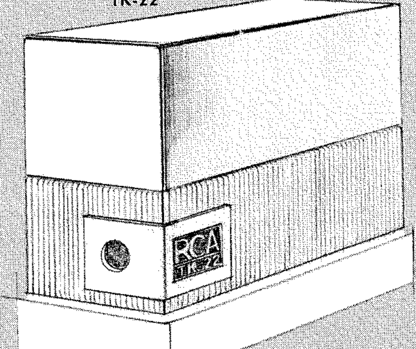


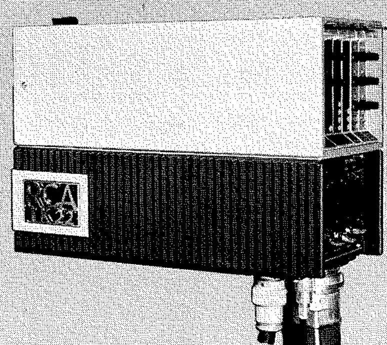
TK-27

TK-42



TK-22





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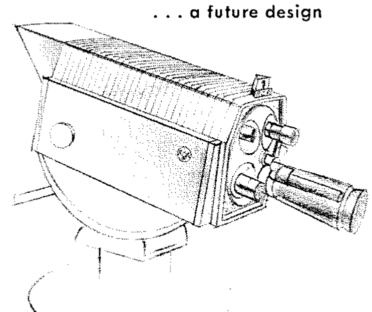


Fig. 1—Early functional design sketches and actual photos of current designs of the TK-27 color film camera, TK-22 monochrome fi.m camera and TK-42 studio color TV camera.

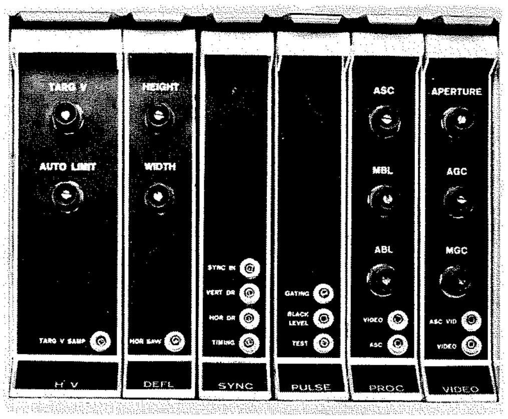


Fig. 2a—These six modules (high-voltage, deflection, synchronizer, pulse, processor and video) comprise the TK-22 film camera head assembly.

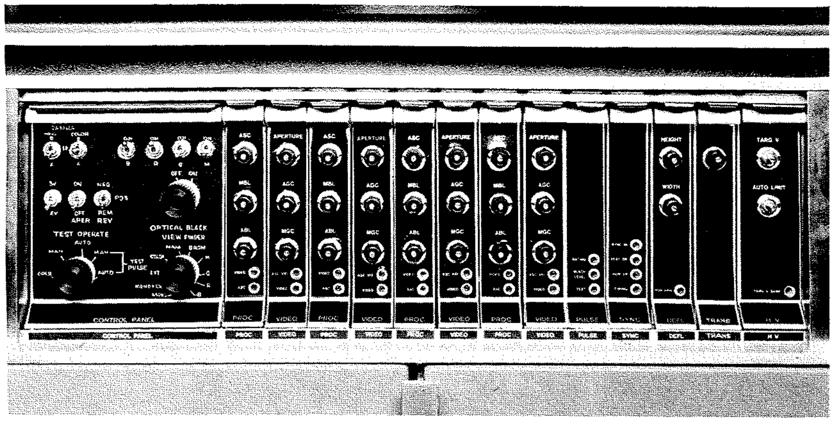


Fig. 2b—TK-27 film camera head which uses all six of the interchangeable modules used in the TK-22 camera head assembly.

How *far and how fast should the product designer go in perfecting new equipment for the broadcast market?*

Should engineering changes be radical or conservative?

Is economy of operation a major factor?

What about small size and compactness?

Should technical equipment be automated to a high degree?

Can a pioneer leader such as RCA wait to see what moves competition makes—or, to be the true leader, must RCA come up with major innovations for the market?

Obviously, there is no pat answer to these questions. However, some indication of the answers became apparent when TV broadcasters exhibited interest in transistorized equipment to replace older vacuum tube types. Significantly, because of RCA's extensive experience in the design and development of transistorized equipment for commercial and defense applications, such questions were directed to RCA for solution.

Thus, it was recognized by RCA that to remain the leader in TV camera equipment, a major design program would have to be undertaken to utilize solid-state components wherever possible. It was also apparent that the redesign of each camera equipment independently, as had been done previously, was completely unacceptable from the cost and product availability viewpoint. Thus, a new product design philosophy has been adopted which attempts to relate the answers to the broadcasters' needs in terms of TV camera equipment providing greater ease and simplicity in programming, and maximum economy of operation.

To obtain maximum economy, for both the broadcaster and RCA, this philosophy is being extended into as many camera equipment designs as possible; this includes monochrome and color studio cameras, and monochrome and color film cameras.

The new design approach required that costs be kept to a reasonable level and the availability of the equipment to the customer be accelerated with no sacrifice in stability or reliability. In fact, one of the major design goals was to improve the stability of the system to the point where the basic setup and adjustment by the average broadcaster would become a routine maintenance procedure practiced monthly instead of daily. The extent to which the above philosophy has been adopted in RCA camera equipment is described in this and other papers.[1,2]

THE BROADCAST USER'S VIEWPOINT

In years past, nearly all major television stations had adequate engineering departments to handle problems associated with a new and growing industry. However, to remain competitive, most broadcaster's engineering departments today have either disappeared or dwindled to just a few people. To find more economical ways to operate, the broadcaster now looks to the equipment manufacturer to help him in his search to reduce operating costs. The most consistently repeated requests by broadcasters express the following needs:

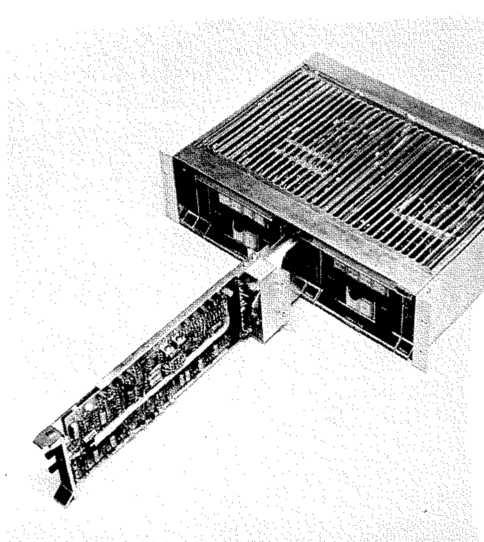
1) More reliable equipment to reduce maintenance costs and rebates to sponsors; rebates to sponsors for loss of a network commercial are costly.
2) More serviceable equipment to speed up replacement and minimize "down time."
3) More simplification in the setup, adjustment, and operation of the equipment.
4) More stability to increase the time between readjustments of setup controls.
5) More built-in test facilities.
6) More automatic operation of the equipment.
7) More compactness of the equipment to reduce costs of floor space in the studio and to ease handling of the camera equipment in the field.
8) Reduced power consumption to minimize air conditioning costs.

THE PRODUCT DESIGN PLAN

In addition to the ever present need to fulfill all customer requirements, the product designer must also satisfy the following major RCA engineering goals of reduced engineering costs, reduced production costs, shortened product availability cycle, and the introduction of a new appealing style of equipment (see sketches and photos of Fig. 1).

Camera equipment designed to meet the requirements of the television broadcasting industry requires that certain basic electrical functions (such as video amplification, deflection, aperture correction, clamping, gamma correction, blanking, etc.) be *performed within each equipment* whether the unit is for monochrome or color or for live pickup or film pickup.

Fig. 3—Shown on an extender available for servicing is a blanker module, one of the "identical-circuit" modules used in the various camera systems. Shown in a cabinet-width frame assembly are two TK-22 film camera ancillaries comprising control panels, power supply, blankers and regenerators.



Final manuscript received June 3, 1964

Identical Circuitry

With this similarity of electrical functions of the various camera systems in mind at the inception of the over-all camera design program, an excellent opportunity arose to design the cameras to use identical circuitry. Such a plan provides savings in engineering, production testing, and customer servicing. The *identical-circuit* approach allows a greater concentration of engineering effort on a single design problem which tends to result in a more reliable design and the consumption of less total engineering time.

To achieve truly identical circuits, the circuit layout and placement of components must be identical in each equipment. The thought of using transistors in identical circuits led directly to a compact modular approach. In addition to the identical-circuit concept adopted, it was easy to see at this point in the planning that mechanical standardization was equally important to provide further cost savings in both engineering and production. Therefore, the next logical step was to "freeze" on the circuitry to be used with the standard mechanical module for all cameras; see Figs. 2a and 2b.

Serviceability

Maximum serviceability dictates that such a standardized module be readily removed and another inserted during emergencies to effect minimum "down time" for the broadcaster. The removed unit may then be serviced at any convenient time (see Figs. 3 and 4).

A more appealing approach for the customer may be to return inoperative units to the manufacturer for repair; this method minimizes the technical skill required at the TV station (*ABC-TV* and *CBS-TV* are already doing this with RCA on the TR-22 Television Tape Recorder). Not only does the quick-interchange feature help the broadcast user, but it is also of great advantage during RCA production; the ready replacement of inoperative circuitry greatly reduces the time to complete final testing and troubleshooting.

Mechanical Design of Standard Module

The standard module uses solder-type connections in a "pin-and-jumper" technique (Fig. 5) which allows quick replacement of faulty components. From an engineering viewpoint, the "pin-and-jumper" technique was adopted for these reasons: 1) components can be readily removed for emergency servicing, 2) requires minimum engineering time to plan and finalize board layouts, and 3) provides flexibility for making revisions or additions to board assemblies.

Many of the electrical interconnections on the module are accomplished by printed wiring (Fig. 5) to reduce the chances for poor joints or wrong connections. Crimp-on connections are used wherever possible to improve reliability; however, the module board mating connector will accept either the crimp-on-push-in or solder-type inserts.

The size of the module was chosen to fit compatibly into present rack-mounting frame sizes; module size and mechanical construction are such that a simple adaptation can be made to printed circuit techniques now used in some companion broadcast equipment (Fig. 6).

The component board of the module has a metal support that provides stiffness and serves as a runner for locating the unit in the module frame assembly; a single, low-cost stamping is used for the guide plate for all modules in the frame; the module connector was selected for its simplicity, large number of contacts, compactness, crimp-on-push-in terminals, keying provisions, and low cost.

A spring retaining clip at the top front of the module provides positive retention of the unit during vibratory conditions; by depressing this spring, the module is easily pulled out for quick replacement (Fig. 6).

Fig. 5—"Pin-and-jumper" technique; printed wiring is used freely for many of the jumpers; labelling shown below the transistors indicates the type number, collector position, and corresponding schematic number.

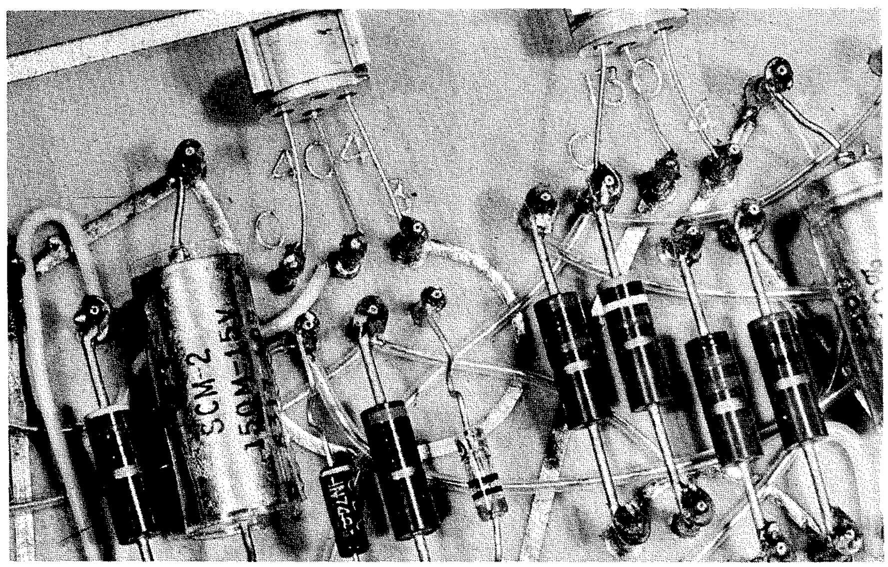


Fig. 4—Closeup of standard extender removed from rack frame and shown in the same position used in Fig. 2; module has been removed.

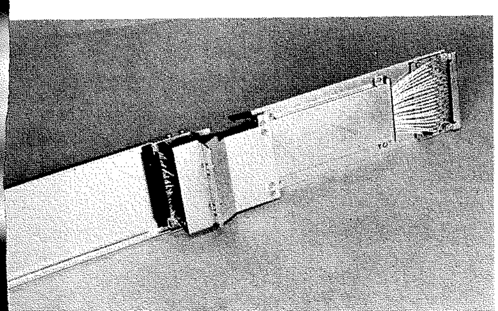
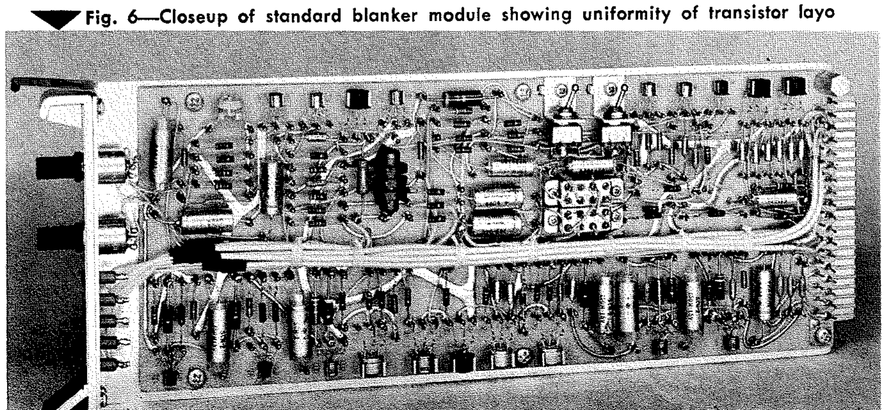


Fig. 6—Closeup of standard blanker module showing uniformity of transistor layo



N. L. HOBSON graduated with honors from Wayne University in Detroit, Michigan in February 1949 with a BSEE. He has attended the University of Pennsylvania, taking post graduate work in electrical engineering. He joined RCA in Camden, New Jersey, as a specialized trainee in March 1949. He worked in Broadcast Studio Engineering in the Advanced Development Group on video circuits. He has since engaged in the development and design of circuits that are associated with almost every part of the television system. After becoming Leader responsible for the design of the TK-26 Color Film Camera, he was assigned to the TV Tape Recording Group, responsible for the product design of the TRT-1 Television Tape Recorder. He was elevated to Manager of Quadraplex Tape Recorder Design in 1960. In 1961 he was transferred to present position as Manager of TV Camera Equipment Engineering responsible for design of television broadcasting cameras. He is a member of the SMPTE, IEEE, and Sigma Xi.

Accessibility and Compactness

To assure quick, correct insertion of modules, matching identification nomenclature appears both on the frame and the module (Fig. 7); a mechanical keying arrangement prevents engagement of the connector for all except the proper module and thereby avoids possible circuit damage (Fig. 8)

The standard module mounting frame fits the standard rack assembly; it occupies three basic units, totalling 5¼ inches in height; the module mounting frame accepts any combination of module widths of two units or greater, up to a total of 36 units. Fig. 3 shows a module frame with a module mounted on an extender for servicing.

The module standardization program has now been extended to the entire Broadcast TV Studio line of equipment. Transistorization and the accompanying reduction in power (heat) provide a technical breakthrough that results in a new compactness for broadcast circuitry.

Greater Reliability

Reliability must be included in the original design of any equipment; to acquaint engineers making the transition from tube circuits to transistor circuits, an *in-the-house course* was given to pass along the knowledge gained by other Broadcast and Communication Products engineers who have had experience in designing reliable circuits using semiconductors. Conservatively rated and used in a stabilized circuit, the transistor has proven to be extremely reliable; less power consumed by the use of transistors results in lower ambient operating temperatures which in turn extends the life of all components.

The high reliability and the use of standard modules contribute to a greater total on-air time for the broadcaster by reducing the frequency and the duration of maintenance occurrences.

Simplified Operation

The ultimate in simplified operation of camera equipment would be unattended control over extended periods without need for a human operator; if the optical signal coming to the camera tubes photosurface was a well behaved function, the solution to providing simplified operation would be considerably easier; given such ideal conditions, it would be a matter of having adequate stability and reliability under prescribed environmental conditions.

Early camera equipment designs usually supplied just about every conceivable control at the operating position; such controls normally fit into two categories; those provided to compensate instabilities within the equipment, and those provided to obtain a special effect in programming.

In the past, the operator at a console has attempted to keep under control all of the variables associated with both the instabilities of the equipment and the incoming optical signal. The state-of-the-art of stability in design has now reached a point where there is no longer a need for the adjustments associated with instabilities.

The essential controls (white level, black level and sensitivity) for a monochrome camera are also the primary controls for the operation of a color camera. These are grouped on one panel for the simplified operation of a monochrome or color camera. Additional controls for color operation are grouped on a second panel to simplify the intermixed control of camera equipment (Fig. 9).

Automatic Control

As competition between telecasters grew, the pressure for increased economy became greater; thus, the telecasters began looking for ways to obtain acceptable performance with a minimum of operating cost. Therefore, a demand was created for preset equipment that would provide automatic control of system variables equivalent or superior to that produced by a skilled operator. In view of this demand, the standard module circuitry is designed so that all camera systems (monochrome or color) can operate with automatic sensitivity, automatic white level, and automatic black level control; such automatic functions are actuated from the console control panel. For many applications, the automatic mode of operation provides satisfactory performance.

Ordinarily, for film, an operator is required whose job it is to decide on a continuous basis what adjustments of the operating controls are needed to give the audience the best possible picture. By observing the picture, a skilled operator also uses his intelligence to reproduce special artistic effects, such as: smooth fades to black, mood shots, flickering firelight scenes, etc., as the film producer had intended. The design target for automated control is to equal the performance of such a skilled operator. Since new RCA camera designs provide simultaneous operation of automatic sensitivity, automatic white level, and automatic black level functions, these camera systems represent a forward step toward solution of this problem.

Automatic Camera Cable Compensation

In addition to automatic signal level operation, all camera equipments include automatic compensation for camera cable length for both DC voltage and time delay. The DC voltage at the camera end of the camera cable is sensed and the voltage at this point corrected to account for the voltage drop due to transmission loss down the cable. The timing of the horizontal synchronizing pulses for the camera is advanced automatically to compensate for camera cable length so that the outgoing, "on-air" signal is timed as though there were no cable in the system. This automatic compensation assures that the maximum system blanking time is always available to mask the ever present problem of camera horizontal deflection return time.

Built-In Signal Level Test

Another design feature contributing to simplified operation is the incorporation of test pulses to speed up the initial adjustment of camera signal levels; such pulses determine that the pickup tube and amplifiers are operating at their proper levels. Circuits are arranged within the camera system so that one man (formerly two) can now set up and adjust the camera by use of these pulse techniques. By depressing a switch on the control panel, these same test pulses may be inserted into the system at any time for a monitoring check of stability.

The "New Look"

In addition to the product design philosophy presented above, considerable effort was exerted by the Broadcast and Communications Products Division's Functional Design Group (Marketing Services) to inaugurate an attractive "new look" family styling for the camera equipment line (Fig. 1); this same decor (silver and a two-tone horizon and space blue) is being included in the styling of all lines of broadcast equipment.

CONCLUSION

The product design philosophy described herein is being followed for all new designs of television camera equipment. An indication of the extent to which the common module approach is being applied to RCA camera equipment is shown in Table I.

The TK-22 Monochrome Film Camera is first of the series of cameras to be produced; this equipment is described in another paper[1] by N. P. Kellaway. The TK-27 Color Film Camera is the next in line with the TK-42 Live Color Camera following close on its heels; the Advanced Development model of the TK-42 color camera is described in another paper[2] by Dr. H. N. Kozanowski and K. Sadashige. With future cameras following the common module concept, the broadcaster will need only a minimum number of spare modules (low capital outlay) for emergency use.

With the common module approach to design, improvements have been made in all of the areas of interest to the broadcaster; i.e., increased system reliability, improved serviceability, simplified setup and operation, better stability, built-in test facilities, automatic operation, compactness, and reduced power consumption.

ACKNOWLEDGEMENT

Much of the system planning and the product design philosophy described in this paper have been contributed by R. A. Dischert.

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2. Dr. H. N. Kozanowski and K. Sadashige, "A Brief Review of Color TV Camera Development," RCA ENGINEER, *this issue.*

TABLE I—Use of Standard Module Concept in New Camera Product Lines

	Quantity of Modules Used		
STANDARD MODULES	*TK-22 Mono Film Camera*	*TK-27 Color Film Camera*	*TK-42 Color Live Camera*
Blanker	1	2	2
Regenerator	1	1	1
Equalizer	1	5	5
Video	1	4	4
Processor	1	4	4
Synchronizer	1	1	1
Pulse	1	1	1
High Voltage	1	1	1
Deflection	1	1	—
Monitor	—	1	1
Detector	—	1	1
Subcarrier	—	1	1
Modulator	—	1	1
Driver	—	1	1
Matrix	—	1	1
Bar Generator	—	1	1
Level Control	—	1	1
"M" Delay	—	1	1
Power Supply B	—	2	1
Servo Amplifier	—	—	1
OTHER STANDARD UNITS			
Preamplifier	1	4	—
Yoke Assembly (1½")	1	1	—
Yoke Assembly (1")	—	3	—
Intercom	—	—	2
Viewfinder	—	—	1
Mono Control Panel	1	1	1
Color Control Panel	—	1	1

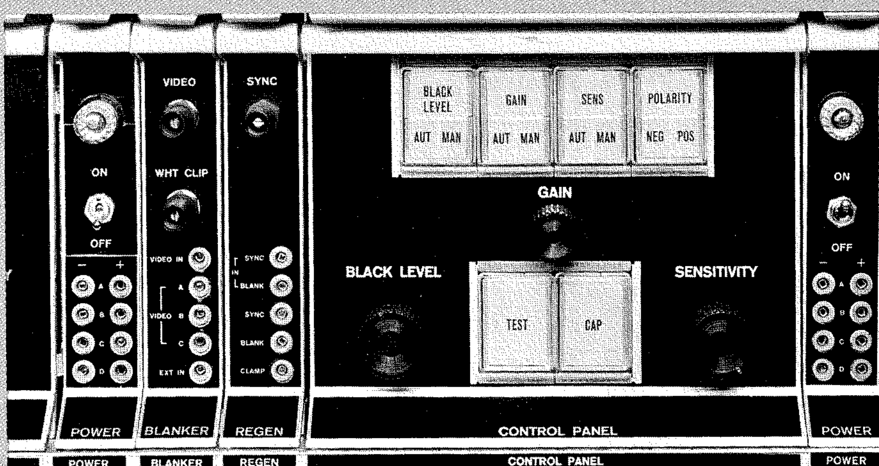


Fig. 7—TK-22 camera ancillary group showing (at bottom of photo) matching identification nomenclature on module and frame.

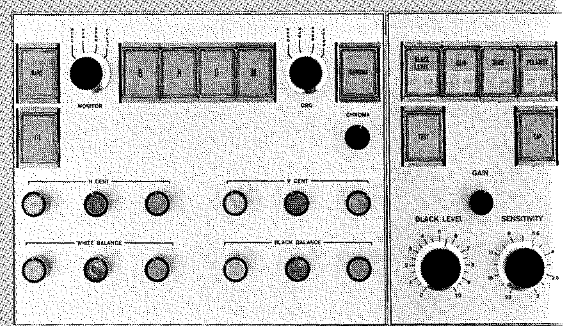


Fig. 9—The primary control panel used for monochrome camera operation (right above) and the auxillary panel (left) used in conjunction with the primary control panel for color camera operation.

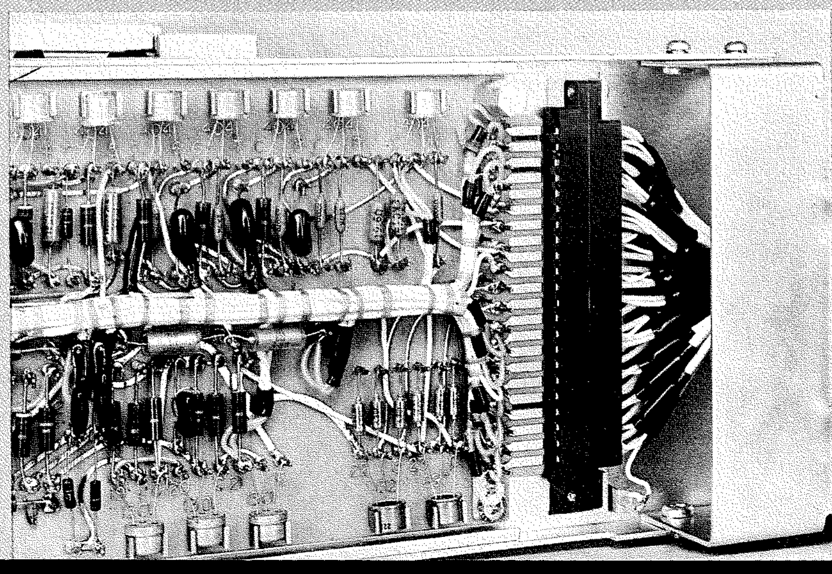


Fig. 8—Module disengaged from extender to show mechanical keying of board connector.

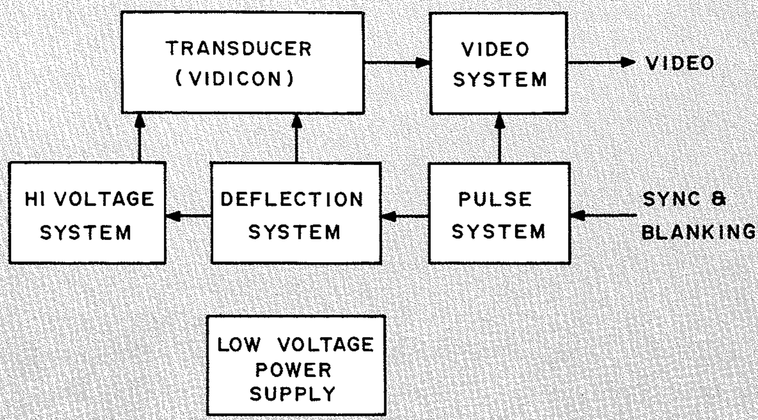
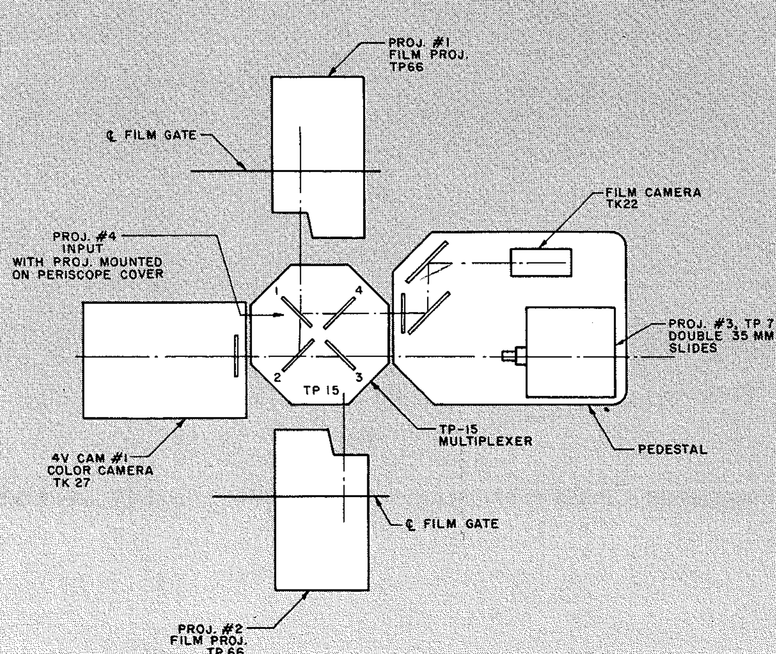


Fig. 1—A typical television camera.

RCA'S NEWEST MONOCHROME TV FILM CAMERA, TK-22

In television broadcasting, much program material originates as film — spot commercials, news material, and original film programs produced for television, as well as the familiar reruns of movies — thus making the television film camera a vital component in broadcasting operations large and small. The new TK-22 monochrome film camera is transistorized to gain very significant advantages in operation, maintenance, and efficiency. Emphasized herein are the design concepts behind this new camera, with details on its primary video signal-processing functions.

Fig. 2—A typical multiplexing arrangement for handling three film sources (two film projectors and a slide projector) which may be optically selected for projection onto the TK-22 monochrome film camera (or TK-27 color film camera).



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The *TK-22 Monochrome Film Camera* is the first of a series of new transistorized and modularized cameras increasing the reliability and versatility of programming in film centers of commercial and educational television stations.

Regardless of the size of such stations, much of their programming is generated from film. Many Hollywood studios that once produced motion picture films solely for the theater now produce syndicated releases for use as prime program material on television. News programs use large amounts of 16-mm negative film, often developed in the last minute before air time; however, the most important inputs to the film camera continue to be bread-and-butter commercials. Therefore, the double-frame 35-mm slides used for the 5-second spots and the 16-mm film strips used for your favorite soap commercials must be executed with precision to satisfy the broadcaster and his clients.

FILM CAMERA FUNCTION

The film camera converts optical images projected on its vidicon pickup tube into television signals that are processed and broadcast for ultimate home receiver viewing. As in any typical TV camera (Fig. 1), the TK-22 film camera contains the primary video system that performs exact operations on the signal produced by the vidicon pickup tube.

Such primary signal processing functions within the film camera's video system receive major emphasis in this article. Other subsystems such as pulse and timing, deflection and power supply, are only summarized for brevity. Features of the new electrostatically focused vidicon, a major innovation, are mentioned briefly herein but covered in more detail in a paper[1] by R. G. Neuhauser.

The most common TV film-studio installation (Fig. 2) optically multiplexes the following picture sources; two 16-mm film projectors (TP-66), and a double-frame 35-mm slide projector (TP-7) for use with a single monochrome film camera. A second multiplex system provides for two cameras, a TK-22 film camera plus a TK-27 color film camera with three film inputs. Additionally, network stations use 35-mm film projectors when the ultimate in quality is desired.

Final manuscript received June 9, 1964

TRANSISTORIZATION ADVANTAGES

The decision to transistorize the RCA broadcast television product line provided an opportunity to incorporate new approaches to solve several long-standing problems in the operation of film camera equipment. The prospect of smaller size and reduced power consumption through transistorization suggested concentration of circuitry at the camera-head position, allowing the remaining circuitry required at the rack and console positions to be kept to a minimum. Operating controls are restricted to passive circuits unaffected by time delay, frequency response, insertion loss, and similar transmission line characteristics. As shown by the more detailed problems and solutions that follow, transistorization increases the operating and maintenance efficiency, and equipment layout economy for the new broadcast film camera (Fig. 3).

A Maintenance and Control Conflict Eliminated

Heretofore, the overlap of traffic patterns within the operating area of the video operator and the technician responsible for setup and maintenance has been a problem. The operator may be required to direct his attention toward as many as six or more individual signal sources that include film cameras, tape recorders, live cameras, and remote signal feeds. His concern is to compose these signal sources into a carefully prearranged program. A malfunctioning camera may be temporarily bypassed to circumvent a problem, but a conflict soon develops if the technician has to move into the busy control position to do maintenance work.

Transistorization, with its attendant reduction in size and power consumption, has permitted the placement of most of the circuitry at the camera head with only the essential operating controls located at the control console. Moreover, limiting the circuitry of the control panel to passive components has increased the reliability of equipment at the control console. The camera may now be set up completely at the camera head independently of the control position (Figs. 3 and 4).

Centralized Locale for Easy Maintenance

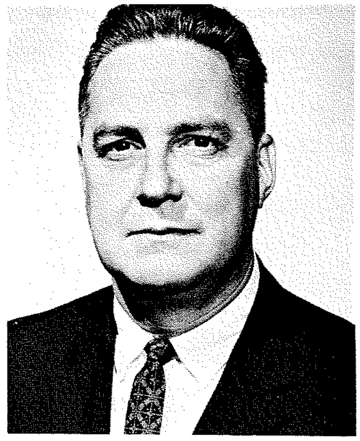
A second problem, not too different from the first, concerns the difficulties experienced in servicing a chain of equipment, the major portions of which are located remotely from one another. Where such scattered equipment arrangements were necessary, much time was lost in tracing and pinpointing technical troubles to a particular location.

The regrouping of functions and circuitry into one equipment unit not only saves time for the technician, but also permits him to do a consistently better job of equipment maintenance.

New Simplicity Solves Complex Control

Another operating problem can be related to the complexity of older equipment and the marked differences between older existing equipment at the broadcaster's plant and newer types of equipment as they evolved over the years. Confusion develops when operators familiar with one type camera are asked to work with a later and widely different model; such dissimiliarity often produces marginal performance.

With the adoption of the totally new concept of greater simplicity and directly interchangeable control panels, the operator's versatility and adaptability is greatly increased. Although the change to the new control concept has been dramatic, the avoidance of complex operating and monitoring procedures has been welcomed by the broadcaster. The complete answer to this problem will come when the broadcaster replaces older color film camera systems with the new equipment using the directly interchangeable control panels. For example, the sensitivity control in the TK-22 film camera, which uses a vidicon, adjusts the target voltage of the vidicon to increase system sensitivity. In an image orthicon camera, this will be the iris control for the camera's lens which adjusts the light into the pickup tube. In either case, the outward effect will be the same and, to the operator, a logical one. The versatility of the operator improves when such points of difference are eliminated.

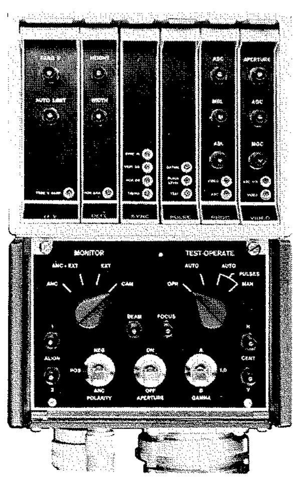


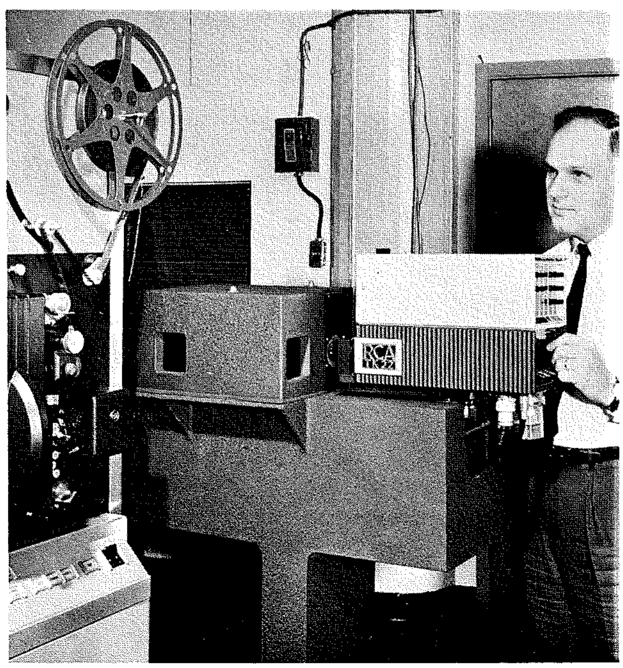
NORMAN KELLAWAY graduated from the Drexel Institute of Technology in Philadelphia in 1949 with the BS in Electrical Engineering. He then joined RCA, and between 1949 and 1961 was a design engineer in the RCA Broadcast Division's Television Terminal Equipment Engineering. There, he worked on a variety of equipments, including color and monochrome monitors and video tape. In 1961, he was named an Engineering Leader, Camera Equipment Design. He is a Member of Eta Kappa Nu.

Transistors as Remote DC Control Devices

One of the major design goals was to improve the stability of the system to the point where basic setup and adjustment would become a routine maintenance procedure practiced monthly instead of daily. This set-and-forget requisite demands complete stability of adjustment; in relegating all setup controls to the camera head, it is *imperative* that this stability be met. For the setup to be independent of the control location, considerable effort was put into the development of circuitry that would operate from DC controls. Motor-driven controls have always been available, but require an inordinate amount of equip-

Fig. 3—The TK-22 film camera mounted atop a TP-11 multiplexer. The operator sets up the camera completely at this point before switching back to normal operation. The closeup below is the film camera-head control (bottom) and circuit modules (top).





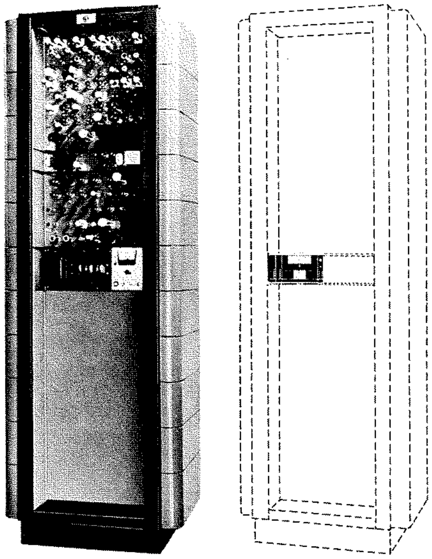


Fig. 4—The ancillary of the TK-22 film camera (right) now occupies only one-half of a standard rack width (height is only 5¼ inches). Cabinet at left shows rack space formerly required for individual chassis before transistorization; deflection and processing circuitry included here is now in the camera head assembly.

ment to do the job. However, as discussed in detail later, the employment of a video processing system using pulses is based on the application of the transistor as a DC control device. The DC controls are provided to produce changes in both amplitude and polarity of the control pulse. Cable lengths are no longer critical when using DC transmission.

FILM CAMERA STABILIZING TECHNIQUES

From the broadcaster's viewpoint, the most important item on a list of camera equipment design features is *stability*. This feature depends not only upon the basic design of the film camera itself, but on the operation of film projection equipment, exact operating characteristics of the vidicon tube, and other components. Therefore, in the design of the TK-22 film camera, circuits have been included to account for the operation of associated equipment.

Looking at the overall film camera system, possible sources of instability can be classified into these parts: 1) *film and projector characteristics*, 2) *the film camera vidicon charatceristics*, and 3) *the basic electronic circuitry of the film camera*, the stability of which must be inherent in the basic design.

The TK-22 film-camera video system has been designed to deal with all categories effectively. Following are technical descriptions of problems and solutions concerning stabilizing systems such as automatic sensitivity, automatic black-level, and automatic white-level controls provided in the final design; these are superimposed on the basic camera circuitry which is described in detail under *Design of a Stable Video Gain Stage.*

Film and Projector Considerations

The vagaries of characteristics of all types of films (especially theater films with wide contrast ranges) such as average density, gamma, contrast range, grain size, and limiting resolution are the most difficult variables to be handled. Although simplification of the camera equipment would be possible with better film, this element of the system is largely outside the control of the film camera equipment designer. Moreover, the large libraries of theater films in existence constitute an extensive source of program material that must be handled.

In addition, the variations of light striking the camera start with the projection lamp—for example, a slump in its light output occurs with age; even the regulation and reduction of lamp voltage does not prevent light-output variations or slumping.

Vidicon Characteristics to be Considered

The second part of this system, the vidicon, is a thermionic device having characteristics that must be taken into account. These include the short- and long-time variations of beam currents, focus drift, dark-current changes with temperature, target voltage, and shading. In general, the direct elimination of any problems in these areas would also result in a simplification of the camera.

Three automatic control circuits have been added to overcome stability problems in the film, film projector, and vidicon areas:

1) *Automatic Sensitivity Control (ASC)*—adjust for the variations in highlights of film, the slump of the projection lamp, and the variation of sensitivity of the vidicon with temperature and age. Control of sensitivity may be accomplished by maintaining constant light into the system and fixing the operation of the vidicon or allowing the light to vary and raising or lowering the vidicon target voltage to maintain a constant output.
2) *Automatic Black Level (ABL)*—takes the darkest part of the scene and sets it at a predetermined black level. This is the first step in the process of handling the variable contrast range of films. The ABL eliminates the effect of *dark current*, a peculiarity of the vidicon. Variations of dark current are produced in the photoconductor of the vidicon as target voltage is adjusted or as temperature changes. These changes produce corresponding undesirable changes in the background of the picture.
3) *Automatic White Level (AWL)*—samples the highlight in the picture and adjusts the gain of the camera's video system to provide the proper peak white level.

The ASC is a closed loop that maintains a constant peak level into the processing module. The combination of the ABL and AWL establishes peak black and white levels, and with the introduction of gamma correction matches the contrast range of the film to the contrast range of the television system.

Basic Electronic Film Camera Circuitry

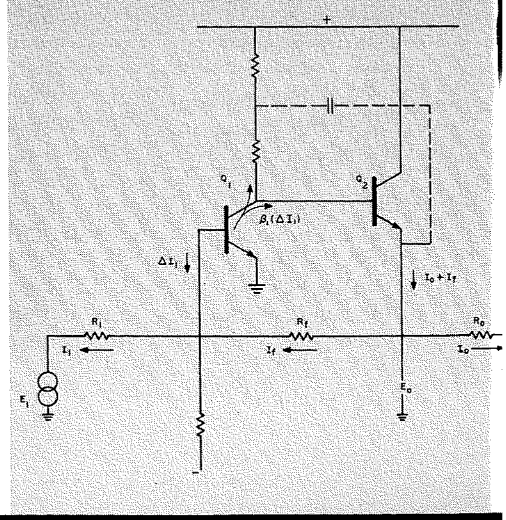
Fundamental to the overall stability of any system is the stability of each stage required within the system. Thus, a video-amplifier configuration must be considered from the standpoint of producing a stable, predictable gain relative to the design goal established for total system stability. To achieve this goal, a standard video-amplifier configuration capable of meeting these objectives was adopted. The technical development, design, and operation of such a video gain stage will now be described.

DESIGN OF A STABLE VIDEO GAIN STAGE

The film-camera amplifying and processing circuits are the first areas that received attention. Gain stability and predictability have been achieved in a variety of ways; wherever possible, the individual amplifying stages make use of the feedback pair shown in Fig. 5. The video amplifier incorporates a series of gain stages whose individual gains and bandwidths are both predictable and stable.

The effect of the video-amplifier current feedback from the emitter of the second transistor to the base of the first transistor lowers the input impedance to a fraction of an ohm. The input current I_1 is then determined by the input voltage divided by R_1. If the betas of the transistors are high, only a very small amount of signal current, ΔI_1 flows into base of the first transistor. The product

Fig. 5—Video feedback amplifier used extensively in the TK-22 tape recorder has been adopted in the camera design program. Variations have been added to enhance circuit performance.



of this base current and the current gain of the pair, $\Delta I_1\beta_1\beta_2$, supports the sum of the currents I_f and I_o (emitter current of Q_2).

If the betas of the transistors were infinite, the voltage gain would be:

$$I_f = I_1 \qquad \frac{E_o}{E_i} = \frac{R_f}{R_1}$$

Further, the current gain would be:

$$\frac{I_o}{I_1} = \frac{I_o}{I_f} = \frac{R_f}{R_o}$$

For practical betas, as the current gain is raised the loading is reflected back through the transistors to cause an increase in the base current of Q_1. This subtracts from I_1 and the voltage gain reduces.

For low-level stages, gain-bandwidths of 100 Mc are possible; for higher-level stages, the collector resistance of Q_1 must be lowered to raise the quiescent currents and voltages. Signal current at the collector of Q_1 should, if possible, flow only to and from the base circuit of Q_2. To offset the loss of signal current to the collector resistor of Q_1, "bootstrapping" is utilized which raises the impedance of the collector and restores the original gain expressions.

Other factors which determine the choice of transistor types include, but are not limited to, beta vs. frequency effects, staggering of cutoff points within the feedback loop, and distributed capacitance effects.

TK-22 VIDEO SYSTEM

Preamplifier

Figs. 6 and 7 illustrate the video system operations performed in the TK-22 monochrome film camera. Briefly, the preamplifier has an overall current gain of 10; this takes into account a current gain of 1,000 ahead of the high peaker. The peak current out of the vidicon, which corresponds to peak white, produces a peak negative signal; zero signal current (neglecting dark current) represents black. A single inversion within the preamplifier, combined with the overall gain described above, delivers to the video amplifier module a signal that corresponds with the output of the least-sensitive image orthicon.

Input-Stage Video Amplifier

The low input impedance (only a fraction of an ohm), provides a convenient means of physically separating the video preamplifier from the video amplifier. Because both positive and negative films are used, a polarity switch is provided.

The video amplifier was also designed for use with the TK-42 studio camera's image-orthicon pickup tube. The low input-impedance serves as an excellent current sink and eliminates the need of a high peaker. The polarity switch becomes a special-effects device.

Gated Detector

The gated detector samples the peak-to-peak video signal level with a pulse that ignores the edge effect encountered in scanning the vidicon. With light falling over an area exceeding the scanned portion, the unscanned photosensitive surface of the vidicon becomes a very low impedance; thus, peak target currents (exceeding peak white) develop at the boundaries of the scanned area. Without gating, spikes occurring at the edges of the video signal both horizontally and vertically (Fig. 8a) would operate the system instead of the scene content of the film itself. The detector is followed by a DC amplifier which amplifies small deviations from the nominal 0.7-volt output.

Gain Stabilization

Although gain is required in the Fig. 7 video-processing system, the term *processing* is applied because the following electrical modifications are made to the video signal to enhance its reproduction:

1) Gamma (film) correction
2) Automatic-manual black level
3) Black pulse insertion
4) White pulse insertion
5) Automatic-manual white level

To stabilize the overall gain of this part of the system, it is necessary to consider the stability of the individual blocks of the system.

White Level Control

The gain control device used in the white-level adjustment circuit is a photovoltaic cell packaged with a lamp in a TO-5 transistor case; the resistance element and lamp leads are brought out individually. A pair of these devices is used as the feedback element (Fig. 5) of the controlled-gain video amplifier stage. Speed of response of the lamps is a few milliseconds and the frequency characteristics of the resistice elements are excellent; but, the photovoltaic material is temperature-sensitive and therefore unstable. To offset this instability, the control device is included within the feedback loop shown in Fig. 7.

The white-level feedback-loop wave form shown in Fig. 8a would be a grey scale of five steps (shown for convenience to be five equal steps). The negative portion of the signal is the horizontal blanking interval; it is during this time that horizontal retrace takes place and the vidicon target is electrically turned off. This interval is just less than 10 μsec; white spikes that may develop at the edges of the picture are cropped when wider system blanking is added in the ancillary equipment.

Fig. 8b illustrates how the white pulse is added to the video waveform during the blanking interval and fed to the keyed detector; Fig. 7 (a + b) illus-

Fig. 6—The automatic sensitivity control (ASC) is a closed loop whose operation relies on a fixed video gain from the vidicon output to the keyed detector input; any variation in peak vidicon output is offset automatically by the ASC.

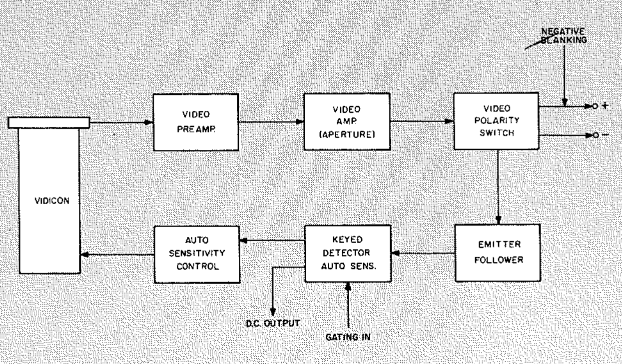
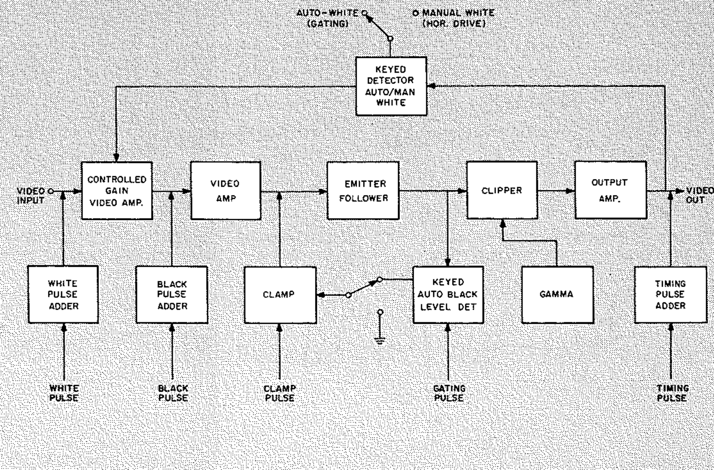


Fig. 7—TK-22 video processing diagram; video white level is held constant by the primary keyed gain control loop (top). Video black level is held constant by the secondary gain control loop (bottom center).



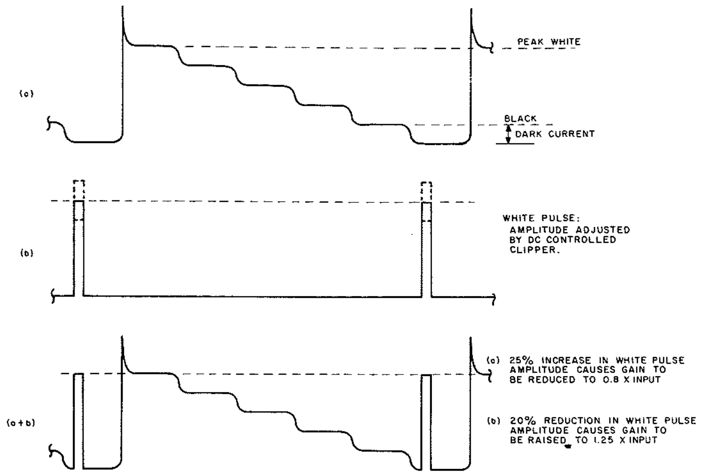


Fig. 8—Waveforms showing addition of a white pulse for manual operation of the white level control loop of Fig. 7.

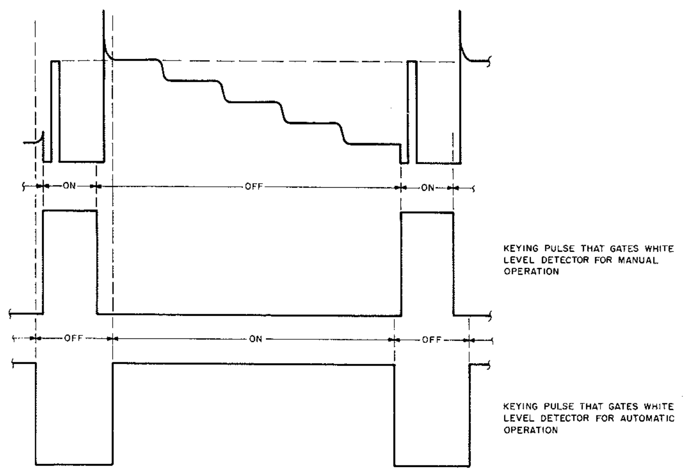


Fig. 9—The keyed detector used with the white level control may be switched between two keying pulses.

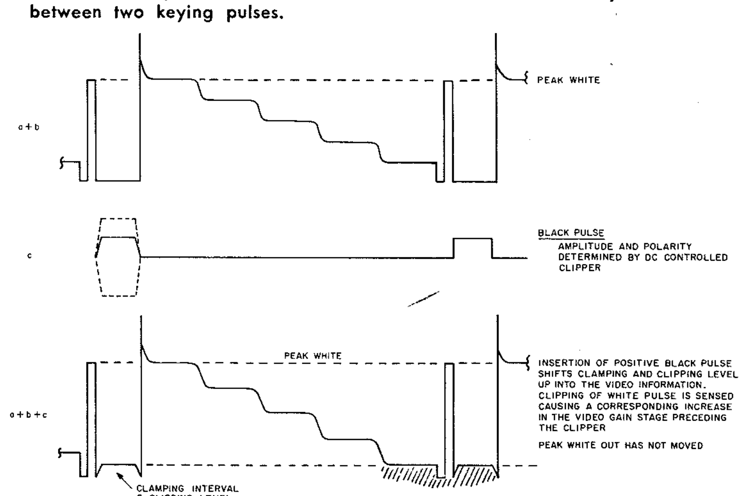


Fig. 10—Waveform (a + b) has an adjustable black pulse (c) added to produce waveform (a + b + c). This summation represents simultaneous operation of the two control loops (black and white levels); automatic or manual operation of either loop is optional.

trates the addition. When the nominal value of the pulse is 0.7 volt, and the overall gain of the processing system is unity, the keyed detector samples only the white pulse, and then notes and maintains the gain-control setting in the controlled gain amplifier. By adjusting the DC voltage applied to the collector of a transistor, the amplitude of the pulse may be reduced or increased; the detector circuit senses this deviation from the normal 0.7-volt level and generates a correction voltage and changes gain to offset the error.

Three important features of this control arrangement are as follows: 1) *The non-frequency-selective gain adjustment is easily remoted,* 2) *although the control device itself is unstable, the feedback loop compensates for the instability,* and 3) *a means is provided for the precise tracking of two or more gain controls simultaneously.*

To control the white level of the picture automatically means that the peak white of the video signal (Fig. 8) must be adjusted for the gain of the system so that it corersponds to 0.7 volts; Fig. 10 shows how this is accomplished by changing the keying time of the detector. The waveform of Fig. 9b is the pulse used to sample the white signal level, irrespective of the video information. The waveform of Fig. 9c samples the complementary interval except that the *off* time is widened to ignore the spikes that exceed peak white.

Black Level Control

Located within the processing system, and in particular inside the keyed automatic-gain-controlled loop, is the means of altering or adjusting the black level of the video signal. Fig. 7 shows a black pulse adder, video amplifier, a clamp, an emitter follower for isolation of a clipping stage, and another keyed detector used for automatic black level. Fig. 10 illustrates how manual black level adjustments are accomplished. The waveform of Fig. 10 (a + b) is the same video signal with white pulse. Fig. 10c, a black pulse whose amplitude and polarity are adjusted around zero volts or ground, is added immediately after the white pulse but within the blanking interval. The clamp sets this pulse to ground which allows the clipper that follows to remove any desired amount of the video or to introduce a pedestal of as much as 50% of peak white. It is important to note that this adjustment of black level is *inside the keyed automatic-gain-controlled loop;* as black level adjustments (either automatic or manual) attempt to alter the white pulse of video amplitude, the *automatic or manual white level control* introduces the needed compensation to maintain peak white.

Operationally, the system white level remains fixed and independent of black level adjustments. Also, the system black level remains fixed and independent of white level adjustments.

Final Signal Processing (Blanking and Sync)

In the total camera video system (camera, ancillary, and control panel), there remains only the addition of system blanking and sync at the ancillary. In multiple-camera systems where lap-dissolve and mixing techniques are used, many video signals are added together; the coincidence of the blanking pulses of such signals is mandatory to prevent lateral shifts in pictures at the home receiver.

To achieve such coincidence, time delay is made negligible by locating the ancillaries of several camera systems in one rack where the coxial cable lengths (blanking feeds) between ancillaries are kept short. Program lines connecting these same ancillaries to the switching system will be of equal lengths, thus keeping differential delays negligible and preserving the coincidence achieved.

As shown in Fig. 11, the last module of the video system, the blanker, includes two clamping circuits. One removes hum, while the other removes the pulses previously added to process the video and the waveform spikes or edge effects shown in Figs. 8, 9, and 10.

Although the voltage gain between the input and output stages (Fig. 11) is two, power gain is required to drive the four low-impedance output lines simultaneously. In summing up the operation of the video system, it is fitting to note that the *same* feedback pair circuit configuration (Fig. 5), with its two transistors, performs this key function admirably.

SUPPORTING SYSTEMS WITHIN THE CAMERA CHAIN

Pulse System

While the preceding descriptions have dealt primarily with the overall video system within the film camera, it is apparent from the waveforms and block diagrams that a separate pulse and timing system for the various signals is in itself rather extensive. The transistor has provided the means of generating precise pulse amplitudes and widths that are a vital need in a stable video processing system. *This critical and complex array of pulses is produced without adjustment, alignment, or special selection of components.*

Deflection System

The TK-22 deflection system used in conjunction with the new vidicon includes a module having two current-feedback amplifiers whose loops include their respective yoke windings. The combination of the deflection circuit, yoke, and vidicon results in excellent linearity and a geometric fidelity with less than 1% distortion. No linearity controls are required to achieve or maintain this performance.

Power Supply System

The low-voltage supply for the TK-22 film camera is located in the ancillary (Fig. 11). To assure a constant voltage at the film-camera head, power-supply voltage is sensed at this point and fed back to the source—where it is changed to offset the variable voltage drop resulting from different camera-cable lengths. Short-circuit protection avoids possible damage from power surges and transients. *The power supply requires no adjustment.*

New 1½-Inch Electrostatic-Focus, Magnetic-Deflection Vidicon

The new RCA-8480 vidicon was designed specifically for the TK-22 film camera and is a major factor in its performance. Focus stability is achieved simply by operating the elements of the electron optical system from a common voltage source; proportionality of voltages between elements is held constant over wide variations in supply voltage. This represents a considerable simplification over the all-magnetic system formerly used. Eliminating the focus coil and its regulated current supply, and simplifying the high-voltage supply, have drastically reduced the power consumed and the space required by the vidicon. The flatness of electrical focus and shading, excellent geometry, and reduced deflection power are other features of this tube.

In essence, the quality of the picture may be preserved and possibly enhanced by electronic camera circuitry—yet, its inherent characteristics and acceptibility are implicit in the design of the vidicon.

CONCLUSION

The initial step in the design program for the new line of television cameras has been taken with the release of the TK-22 film camera. The objectives of the design program were to project a new line of equipment that will promise the broadcaster immediate and substantial economies in maintenance and operating costs and also reduce his overall space requirement.

ACKNOWLEDGEMENTS

This project involved the following engineers who contributed materially to the completion of the design: R. A. Dischert on overall system concepts; A. Reisz on vidicon, yoke, and deflection system; C. L. Olson and B. S. Vilkomerson on the video system; D. C. Herrmann on ancillary design; F. V. Kern on high-voltage supply and automatic sensitivity control; H. G. Seer on pulse system and low-voltage power supply; J. Keuhne on electron optical design of the vidicon; H. E. Reeber and J. P. Stewart on mechanical design.

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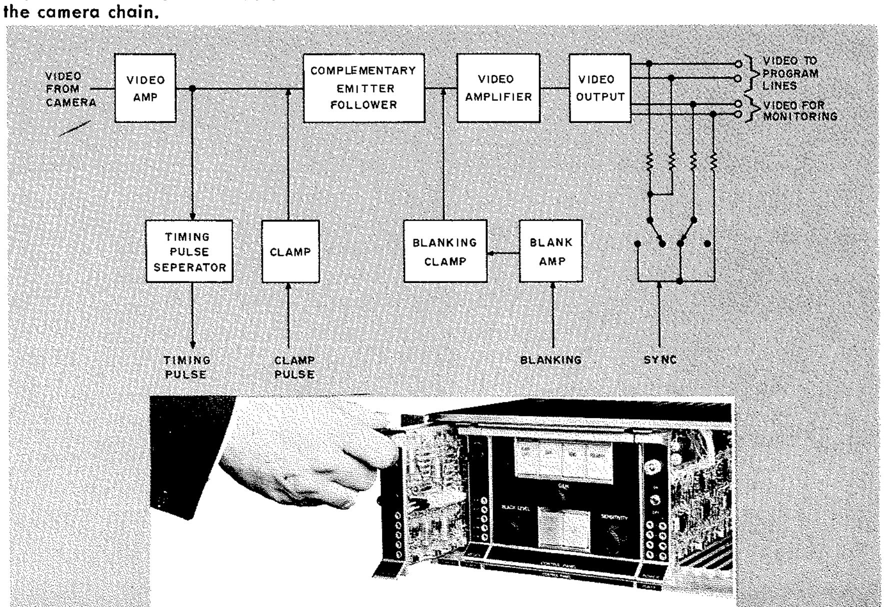
Fig. 11—In this application (photo below) the control panel is mounted with the ancillary (blanker, regenerator, and power supply); The block diagram shows the blanker, the final video module of the camera chain.



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ULTRA-PORTABLE TELEVISION CAMERA SYSTEM

This portable television camera system, readily set up and carried by one man, consists of camera, monitor, power supply, transmitter, and many devices to enhance operating convenience and versatility in situations where conventional cameras either could not be set up or else would be too slow or awkward. The transmitter relays by microwave radio link the television picture to a remote receiver, the video output of which, in turn, meets the standards of a conventional television broadcasting network. While the initial requirement was for operation of the man-pack camera unit a few hundred feet from the microwave receiver, the equipment produces good broadcast-quality signals at ranges of several hundred yards, and at 1.5 miles with the camera system in a helicopter and a 2-foot parabolic antenna on a ground receiver. A portable transmitter-adapter-and-antenna accessory for the camera system allows long-range operation at 20 miles. The camera system's stability is outstanding: It operates for long periods, or continuously off-and-on without needing adjustment; similarly, it may be left off for several days and yet immediately produce optimum pictures without adjustment. The system is adaptable to many TV broadcasting and other military and commercial TV applications—wherever real-time visual coverage of events—foreseen or unforeseen—is of prime importance.

Real-time television coverage of news-worthy events using conventional present-day cameras is hampered by the necessity for transporting bulky equipment to the site and the operating inconveniences of the cables that connect the camera itself to its associated equipment. These cameras are not easy to set up rapidly and, unless a special platform is provided, are not effective in a crowd. Motion-picture coverage for subsequent TV transmission has good visual quality and great versatility at the news-site, but immediacy is lost, since the film obviously must first be developed and printed before it can be televised.

At recent national political conventions, NBC has tried several portable television cameras (i.e., that did not need cables) in an attempt to adapt existing equipment. The most famous of these, the "creepie peepie", was adapted from a tactical television system developed under a U.S. Army Signal Corps contract. Its major shortcomings were very short battery life, severe ghost-image interference from reflections when operating indoors, and considerable difficulty in holding the camera steady.

To find a better approach, NBC contracted with the DEP Communications Systems Division for the development of the Ultra-Portable Television camera system described in this article. The requirement was for a man-portable equipment capable of relaying, via a microwave radio link, broadcasting-quality television images to a receiver a few hundred feet away. Since those signals would then be utilized by the regular television broadcasting network, the video signal at the output of the microwave receiver had to conform to the Electronic Industry Association

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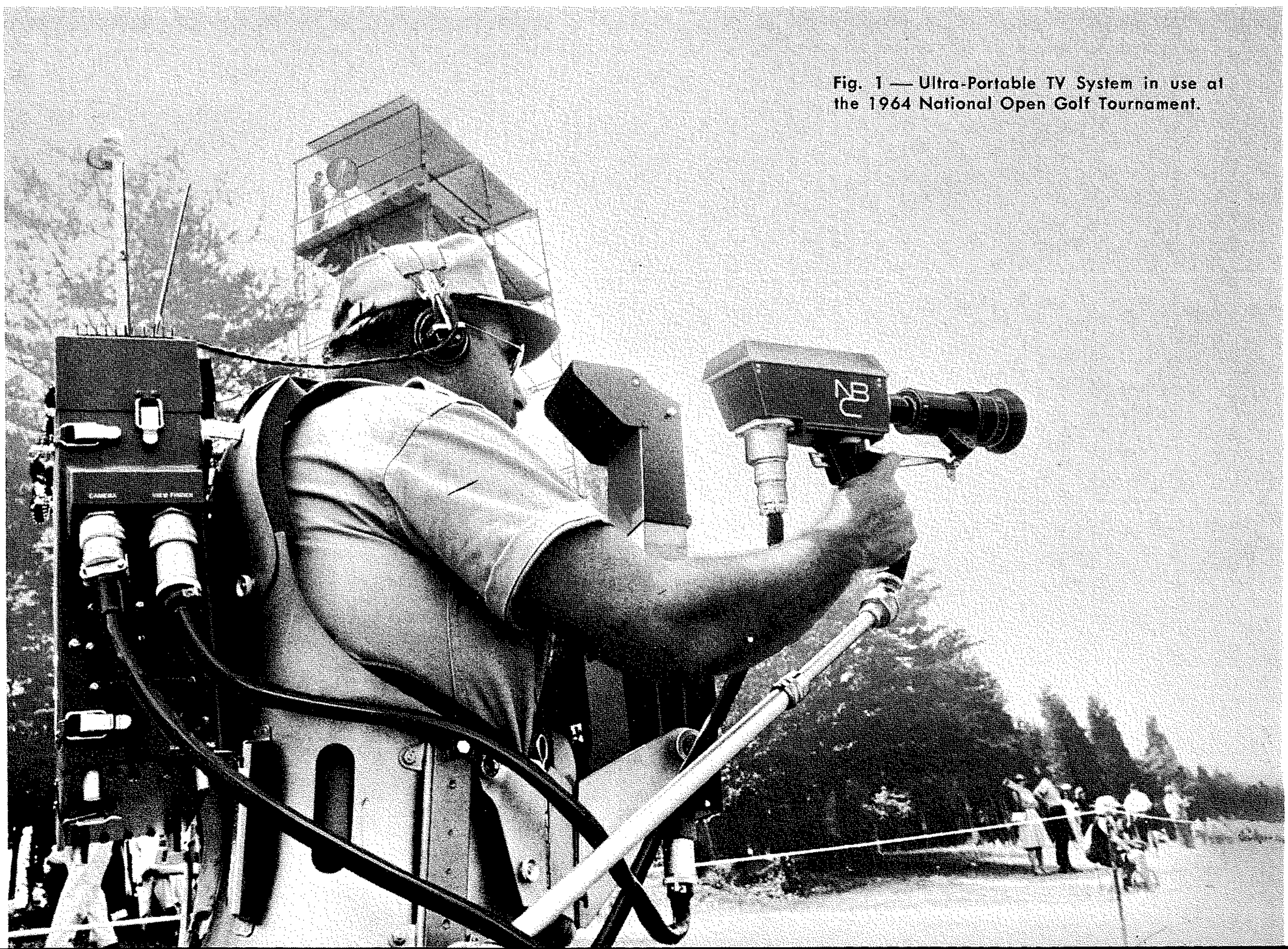


Fig. 1 — Ultra-Portable TV System in use at the 1964 National Open Golf Tournament.

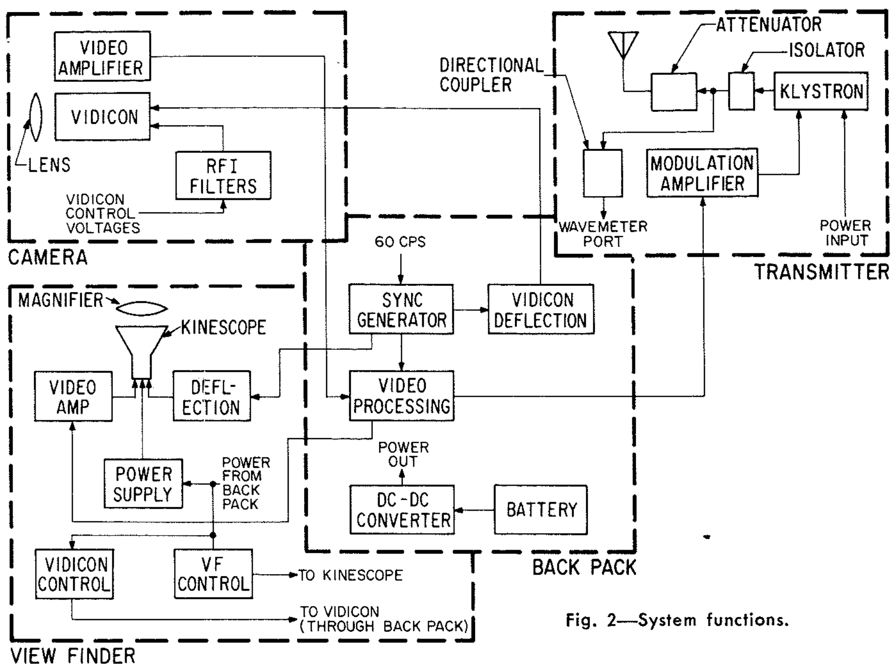


Fig. 2—System functions.

standards for broadcast television signals. Additional requirements were that the portable television system: 1) should produce usable pictures over a wide range of light levels; 2) should not radiate signals which would interfere with other electronic equipment; 3) should not be affected by high-power RF signals and 4) should operate satisfactorily under all usually encountered environmental conditions. To fulfill the original mission of providing coverage at a political convention, the television system had to have good resolution and a good signal-to-noise ratio over a range of at least 500 feet. In actually developing the new camera system, the potential for its versatile use in many other kinds of news-coverage situations, and at distances from its receiver ranging up to 20 miles, were exploited, thus leading to many broadcasting, industrial and military possibilities. Further, the transmitter frequency needed to be chosen so that there would be a minimum of reflection interference. Stability was to be such that after initial set-up, the system would not require readjustment between battery chargings (approximately 1.5 hours). During this time, the system, including the transmitter, had to provide full operation within seconds after being switched from *standby* to *operate*.

GENERAL DESCRIPTION

The Ultra-Portable Television system resulting from this program is shown in Fig. 1. The harness worn by the cameraman supports the camera, the viewfinder, and the back-pack. Each of the units of this system was designed to facilitate maximum system versatility and to minimize operator fatigue. For example, the cameraman can operate the camera above the heads of the people in a crowd, adjust the focal length of the lens to properly frame the picture, and adjust fine optical focus—all at arm's length. Since the cameraman can monitor the transmitted picture by glancing down at the viewfinder, he can follow exactly the wishes of the program director. Further, the operator will not be greatly fatigued by holding the camera in this manner, since its weight is supported by the telescoping unipod. The camera may be raised, lowered, swiveled about the base of the unipod, or tilted about the base of the pistol grip, providing a stable platform for picture-taking in any position.

Fig. 2 shows the distribution of the circuit functions among the various subunits. The location of each function was determined by 1) operator convenience and safety; 2) electrical performance considerations; and 3) simplicity of design. For example. the design would have been simpler if the vidicon controls were on the rear of the camera, but they would then be inconvenient to adjust; similarly, weight and power would have been saved if the kinescope high voltage supply had been integrated into the DC-DC converter, but this would have been dangerous, as it entailed running a 5,000-volt lead in the viewfinder cable.

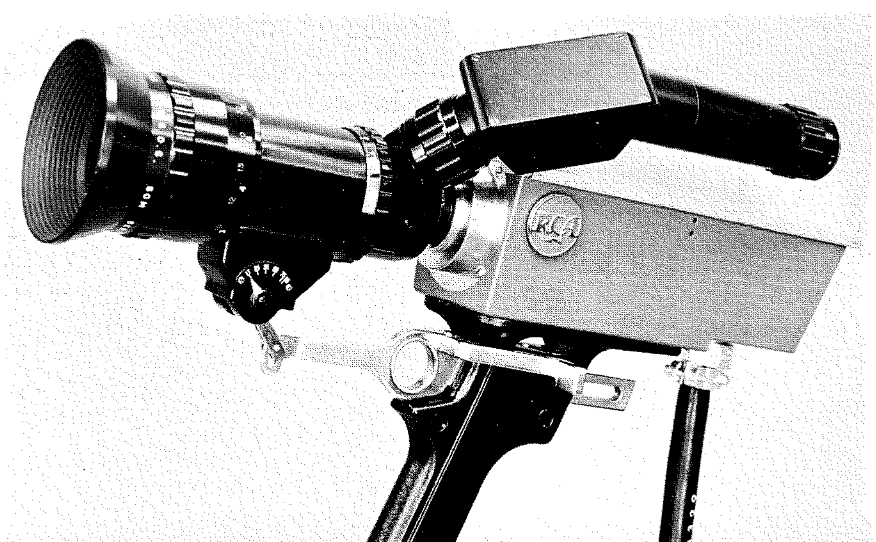
SYSTEM COMPONENTS

The camera (Fig. 3) is designed around the RCA-8134 *hybrid vidicon* (electromagnetically deflected, electrostatically focused), which has the very desirable attributes of high light-sensitivity, good target uniformity, light weight and low power-consumption.

The camera housing is an aluminum casting with a formed aluminum cover which slides into grooves on the sides of the casting. This packaging technique combines light weight and rain protection with good RF shielding. This housing contains the vidicon-deflection assembly, the video amplifier, and the filters for the vidicon control voltages. The small housing at the bottom rear of the camera contains the feed-through filters, which prevent radiation of any signal generated in the camera and also prevent any RF signal in the camera cable from the interfering with the video signal. The vidicon-deflection assembly is mounted on a carriage whose position relative to the lens is controlled by the thumb-wheel seen at the top of the pistol grip handle. This arrangement makes it possible for the cameraman to hold the camera and adjust optical focus with the same hand.

The lens, an L-20 Berthiot, provides a 5:1 zoom range (from 23 to 115 mm) which, with the portrait attachment, covers the full range of fields of view required by the director. Pushing with the thumb on the trigger increases the focal length and pulling with the fore-

Fig. 3—Camera-lens assembly with optical viewfinder.



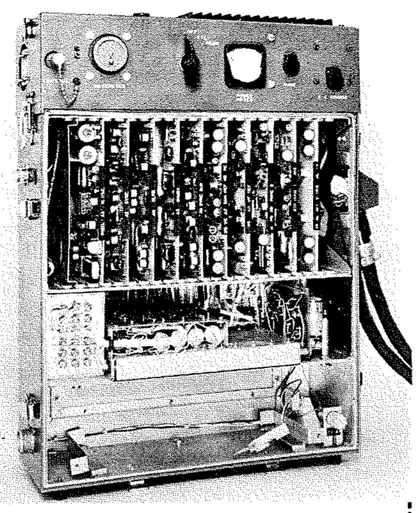


Fig. 4—Back-pack with cover removed.

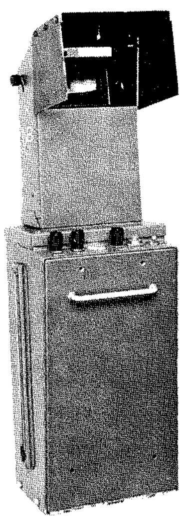


Fig. 5a—Side of viewfinder toward cameraman.

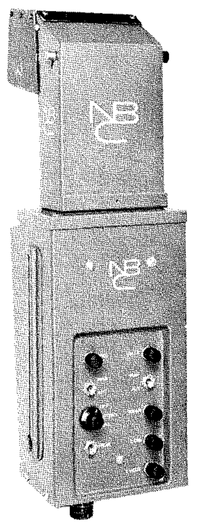


Fig. 5b—Side of viewfinder away from cameraman.

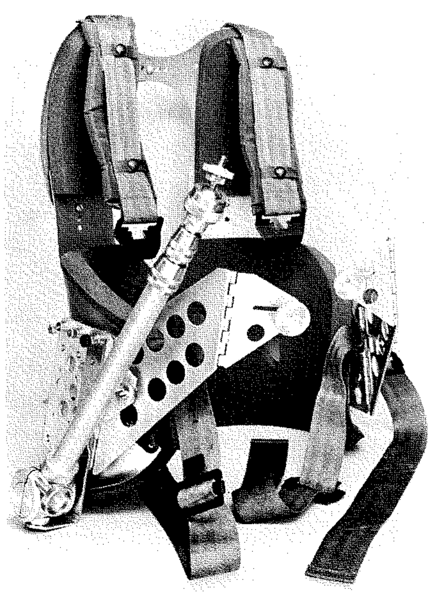


Fig. 6—Harness with brackets and unipod in place.

finger decreases the focal length of the lens. The pistol-grip handle, the trigger mechanism, and the optical-focus thumbwheel are symmetrical so that the camera may be used by either right- or left-handed cameramen.

An optical viewfinder may be attached to the port at the top rear of the lens if the cameraman wishes. The viewfinder "sampling mirror" remains in the optical path at all times; hence, the speed of the lens (f2.6) is not affected by the attachment or removal of the optical viewfinder. The back-pack (shown in Fig. 4 with the access cover removed) contains the power, control, synchronizing, and video processing circuitry.

POWER AND CIRCUITRY

A silver-cadmium battery, in the bottom compartment, provides a minimum of 1 hour of continuous *on the air* time. Although the battery output will slump if it is stored below 40°F, it generates enough heat when supplying power to maintain its internal temperature above 40°F at ambient temperatures as low as 0°F. Hence, full operating life can be realized by keeping the batteries in a warm place until the system is to be operated. Provisions are made for quickly replacing the batteries, charging them in place, or operating the system with a "floating" battery.

Immediately above the battery is the DC-DC converter which supplies the regulated voltages required by both the television and microwave systems. A series regulator compensates for variations in battery voltages and for variations in load such as are caused by changing from RF output to a video output. The problem of minimizing acoustic radiation was solved by impregnating the power transformer with silicone varnish and then filling the transformer can with polyurethane foam. This reduced the audible sound below the level likely to attract attention in a crowd.

The nest of printed-circuit boards which controls the television system is immediately above the DC-DC converter. The set of boards generates the synchronizing signals, performs the video processing functions, and generates the vidicon deflecting currents. The connectors are interlocked so that the system will not come on if a board is missing.

The sync-generator master oscillator may be operated in either of two modes: locked to a 60-cps signal from an external source, or locked to a self-contained crystal. The circuitry is so designed that when the system is turned on, it always starts in the crystal mode. If the operator so desires and a 60-cps signal is available, he can switch over to 60-cps lock. If the 60-cps signal is lost, the oscillator will automatically change back to crystal.

The output of the master oscillator, through a series of counters and gates, is used to derive the EIA synchronizing signals and the control pulses utilized within the unit. Drive pulses from the sync generator are used to generate the sawtooth waveforms required to deflect the vidicon. These pulses are also used to generate the sawtooth waveforms which are transmitted to the view-finder where they are further amplified to deflect the kinescope. Size and centering controls facilitate adjustment for variations in vidicon and kinescope characteristics.

The video processing circuitry sets the black level of the video signal, adds synchronizing and blanking signals to the video, and provides two 1-volt, 75-ohm composite video output signals. The automatic pedestal-control circuit senses the blackest portion of the picture and causes video blackness to assume this level. An AGC circuit senses the average amplitude of the video signal over several frames and varies the gain of an amplifier to maintain constant video output over a 3:1 variation in vidicon output signal.

The microwave transmitter is contained within the small box attached by suitcase fasteners to the top of the back-pack. Power and the video signal are fed to the transmitter via a single connector on the top of the back-pack. The only operational control on the microwave transmitter is the *standby-operate* switch. The set-up controls require adjustment only on the rare occasions when the transmitter is set on a new channel or the klystron is replaced. The center frequency of the transmitter may be set on any one of the 22 channels in the range from 12.7 to 13.2 Gc.

A modulating amplifier, contained within the transmitter, varies the klystron repeller voltage linearly with the amplitude of the video signal causing the frequency of the klystron to vary with the amplitude of the video signal. A 0.7-volt (peak-to-peak) video signal from the processing amplifier causes full deviation of the klystron frequency.

DESIGN FEATURES

The transmitter contains several devices which, while adding only slightly to the weight, greatly enhance system performance and flexibility. An isolator at the klystron output effectively eliminates the possibility of changes in antenna or waveguide characteristics affecting the klystron frequency. A self-contained 40-db attenuator may be inserted in the waveguide leading to the antenna, making it possible to tune the transmitter without radiating a signal. A directional coupler samples the transmitted signal so that with the aid of a wavemeter the transmitter frequency can be determined.

The antenna (shown at the top of the unit in Fig. 1) is attached to the unit by a quick-disconnect flange, making it easy to quickly replace the antenna, which could become damaged in crowded conditions. The omnidirectional antenna radiation pattern with the lobe tilted up 15° with respect to the horizontal was chosen to radiate most of the energy over the heads of the crowd around the camera toward the receiving antenna which, in political-convention usage, could be on a balcony.

Tests have shown that this antenna with the 200-mw transmitter has reliably produced broadcast quality signals at ranges of several hundred yards. (A range of 1.5 miles with good picture quality was attained with the camera and transmitter in a helicopter and a 2-foot parabolic receiving antenna on the ground).

A corner reflector, (shown in Fig. 1 just below the antenna on the waveguide) may be snapped in place on top of the antenna to restrict radiation to one quadrant of the horizontal plane. Direction of radiation is established by rotating the reflector on top of the antenna. Tests made in Madison Square Garden and Camden Convention Hall confirmed the assumption that reflections of the 13-Gc signal will not be a problem during indoor operation, as it was with the 2-Gc signal.

The viewfinder (Fig. 5) is held in the position shown in Fig. 1 by the hip-pack. In this position, the cameraman can look out over the viewfinder or, by glancing down at the mirror in the top of the viewfinder hood, see the picture being fed to the transmitter. Thus, the viewfinder permits the cameraman to frame and focus the chosen scene as well as to quickly evaluate system performance.

The viewfinder is designed around a specially developed 3-inch electrostatically-deflected, electrostatically-focused kinescope featuring small spot size, high brightness, and good deflection sensitivity. A magnetic shield minimizes the effects of external fields.

The filament, accelerating and control voltages for the kinescope are developed in the viewfinder from a 44-volt (peak-to-peak), 100-cps square wave obtained from an isolated secondary winding on the DC-DC converter transformer. This arrangement eliminates the necessity for high voltage leads in the viewfinder cable.

The two groups of controls on the viewfinder are arranged according to function and frequency of use. The viewfinder controls (*contrast, brightness*) are with the *modulation* indicator and *crystal mode* switch on the small shelf toward the cameraman. The camera controls and the seldom-used kinescope controls (*focus* and *peaking*) are on the side of the view-finder away from the cameraman. This last set of controls is recessed to preclude accidental misadjustment. The modulation indicator is a miniature meter which, by indicating the average video level, shows the percentage modulation of the transmitter. The crystal mode switch contains a light which is on when the master oscillator is in the crystal mode.

The harness (Fig. 6) was adapted for this application from the harness developed by Bell Aerosystems for their one-man rocket. (It should be mentioned that in the rocket application, the soldier carries a total load of 150 pounds.) Outstanding features of the harness are that any load attached to the harness is transferred to the hips of the wearer, both hands are free and the harness is adjustable to a wide variety of body sizes and shapes.

Fig. 6 shows how the back-pack, the viewfinder brackets, and the camera support unipod are attached to the harness so that each is easily removed. A man, *without assistance*, can put on or take off the harness with *all* sub-units in place.

The camera support unipod was made in two telescoping sections so that the camera could be supported at the extreme reach of the tallest man or adjusted to eye level for utilization of the optical viewfinder. Friction is applied by tightening the unipod joints thus enabling the cameraman to lock the camera in a particular position or, with less tightening, move the camera freely up and down. The swivel joints at the top and bottom of the unipod facilitate positioning the camera anywhere within arm's reach.

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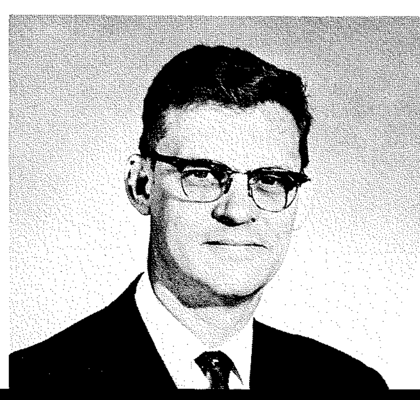

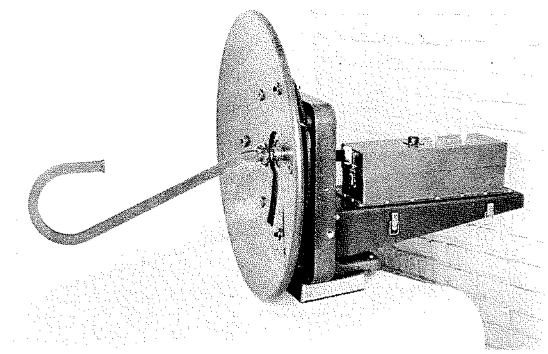

Fig. 7—Transmitter adapter and parabolic antenna.

CONCLUSION

The most outstanding feature of the system is its stability. It has been repeatedly demonstrated that after initial adjustment the system can be left for several days and upon turning it on, optimum picture quality is realized—*without* readjustment. This was achieved by carefully designing the circuits so that they are virtually immune to the effects of temperature and aging. Regulation of all supply voltages, automatically compensating circuits such as video gain and pedestal, and inherent circuit stability, make it possible to operate the system for long periods or repeatedly turn it off and on without readjustment.

Long-range operation (up to 20 miles) of the system is facilitated by the accessory transmitter adaptor and parabolic antenna shown in Fig. 7. In this mode of operation, the transmitter is replaced on the back-pack by a cable adaptor and the transmitter is snapped in place on the transmitter adaptor. Power for the transmitter is supplied via a cable from the back-pack. An input jack permits transmission of either the video signal generated by the Ultra-Portable Television system or any other video signal.

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RECENT DEVELOPMENTS IN PHOTO-TAPE CAMERAS

The basic principles and advantages of recording and storing optical images in the form of equivalent electrical charge patterns on a special kind of flexible tape are presented. The general characteristics of camera systems designed to utilize this newly developed "photo-tape" are outlined. Descriptions follow of two systems that were built to demonstrate feasibility. Advanced models of these camera systems now in construction are expected to satisfy most of the requirements applicable to a flight model.

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A NEW METHOD of image sensing and storage based on the conversion of optical images to electrostatic charge patterns generated and stored by means of a special flexible tape was described previously.[1,2] This program has been carried forward to include the design of feasibility models and subsequently of advanced models that will have many of the characteristics of flight hardware. The brief description of the equipment units that follow include only the more important highlights of these developments.

BACKGROUND

The research phase of this development program was started by RCA in 1955. Successful demonstrations of the concepts basic to photo-tape image sensing in 1959 led to a government-supported research and development program. (The program started under Wright Air Development Center Contract No. AP-33(616)-6365; continued under Air Force Systems Command Contract No. AF33-(657)-8843; and presently is being conducted under AFSC Contract No. AF33-(657)-11485. A Photo-Tape Camera using a different tape-exposure technique presently is being developed under NASA Contract No. NAS5-2503.)

The work done and still continuing in the Physical Research Group of the Astro-Electronics Division includes the investigation of basic principles, photoconductive materials suitable for this application, photo-tape processing techniques, electron-optical problems associated with the recording and readout procedures, and many other related activities.

The favorable outcome of the research effort resulted in a continuation of the program to include the development of feasibility models that could demonstrate effectively the potential usefulness of practical photo-tape camera systems. The first of these was an experimental model of a 70-mm "frame" camera system, which was demonstrated successfully in late 1961.

A feasibility model of a high-definition display device called an Electron Beam Film Recorder (EBFR) was developed in conjunction with the 70-mm camera. The function of the EBFR is to convert TV-type signals from the camera to hard copy with minimum degradation.

The second camera model using 35-mm tape exposed through a narrow slit was demonstrated successfully in early 1962. As a consequence of these encouraging results, the development of advanced models of both frame and slit type camera systems was started. These are now well on their way to completion.

BASIC PRINCIPLES

In performing the image-sensing or exposure process, the photo-tape camera functions in a manner much the same as a standard photographic camera. The principal difference is that a specially prepared, flexible tape is used instead of the usual light-sensitive emulsion-coated film. In the exposure process, the optical image focused on the photo-tape is converted to an electrostatic charge pattern stored on the outer insulating layer. This charge pattern can be "stored" from seconds to weeks, but is available at any time for conversion into an electrical signal by means of a readout scanning process. The signal can be transmitted over conventional communication links; and the original image can then be reconstituted on a suitable display device.

One of the principal advantages of this new recording method is that stored images can readily be erased and the same roll of photo-tape used repeatedly without appreciable degradation.

Tape Description

A cross-section of the photo-tape is shown in Fig. 1. The base is made of Cronar, a special high-quality grade of Mylar used principally as a base for motion-picture film. The edges of the tape are folded to provide a small clearance between adjacent layers on a reel and so avoid the possibility of abrasion. Material is deposited on this Cronar base in three layers (in sequence) in an evacuated, semi-automatic processing facility which insures a high degree of uniformity.

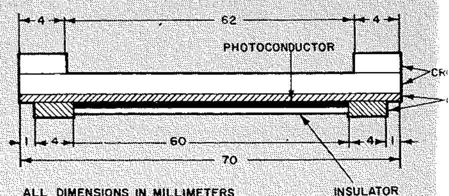
The first layer is a combination of gold and copper, approximately 0.02 micron thick. This forms a transparent conducting coating that serves as the electrical connection to one side of the photoconductive layer. Antimony trisulfide, the photoconductive material used in commercial vidicons, has also been used successfully in this application. The conductivity of any particular elemental area of this layer is a function of the amount of light falling on that spot. The final layer is an extremely thin coating (approximately 0.5 micron) of polystyrene. This is the insulating layer that acts as a capacitor for accumulating and storing the microscopic electric charges forming the charge-pattern equivalent of the original image.

Advantages of Photo-Tape Image Recording

The principle advantage of photo-tape is the feature of reusability; recorded pictures can be erased and new pictures recorded, as desired. However, there are additional significant advantages:

1) The inherent resolution capability of the photo-tape is extremely high and even compares favorably with high-quality film intended for use in aerial photography. Over-all resolution capability is primarily a function of the read process and is determined by the size of the scanning spot. By utilizing an extremely fine scanning beam, performance in this respect can be extended far beyond that of conventional TV camera systems.
2) The packing density of information stored on the photo-tape is extremely

Fig. 1—Cross section of photo-tape.



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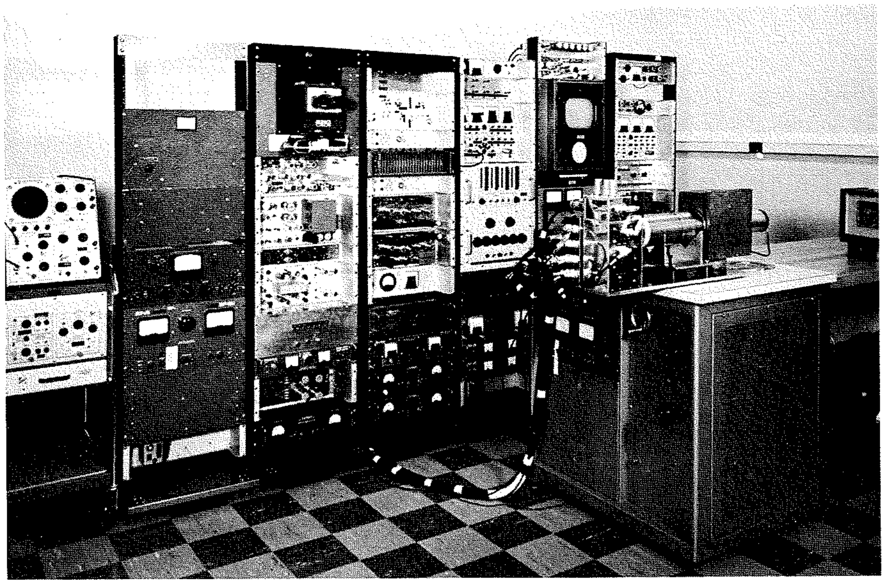
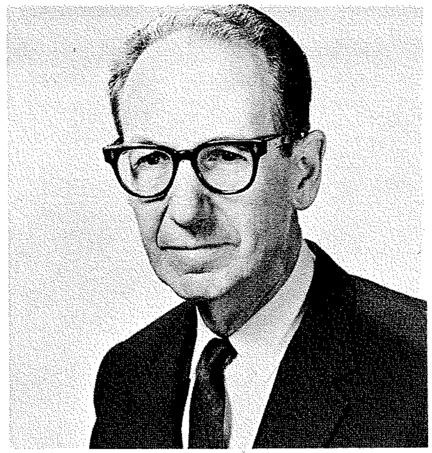


Fig. 2—Feasibility model of the photo-tape frame camera.



W. J. POCH received his BSEE in 1928 from the University of Michigan and his MSEE in 1934 from the University of Pennsylvania. Mr. Poch joined RCA in 1930 as a member of the Radio Receiver Design Group. From 1931 to 1938, he was a member of the Research Group on Television Receivers. From 1938 through 1950, Mr. Poch was responsible for the design and development of various types of studio TV equipment and TV equipments for military applications. From 1950 through 1955, he served as Engineering Section Manager in charge of the development and design of TV broadcast studio equipment including image orthicon cameras, camera control and switching equipment, vidicon film cameras, TV film projectors, sync generators, and TV microwave relay equipment. From 1955 to 1960, he was responsible for corporate fund administration and for corporate staff engineering liaison activities. Since transferring to the Astro-Electronics Division in 1960, Mr. Poch has been responsible for directing photo-dielectric tape camera activities. Mr. Poch has 31 issued patents and several published papers. He is a member of Tau Beta Pi, Sigma Xi, and Phi Kappa Phi, a Fellow of the IRE, and a member of the SMPTE, ISA, and Fernseh Technische Gesellschaft. Mr. Poch is a Registered Professional Engineer in the State of New Jersey.

high, at least 10 times that normally used when storing video information on magnetic tape.

3) The two processes of 1) recording optical information on the photo-tape, and 2) read-out of the stored information may be done at widely different rates of speed. This flexibility can be used to satisfy an extensive range of system requirements.
4) A high degree of immunity to nuclear radiation has been demonstrated. Radiation levels that will blacken ordinary film have no effect on the photoconductive photo-tape.

TYPES OF CAMERA EQUIPMENT

Overall Considerations

Many of the optical exposure techniques used in conventional photography can also be applied to a photo-tape camera system. The most common technique is that used in a standard frame camera where the film is held stationary during exposure. As in photography, exposure is a function of lens aperture, shutter speed and sensitivity of the medium. If image motion is involved, exposure time will be limited by the amount of image smear that can be tolerated without reducing resolution appreciably.

The slit camera optical system is similar in design to that used in some types of panoramic cameras intended for aerial photography. In this camera, the tape is exposed through a narrow slit close to the tape surface and at right angles to its direction of travel. By matching the speed of the tape to the motion of the optical image resulting from the panoramic scanning process, smearing of the recording charge image can be avoided. This technique is particularly useful in obtaining wide-angle coverage with a relatively narrow-angle lens.

Feasibility Model of a 70-mm Frame Camera System

An overall view of this equipment is shown in Fig. 2. Only two of the racks in the background of the photograph form an integral part of the camera system. The remaining racks are used to house various types of test and monitoring equipment. Since the principal objective of this program was to demonstrate feasibility without regard to size or weight, no attempt was made to miniaturize components. The camera proper, or sensor head, mounted on the high-capacity vacuum pump is shown in Fig. 3 and the interior of the camera enclosure is shown in Fig. 4.

The optical image is focused on the photo-tape area held in position by an aperture mask in a plane perpendicular to the optical axis. The aperture mask is in close proximity and parallel to the optical-flat quartz window in the right wall of the enclosure. The cylinder extending from the right side of the enclosure provides a mounting for the lens, as well as a lightshield for the optical path. Several different types of photographic lenses available on an off-the-shelf basis have been tried in this application. None of these has been entirely satisfactory with respect to resolution capability, and efforts to find a more suitable lens are continuing.

The flood gun is mounted directly in back of the aperture mask, so that the area of the tape exposed to the optical image can be flooded with an electron stream from the reverse side of the tape. The path over which the tape moves in the enclosure is shown in Fig. 4. Starting from the supply spool at the upper right, the tape moves first to a position directly behind the optical window where the aperture mask guides the tape to the *write* position perpendicular to the axis of the lens. Two rollers are next in succession along the tape path, with a brush-type electrical-contact device in between. This device provides an electrical connection to the tape-conducting layer by contact with the heavy gold strips on each side of the tape. After passing the second roller, the tape takes an almost vertical direction upwards to the capstan roller. The direction of rotation of the capstan determines the direction of motion of the tape. Originally, sprocket teeth on the edge of the capstan engaged holes in the edges of the tape to provide a positive drive mechanism. Since new photo-tape samples having folded edges no longer have sprocket holes, motion is transmitted from the capstan to the tape entirely by friction. Contact over a considerable part of the capstan surface, aided by pressure rollers at the edges, is effective in eliminating slippage.

From the capstan, the tape passes over another aperture plate, this one being perpendicular to the axis of the *read* gun. The surface of the tape within the rectangular area provided by the

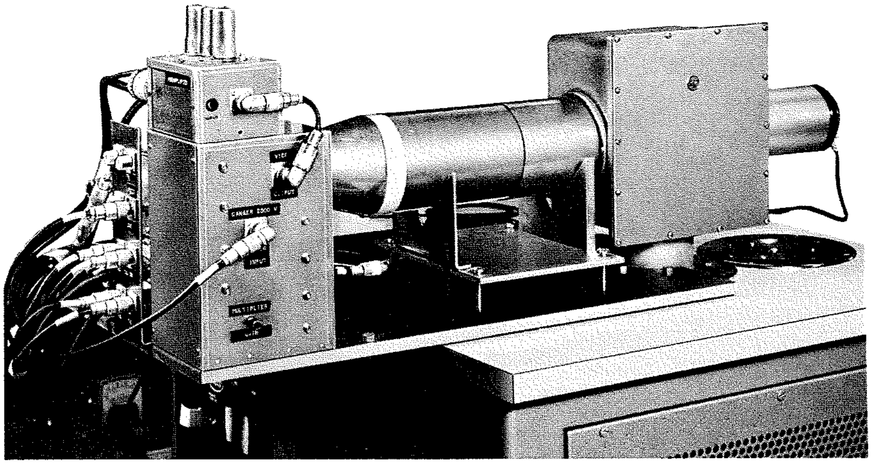


Fig. 3—Sensor head (feasibility model photo-tape frame camera.)

aperture plate is scanned by the read beam during the readout process. Finally, the tape is wound around the take-up reel located at the lower left of the enclosure. Both the supply and take-up reels are equipped with negator (i.e. constant tension) spring assemblies that exert torque on each of these reels in such a manner that the tape is kept under tension over its full range of travel.

The shaft on which the capstan is mounted is coupled to another shaft in line with it and external to the enclosure. The coupling between the two shafts is provided by a cylindrical magnetic structure that allows motion to be transmitted through a relatively thin section of the wall sealed into one face of the camera enclosure. A suitable magnetic shield structure prevents stray fields originating in the magnetic coupling from affecting the read beam.

The read-gun envelope with its surrounding yoke assembly is mounted on the left side of the camera enclosure. Components originally designed for use in a TV camera employing a standard 3-inch image orthicon were modified slightly for this application. Since the beam in the photo-tape camera scans a somewhat larger target area (57 mm x 57 mm) and since no image section is needed, the focus coil was modified in the region near the target, and the configuration of the electrodes that determines the electrostatic field was also modified.

The functions performed by the video amplifier and the deflection circuits are identical with those common to most TV camera systems. The relatively low frequency of the scanning rates adds somewhat to the circuit complexity, particularly with respect to the proper reproduction of the DC component of the signal at the camera output. The control system is considerably more elaborate than is required for the equivalent function in a TV camera. This is because the tape camera must perform a number of different operations in sequence. Separate control functions are needed for each of the three basic processes: *prepare*, *write*, and *read*. For this camera, the control system was designed to provide considerable flexibility and convenience in operation but was limited essentially to manual control.

Advanced Model of a Photo-Tape Frame Camera System

Accurate alignment of the optical system in the feasibility-model camera, in order to obtain optimum focus over a full 57-mm x 57-mm frame of tape, proved to be much more difficult than was at first realized. It was found that the focal plane of the lens and the plane of the tape being exposed must match within about 0.2 mil in order to keep the loss in resolution within a tolerable amount. Precision components and means for accurate alignment are, therefore, essential in an optical system for this application.

The design of a new sensor head was undertaken in order to meet these stringent requirements and also to carry the program further in the direction of a flight model. For example, the design of the new camera enclosure will eventually permit operation with a small ion pump in place of the high capacity pump and in this manner demonstrate the "portability" feature of such a system.

The new sensor head, together with the associated components, is shown in Fig. 5. The base assembly is essentially an optical bench. An 8-inch aluminum *I*-beam is mounted on a pair of welded steel pedestals. The *I*-beam provides a rigid mounting for the sensor head, the objective lens with its supporting structure, and the test chart illuminator. These items taken together constitute the optical system. A small rack, also supported by the *I*-beam, provides mounting space for the video amplifier and other components directly associated with the read-gun assembly.

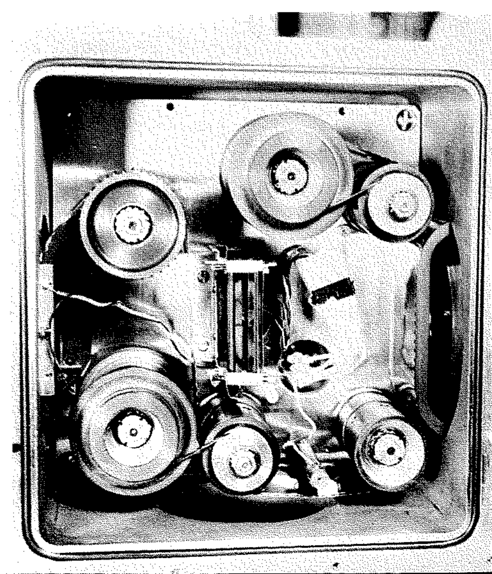
The sensor head or camera proper with the cover removed is shown in Fig. 6. The camera enclosure is made of welded aluminum plate, heavily reinforced. The transport mechanism was designed to accommodate up to 100 feet of 70-mm tape. A negator spring system maintains nearly constant tension on the tape over its full range of travel. This produces the required torque between the reel coaxial with it on the same shaft. Mechanical motion is transmitted through the wall of the enclosure by a magnetic coupling of the same type that has given satisfactory service in the earlier model.

In the write position, the tape is spaced about 4 cm from the optically flat window sealed into one end of the enclosure. This provides room for the flood gun structure, which supplies the high-velocity electrons that strike the tape surface during the write process. These electrons are emitted from a cathode structure located out of the optical path and shielded to prevent stray light from reaching the surface of the tape.

Accurate positioning of the tape in the image plane of the lens is facilitated by an aperture mask which squeezes the tape against a platen whose plane can be adjusted to be perpendicular to the lens axis within extremely close tolerances. To help hold the tape flat against the platen, the latter is insulated so that application of a potential between the platen and the conductive layer of the tape produces a force due to electrostatic attraction sufficient to hold the tape flat over the entire area being exposed.

A similar aperture mask and platen combination is used to hold the tape flat in the read position, perpendicular to the axis of the scanning beam. This platen is also insulated from ground, so that electrostatic attraction can be used

Fig. 4—Interior of camera enclosure. (Feasibility model of the photo-tape frame camera.)



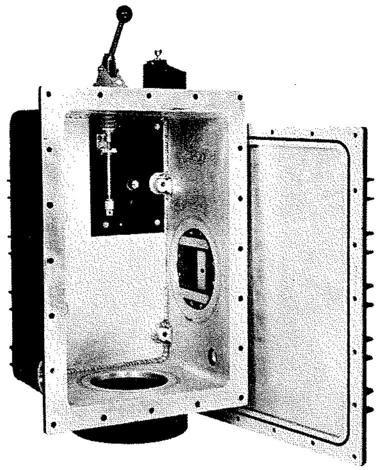


Fig. 5—Sensor head, advanced model frame camera.

in this location to facilitate holding the tape flat. In order to move the tape between exposures, a release mechanism is provided which pulls both platens away from the aperture mask a distance sufficient to release pressure on the tape. A lever external to the enclosure actuates this mechanism through a bellows-type seal.

The read-gun envelope, with its surrounding yoke, extends from the enclosure at a right angle with respect to the optical axis. The design of the electron optical system for the read process is based on the use of components made originally for the 4½-inch image orthicon. A substantial improvement in the uniformity of focus, deflection, and resolution over the full 57 mm x 57 mm raster area is expected to result from the use of the larger components.

The various units comprising the circuitry associated with the camera perform the same functions as the earlier units but have been completely redesigned. The output current capability of the deflection circuits was increased considerably to meet the requirements imposed by the larger yoke and an increase in the axial-focus field. The latter change was made to improve the resolution capability. In the design of the new video amplifier, the principal emphasis was placed on a reduction in noise and crosstalk, as well as an improvement in overall stability and uniformity of response. Significant improvements were also made in the control system. Accuracy and stability of all electrode adjustments for the flood gun and read gun were greatly improved by using high-resolution potentiometers and low-impedance individual regulators for all critical-electrode-potential supplies. In addition, the convenience of making adjustments and obtaining measurement data was greatly improved.

Feasibility Model of a 35-mm Slit Camera System

The optical system for this camera was designed to image the earth's cloud cover as observed from a satellite moving in an essentially circular polar orbit. The optical scanning angle was selected so that, on successive orbits, the imaged areas overlap when the satellite is at a specified altitude above the equator. As the mirror executes its scanning action, the image of a strip of the earth's surface and cloud cover at right angles to the direction of vehicle motion sweeps past the optical slit in the camera and is recorded. The process just described is illustrated graphically in Fig. 7. Two successive strips recorded by the slit camera are shown in outline.

The lens for this camera was selected so that the width of the strip at the sub-orbital point is 50 miles. The dimension of the strip at right angles to the direction of satellite motion is 1,500 miles. The corresponding image on the tape is 15.2 mm wide and 312 mm long. (The difference in the ratios of length to width of these two sets of figures is the result of distortion inherent in the panoramic scanning process.) A 100-foot length of tape will accommodate up to 90 images. If recorded sequentially, the ground area imaged on the tape will be 6.75 million square miles.

The resolution capability of this system is such that objects on the ground 0.2 mile apart will be distinguishable. This value is considered adequate for the purpose and was used in determining the basic parameters of the camera system. The scanning rates and tape speed are such that the over-all resolution capability will be limited primarily by the bandwidth of the transmission channel rather than the characteristics of the image sensor. In this way, optimum use will be made of the limited time available for the transmission of information from the satellite to a ground station.

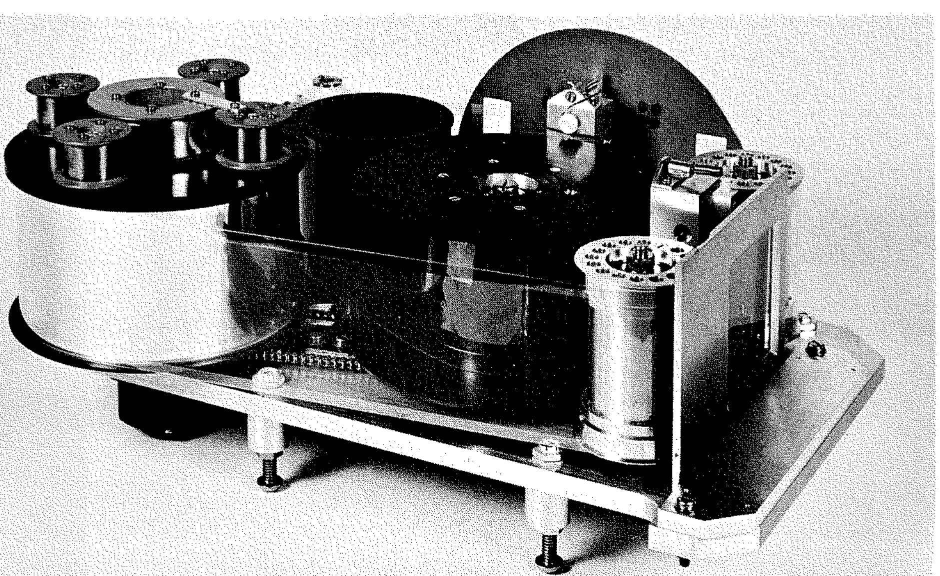
Image motion resulting from the forward velocity of the satellite can be compensated for by proper orientation of the scanning mirror axis with respect to the motion of the tape. Instead of being exactly at right angles to this direction of motion, it is displaced by a small angle whose optimum value can readily be calculated for a given set of system parameters.

An overall view of the equipment taken at an early stage in the development of this type camera is shown in Fig. 8. The camera proper, with its associated components, is mounted directly on the high-capacity vacuum pump. The major part of the circuitry, in the form of breadboard units, is mounted on an adjacent rack.

The optical system designed for this camera includes a lens, a fixed mirror and an oscillating mirror, which is an essential element of a panoramic camera of this type. The purpose of the fixed mirror between the lens and the enclosure is to keep the elements of the optical system close to the camera housing, where a more rigid and precise mounting structure can readily be provided. The mirror is actuated by a cam driven rack which, in turn, engages a pinion on the mirror shaft. Uniform rotational motion of the cam shaft is made to produce a uniform rotation of the mirror of about 48° in a time period of about 11 seconds. At the end of this period, the contour of the cam allows the mirror to return (within 1.5 seconds) to the position required for the beginning of a scan period.

The sketch of the interior of the camera enclosure shown in Fig. 9 illustrates the path followed by the tape when it is moved between the supply and take-up reels. Beginning at the supply reel, the tape is moved past the optical slit where

Fig. 6—Sensor head interior, advanced model frame camera.



exposure takes place. The width of the slit determines the exposure time, and therefore, directly affects the camera sensitivity. Since the motion of a particular point on the tape and a particular point of the image must coincide during the exposure process to avoid image smear, the slit must be made relatively narrow. A difference in speed between image and tape of 1% will limit the slit width to 50 picture elements, if the loss in resolution is to be held to less than 10%.

In line with the slit on the insulator side is another slit, which restricts the area of the tape exposed to the flood beam to about the same area exposed to the optical image. After the tape changes direction 90°, it passes with its insulator side beneath another flood gun used only during the prepare process. This gun is activated normally at the beginning of a sequence of operations, when a uniform electric charge is deposited on the entire length of tape prior to optical exposure. The tape next passes over the capstan roller which determines the rate of motion of the tape. The electron read-gun assembly projecting from the enclosure at this point is located in such a position that the charge image on the tape is scanned across its width while the tape is in contact with the capstan. Only horizontal deflection of the scanning beam is necessary, since the motion of the tape provides the equivalent of scanning in the vertical direction. However, vertical centering adjustments are available, in order to center the scanning beam in the horizontal slit provided close to the surface of the tape in the read-out position. After passing over the capstan, the tape completes its path at the take-up reel.

The read gun and associated components were designed originally for use with a small image orthicon having a diameter of 1½ inches over most of its length. Minor modifications were made to adapt these to the specific requirements of the tape camera. Because of the relatively small size of the yoke, the design of deflection circuits using readily available transistors presented no unusual problems. Also the limited bandwidth requirement of the video channel (690 kc) simplified the design of the video amplifier.

The control system of this camera was made intentionally quite elaborate so that adjustments and measurements could be made with a considerable degree of flexibility. The jack fields and circuit controls located adjacent to the camera (shown in Fig. 7) illustrate this point.

Fig. 7—Pictorial coverage, slit camera system.

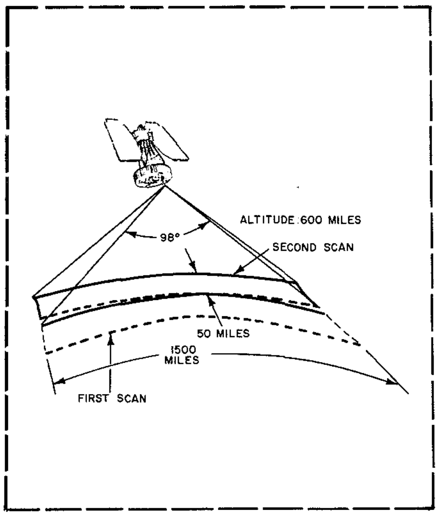


Fig. 9—Interior view of sensor head, feasibility model slit camera.

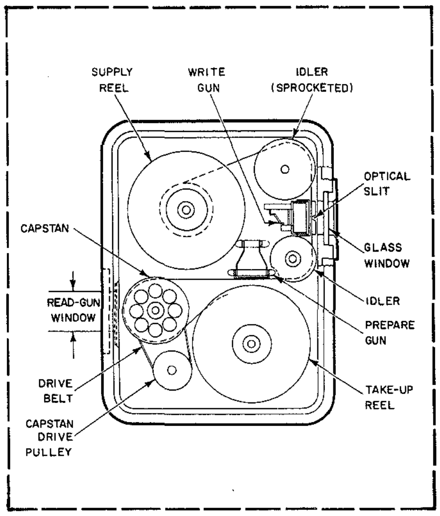
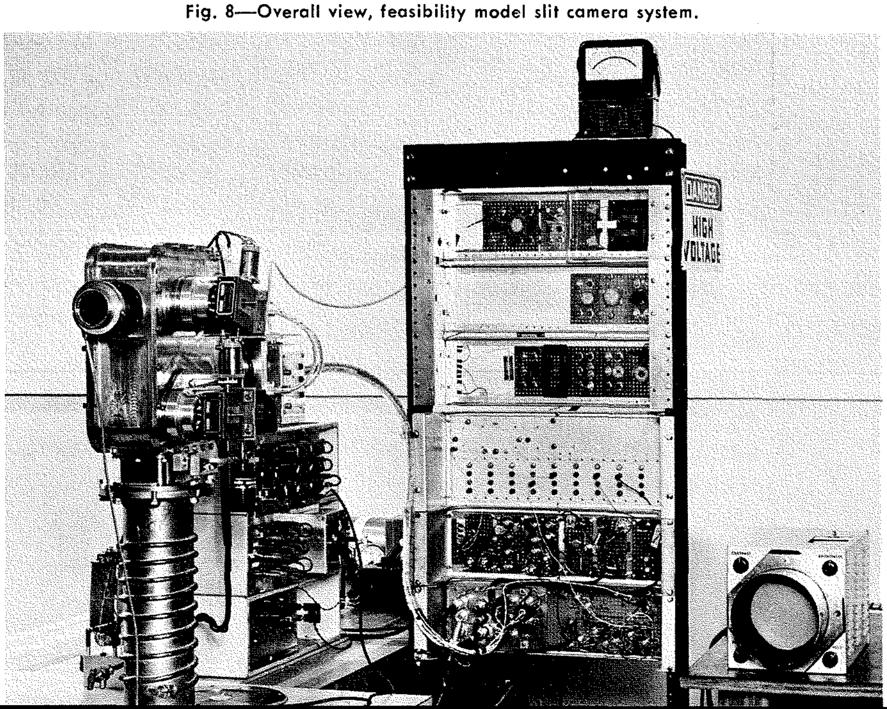


Fig. 8—Overall view, feasibility model slit camera system.



Advanced Model of a 35-mm Slit Camera System

Operating experience gained with the feasibility model of this type camera emphasized the need for improvements, particularly in the method for driving the tape and the oscillating mirror. Slight departures from uniform motion during the write process can cause an appreciable loss in resolution. The same kind of irregularities in motion will also cause a loss in resolution from the readout process.

The design of an advanced model of a slit camera system was undertaken so that special emphasis could be placed on critical problems of this kind inherent in the panoramic-camera-design concept. The present program also includes a requirement for demonstrating normal operation using only a low-capacity ion pump to maintain the proper vacuum. In this and other respects, it is intended that the equipment now being constructed will satisfy the principal requirements of a preprototype flight model.

CONCLUSIONS

The feasibility of this unique method of image sensing and storing, using either frame or slit exposure techniques, has been thoroughly demonstrated. Advanced preprototype models of each have been constructed and will be ready for test in the near future. Many people in RCA, particularly in the Astro-Electronics Division, have made major contributions to this program. This article is, in effect, a summary of the team accomplishment to date.

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VIDICON APPLICATIONS FOR SPACE-BORNE TV CAMERAS

Vidicons have a variety of applications for use in space and present certain advantages over other camera sensors. The specific requirements dictated by a particular space mission require a choice of one of several available photoconductors to provide matching performance characteristics. The parameters of vidicons that are to be used in space must be controlled during fabrication to meet more rigid requirements for standard features plus the same rigid requirements on additional characteristics pertinent only to space borne cameras. The environment of launch and space also imposes the need for additional ruggedization and improved reliability. There is a continuing challenge for the future for development of sensors with higher resolution, higher sensitivity, lighter weight, and lower power.

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THE successes of the TIROS weather satellite have demonstrated the feasibility of using television cameras for space applications. The pictures obtained are of such value to the weather bureau that TIROS has become, in reality, an operational as well as experimental satellite. (The TIROS satellites were designed and constructed by AED for NASA under a series of contracts, the latest of which is NAS 5-3173.)

Various applications for spaceborne TV have resulted from the stimulus of these successes: A second generation of weather observational satellites is now being fabricated for the NIMBUS program (under NASA Contracts NAS 5-877 and NAS 5-667), and several cameras have been built (for RANGER) to obtain pictures of the moon's surface (under subcontract to the Jet Propulsion Laboratories of CIT, under NASA prime Contract NAS 5-100).

PURPOSES OF SPACE-FLIGHT OBSERVATIONS

The cameras for RANGER spacecrafts 3, 4, and 5 were designed to obtain medium-resolution pictures of the moon's surface, and the cameras for RANGER 6 through 9 have the capability of obtaining high-resolution pictures. At some future date, a lunar-orbiting satellite containing TV cameras will be used to obtain details of the moon's geography, paving the way for the manned lunar expedition. The cameras that are now being designed for the APOLLO spacecraft will be used to observe the astronauts during launch, as they travel through space to the moon, and as they explore the lunar surface. In addition, these cameras will be used to obtain television pictures of the moon's surface during approach and the Earth's surface during departure. The cycle of experiments concerning the moon will, of course, be extrapolated for deep space with the next step including Mars and Venus.

There are many possible uses for TV systems in space. Two of these are the observing of space-flight vehicles and satellites in orbit, and the docking and mating of two vehicles in space (such as will be done in the GEMINI experiments). In addition to viewing human occupants of spacecraft, TV cameras will be used to watch lower forms of animal life and will enable many biological studies, including the monitoring of the behavior of cells during space flight by microscopic television. Plans have been made for studying the growth and behavior of plants in the space environment. The monitoring of mechanical operations is of great interest. This is akin to the docking operation already mentioned. Such things as the observation of the sloshing of the liquid in the hydrogen and oxygen tanks is of great interest to the rocket designer, as well as looking into the rocket engines during the firing period and at burn-out. The deployment of inflatable structures in space requires monitoring from the earth.

Somewhat related to the deep-space observations is the use of TV in astronomical studies. The stratoscope flights have indicated the feasibility of using astronomical television from balloons, photographing the surface of the sun. Plans have been partially carried out for extending this type of operation to rockets and orbiting vehicles. Viewing solar flares, observing the effects of solar radiation in space, making ultraviolet measurements of the stars and sky, and the telescopic viewing of stars and planets from space, are examples of providing measurements free of the aberrations of the earth's atmosphere.

VIDICONS VERSUS OTHER TV SENSORS

In using a sensor for a space-borne TV camera (as compared to broadcast television), a new set of criteria must be considered. In designing for these criteria, a decision to use the vidicon has been made in most of the applications. There are a number of reasons why the vidicon presents an easier course of action for space-borne TV cameras. It is a simpler tube and less subject to temperature variations than some of the other sensors which are available. While it is subject to the effects of temperature variations, it is affected to a lesser degree than the image orthicon and some of the other sensors that might be used. The vidicon has been more readily adaptable to slow-scan operation, which permits the reduction of transmission bandwidth, and consequent spacecraft power. Power is directly translatable into spacecraft weight, which is always at a premium. For example, in both the TIROS and NIMBUS satellites, a bandwidth of approximately 60 kc permits the transmission of a high-resolution TV picture. The pictures from TIROS are

MAX H. MESNER received his BSEE from the University of Missouri in 1940, after which he joined the RCA Laboratories. There, he worked on radar and color TV development. He transferred to the Astro-Electronics Division of RCA upon its formation in March 1958. He was responsible for the TV camera systems used in TIROS, and has directed the development of a number of miniaturized TV cameras, including those for NIMBUS, RANGER, and APOLLO. His association with TIROS also included the responsibility for systems checking and environmental testing for the TIROS payload during the prototype phase of TIROS I, also the responsibility for ground station operations at the Hightstown Ground Station during the launching phase. Mr. Mesner is a senior member of the IEEE, a member of Sigma Xi, Tau Beta Pi, and Eta Kappa Nu. He holds 13 U.S. patents.

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TABLE I — Camera Parameters

Spacecraft	Type of Vidicon	Resolution TV Lines Horiz.	Resolution TV Lines Vert.	Frame Time, Sec.	Band-width, kc	Dynamic Range, ft-candle-sec	Exposure Time, msec	Scanning Lines
NIMBUS AVCS	Electromagnetic deflection and focus -- ASOS 1″ vidicon	800	600	6.5	60.0	*0.40 to 0.004	40	833
APT	1″ vidicon electromagnetic deflection and focus — ASOS	700	550-600	200	1.6	0.7 to 0.01	40	800
TIROS	½″ vidicon electromagnetic deflection and focus — ASOS	400	350	2.0	62.5	1.0 to 0.01	1.5	500
RANGER (F)	1″ vidicon ASOS, E-M deflection and focus	700	700	2.56	200.0	0.68 to 0.004	5	1,150
RANGER (P)	1″ vidicon ASOS, E-M deflection and focus	200	200	0.2	200.0	0.27 to 0.003	2	300
RANGER (3, 4, 5)	1″ vidicon ASOS electrostatic deflection and focus	200	150	10.0	2.0	0.3 to 0.1	20	200
OAO	1″ vidicon ASOS electrostatic deflection and focus	350	250	1	60.0	2nd to 5th Magnitude star	No shutter	350
APOLLO	1″ vidicon-hybrid Sps, E-M deflection electrostatic focus	300	220	0.1	500	0.005 to 30.0	No shutter	312

* Exclusive of auto iris control (regulated power input).

comparable to those obtained in commercial TV; the pictures anticipated from NIMBUS will have greater resolution, since NIMBUS uses an 800 scan-line system.

Another reason for using the vidicon is that its mode of deflection has been readily adaptable to transistorized circuitry. Also, an important quality of the vidicon is that it is basically not critical in adjustment and is thus readily adaptable to unattended operation.

The vidicon's lack of sensitivity compared to the image orthicon is offset in a number of other ways. For example, it is possible to build a camera much smaller in size and weight with a vidicon than with any image orthicon under production at the present time. Since both volume and weight are of prime importance in any space-borne operation, this has been the controlling factor that has dictated the selection of vidicons in the cameras used today.

CHOICE OF PHOTOCONDUCTOR

In building a camera using a vidicon, the photoconductor surface must be carefully chosen to match the requirements of the space mission. The basis for choice relates to four factors: 1) whether pulsed light and subsequent image storage is to be used, as contrasted to open-lens portrayal of continuous motion; 2) what frame time is to be used; 3) whether the system is to employ light integration (charge integration in the photoconductor); and 4) whether the system operation requires the employment of erasure techniques to prevent the double exposure effect from a residual image.

A brief explanation of the reasons for slow-scan operation and the use of pulsed light is in order. The basic reason for slow-scan TV is to reduce the rate of information transmission, thereby reducing the required bandwith for a picture of given resolution. The use of narrower bandwidth improves the system signal-to-noise ratio, which is effectively put to use in space transmission by permitting a comparable reduction in transmitter power. For example, the reduction of frame rate permits the 800 scan-line picture to be transmitted with a 60-kc bandwidth. This slow-scan operation also results in a significant reduction in payload weight. Table I lists camera system frame-time, scanning lines, bandwidth, and exposure time for several space-borne TV systems now being built.

Where pulses light is to be used, it is necessary that the charge pattern on the photoconductor (representing the image) be stored for the length of time during which the frame is read out. Since a photoconductor possessing time-lag characteristics must be used to carry out this storage, it follows that picture smear will result from motion. A method of image immobilization similar to that used in film photography is used, that of providing pulses light, either by using a shutter or a flasher. The shutter exposure time used in the TIROS cameras (see Table I) is 1.5 msec, since TIROS is spinning at 10 rpm. The longer exposure (40 msec) used in NIMBUS is possible because the spacecraft is stabilized without rotation, and it is only necessary to stop the linear orbital motion with respect to the earth.

Fig. 1—Vidicon response as a function of integrated illumination.

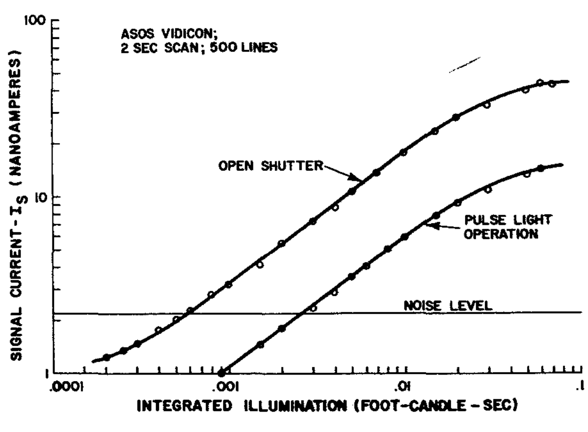
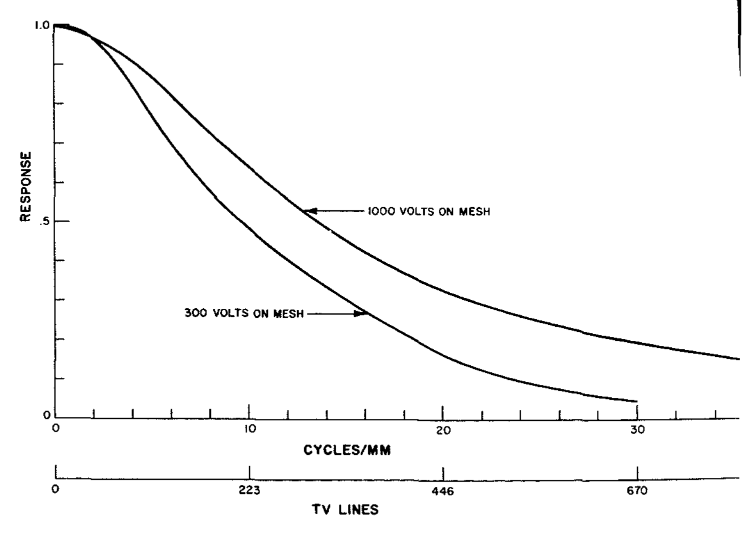


Fig. 2—Typical resolution response of 1-inch vidicon (data taken at 6.5-sec frame time).



The photoconductor materials available are antimony trisulphide (AS_2S_3), variations of which are used in commercial vidicons; antimony sulphide-oxysulphide (ASOS); selenium and selenium compounds; and lead oxide. For adequate performance with pulsed light at frame times from 0.1 to 10 seconds, the ASOS surface, developed by RCA, has been used most often—principally because it has the advantage of high sensitivity, adequate performance over an acceptable temperature range, and remarkable resistance to burns due to raster scanning and to excessive illumination. It has the disadvantage of being difficult to evaporate without spots and blemishes. The storage qualities making it acceptable at slow-scan rates makes its usage impractical for continuous motion pictures.

Selenium photoconductors have good slow-scan characteristics and operate satisfactorily under pulsed light conditions. The problem with this material is its deterioration at temperatures greater than 35°C. Other laboratories have experimented with selenium compounds possessing good slow-scan performance, a sensitivity which is nearly that of ASOS, and which can operate and be stored at higher temperatures (45°C in one case, 60°C in another). Work is continuing on these surface materials to improve their manufacturability and reliability.

Lead oxide surfaces have been evaporated by the Phillips company in Holland, but this sensor (known as the *Plumbicon*) has not been thoroughly evaluated for slow-scan space operation.

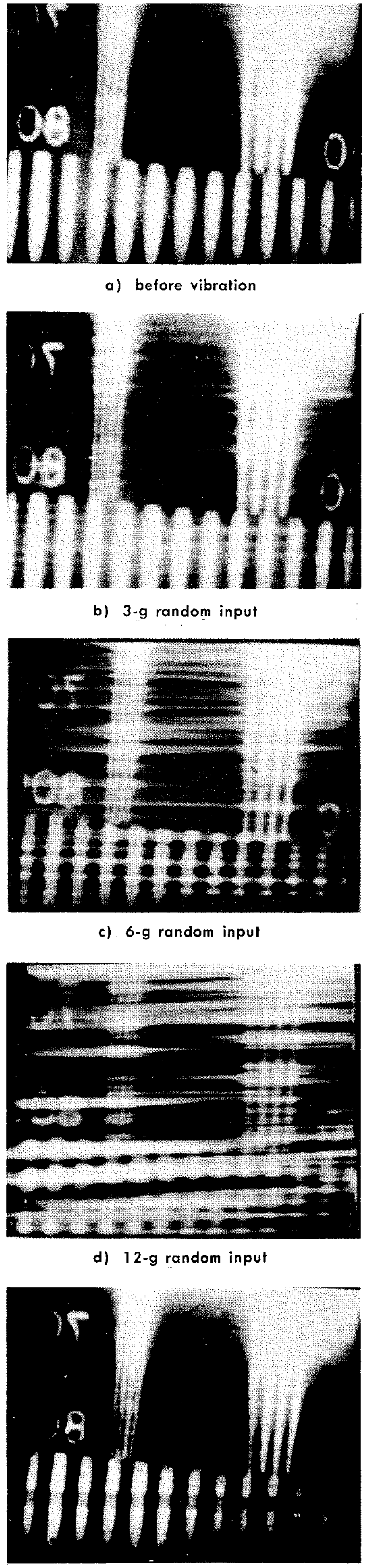
In the APOLLO project, where the astronauts are viewed within the spacecraft in real time, the frame-time selected is 0.1 second. The 10-frame/sec rate will be scan-converted on the ground to make the pictures adaptable to commercial television viewing, allowing the public to watch the astronauts go to the moon. At this frame rate, it is possible to use the commercial version of antimony trisulphide. An ASOS photoconductor has too much lag, being useful only below the rate of 5 frames/sec. (Note the bandwidth and resolution in Table I.)

PHOTOCONDUCTORS FOR INTEGRATION AND LONG STORAGE TIMES

In cases where the scene illumination is very low and no image motion exists, integration can be used to build up an effective signal. An example of this is in the cameras for stellar viewing. The photoconductor charge is integrated a second or more to reach a sufficiently high level to provide a good signal-to-noise ratio in the output signal. This effect is utilized in the cameras being built at AED for the ORBITING ASTRONOMICAL OBSERVATORY (OAO) spacecraft where it is used as part of the attitude-control system[1] (under subcontract to the Grumman Aircraft and Aeronautical Engineering Corporation, on Contract No. NAS 5-814 from the National Aeronautical and Space Administration). In this case, the integration is for a 1-second time, and it is possible to collect enough light with a commercially available lens to observe star intensities as dim as the fifth magnitude. The ASOS surface is quite adaptable to this program. Also, it has been possible to use a surface of selenium which produces approximately the same sensitivity and the same storage characteristics. In considering application requiring longer frame times or storage for greater periods than 10 seconds, it is necessary to employ a storage-type vidicon. The surfaces just mentioned (i.e., the selenium surface and the selenium compound surface) have, in tests conducted at the Astro-Electronics Division, produced satisfactory pictures using storage times of the order of 3 minutes. In the APTS (Automatic Picture Taking System) cameras for NIMBUS, the vidicon used has a polystyrene layer for storage. This vidicon is very similar to the other vidicons in its construction, except for the fact that a thin layer of polystyrene is evaporated across the photoconductive surface (that is, the surface next to the scanning beam in the vidicon). A switching-scanning sequence enables the transfer of charge from the photoconductor to the polystyrene layer.

ERASURE OF RESIDUAL IMAGE

The erasure of residual images is of varying importance depending upon the particular sequence of operation required. In TIROS, a picture is taken every 30 seconds, at which time 15 scans can be produced during the intervening period between pictures, allowing the thorough erasure of the image. In cameras with a shorter time between pictures, a specific technique is required, since with the ASOS surface, the first scan removes only about 40 to 50% of the charge pattern. In the NIMBUS application, where it is desirable for conservation of filament power to shut the cameras off between pictures, sufficient normal scans are not available; making necessary a special erasure technique. A vidicon surface characteristic permitting a higher percentage of erasure, or more destructive read-out during a single scan, is highly desirable. Some of the selenium surfaces have produced results in this direction which are more gratifying than those obtained with the ASOS sur-



a) before vibration

b) 3-g random input

c) 6-g random input

d) 12-g random input

e) 3-g sinusoidal input at 65 cps

Fig. 3—Distortion caused by vibration.

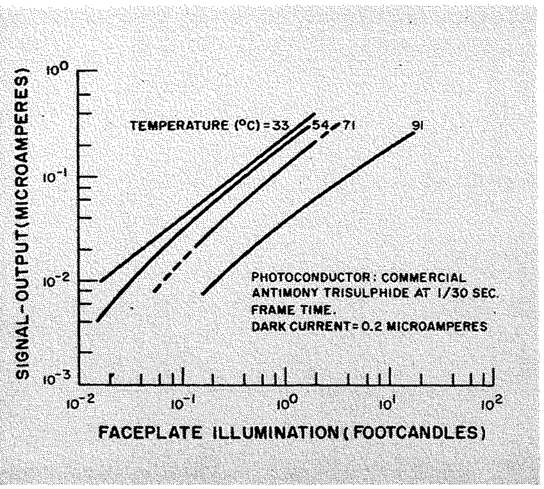


Fig. 4—Vidicon sensitivity as a function of temperature.

face. Also, special techniques in the camera have been developed to produce this erasure in a shorter number of scans. One of the techniques is to flash a light on the photoconductor (making it uniformly conductive) accompanied by a rapid scanning with the beam current at a high value. The charge level is then restored to a proper value, one in which the surface is adequately prepared and at the proper potential for a re-exposure and a new readout scan. This technique has been developed in the RANGER 3 program and the RANGER Television Subsystem which followed, and a similar development has been used for the NIMBUS AVCS cameras. A reduction of this residual image to less than 10% has been accomplished.

VIDICON PARAMETERS RELATED TO SPACE OPERATION

In designing and selecting a vidicon for space usage, there are a number of parameters which must be considered, many of which must be given different emphasis than that applied in considerations for broadcast television. These parameters are:

1) storage capability,
2) sensitvity,
3) resolution,
4) shading,
5) gamma,
6) microphonics,
7) erasure of residual image (already discussed),
8) dark current,
9) spurious coherent signals such as spots on the photoconductor or mesh,
10) mottling due to variations in the photoconductor surface,
11) fine grain mottling (coherent surface noise),
12) signal from the mesh.

In space applications, sensitivity is of the utmost interest. Space missions requiring the operation of cameras under low-light conditions are quite common. Examples of this are viewing the moon illuminated only by earth-shine, and viewing the interior of a spacecraft. Under high-light-level conditions, high sensitivity of the sensor permits faster shutters and lenses which may have a higher *F* number. A higher *F* number means a lighter lens, more readily mounted in a rugged housing. A typical response curve for an ASOS vidicon is shown in Fig. 1. Integrated illumination is expressed in foot-candle-seconds.

Since the basic nature of picture rendition is one which usually requires maximum resolution capabilities, the limiting factor in space applications is most often the transmission bandwidth. In some systems, the sensor may be the limiting item. Fig. 2 is a curve showing the performance of a 1-inch vidicon. Such a vidicon is used in NIMBUS cameras, where 800 scanning lines are used, and in RANGER cameras, where the line number is 1,200. In TIROS, where a ½-inch vidicon is used, the system employs 500 scanning lines. The gamma of a vidicon relates to the type of photo surface employed. Gamma (γ) is the slope of the light transfer characteristic of the vidicon (Fig. 1), and is found from:

$$\gamma = \frac{\Delta \ log \ signal \ current}{\Delta \ log \ illumination}$$

It is desirable to have the ground-based monitor possess the inverse function of the γ to permit the most linear reproduction of the light intensity range. The γ of vidicons using Sb_2S_3 and ASOS photoconductors is approximately 0.6; selenium provides a γ close to unity. (The γ also varies as a function of target voltage.)

Since shading is more important in a system used for instrumentation, its control merits special effort in camera design (for example, the careful adjustment of alignment magnetic-fields and the shaping of the focussing and deflection magnetic fields are necessary to maintain a normal landing angle). The vidicon must have a uniform photoconductor response. Since deflection linearity is maintained at values of less than 1%, this will not contribute to shading.

At slow scan rates, the level of the dark current may exceed the useful signal. In order to prevent the resulting blanking pulse from swamping the transmitter, a clamp-controlled clipper is used. To provide a black reference for this clipper, a black mask on the vidicon is sometimes provided. By clipping the dark current pulse just beyond the range of video variations, the signal can be transmitted without requiring compression or compromising the signal-to-noise ratio.

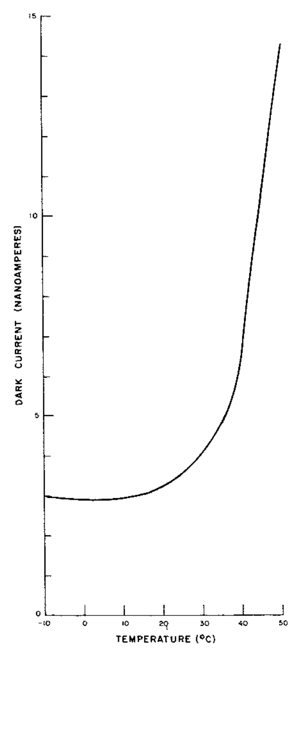
GEOMETRIC RETICLE

When TV cameras are to be used for mapping, weather observation, and optical instrumentation, a reticle is evaporated onto the photoconductor. For example, in TIROS (which looks at the cloud cover and landmarks on the earth) it is desirable for the weather experts to plot the position and movement of clouds and storm areas on their maps. For that reason, they need to have an accurate geometrical presentation of the picture that relates this to the earth maps. It becomes unnecessary to have a scanning system with perfect linearity, since the effects of linearity errors may be compensated for by placing a reticle pattern on the face of the vidicon. This reticle pattern is linear in its spacing, giving accurate space marks on the monitor picture. Data obtained from a calibration photograph permits the production of predistorted grids which allow accurate measurements of the mapping geometry.

REDUCING WEIGHT AND POWER

Transistor circuits requiring minimum power are a prime design requirement. In addition, with relation to the image sensor, two possible areas of improvement are available: the design of a lower-power filament, which has proved practical, and the reduction of power to focus and deflect the vidicon. The use of a coaxial magnetic field to focus the beam produces extremely good spot characteristics and has been standard for a number of years. It does require a heavy electromagnet using 1 to 3 watts. A development of the last few years is

Fig. 5—Vidicon dark currert as a function of temperature.



the hybrid vidicon with electrostatic focus and electromagnetic deflection. This provides characteristics approaching the magnetic vidicon but making possible a significant reduction of volume, weight, and power. This vidicon is used in the present design for the APOLLO TV camera system in which a 1-inch camera, weighing approximately 4.5 pounds, is included in a comparatively small volume (being designed and constructed under subcontract to North American Aviation, Inc., under NASA prime Contract NAS 9-150).

The electrostatically deflected and focussed vidicon is also a solution to the problem of weight and volume reduction, although at the present time the hybrid vidicon is favored because the deflection circuits required for the electrostatic vidicon are less readily adaptable to transistorized circuits (which are basically current devices).

With the elimination of the focussing coil, the camera circuits no longer remain a small percentage of the total weight and volume. For that reason, the use of micromodules or integrated circuits make possible a significant reduction in the mass and volume of the camera. The APOLLO camera, mentioned previously, makes use of integrated circuits in the camera circuitry with the exception of parts of the power converter.

RELATIONS TO ENVIRONMENT

One of the major considerations in designing cameras for space operation is the relationship to the space environment. There must be due consideration given to the shock, acceleration, and vibration experienced at launching and to the video variations of temperature which will occur when the equipment is in orbit or space flight. The lifetime through which the camera must operate unattended without significant changes in picture geometry or quality is an important design criterion. Table II lists typical environmental requirements. This shows that the cameras for APOLLO must operate during high stress, requiring the development of specially designed vidicons, as well as mechanical isolators to minimize the vibration inputs to the vidicon. RCA and at least one other manufacturer have produced vidicons designed to minimize interference from microphonics. The photographs shown in Fig. 3 indicate the kind of interference which occurs at different levels of random vibration. By the additional use of the isolator, it will be possible to reduce this interference to a negligible value.

BEHAVIOR WITH TEMPERATURE

Since both sensitivity and dark current vary markedly with temperature, this behavior is one of the most important criteria influencing the design of cameras for space. Fig. 4 indicates the sensitivity variation as a function of temperature for an antimony trisulphate vidicon, and Figure 5 shows how the dark current varies. In considering these curves, a conclusion may be drawn that optimum operation may be obtained between 25 and 35°C. No assurance of consistently satisfactory performance can be expected above 50°C.

VIDICON LIFE

In many satellite projects, operation of the scientific payload for 6 months, a year, or even longer is desirable. As far as the vidicon is concerned, there are two controlling factors: 1) the cycling life of the vidicon filament, and 2) the steady operating life of the filament and cathode. A graph showing the anticipated life with the filaments cycled is shown in Fig. 6. On a noncycling basis, the anticipated cathode life is 5,000 to 10,000 hours. The 14 TIROS cameras in orbit have given significant data on vidicon life performance—several cameras have operated successfully for over one year.

GROWTH POTENTIAL FOR SPACE-BORNE CAMERAS

The sensors for space-borne cameras constructed by AED have, to date, been ½-inch and 1-inch vidicons. Other sensors are worthy of consideration, and some will, no doubt, be used in future cameras. Candidates for advanced systems are:

1) a multiplier vidicon, for higher sensitivity (improved signal-to-noise ratio);
2) a larger diameter vidicon, for improved sensitivity and resolution;
3) a ½-inch hybrid, for lighter weight;
4) the intensifier vidicon, for greater sensitivity;
5) the secondary emission conductivity vidicon and the image orthicon, for the same reason; and
6) the image-intensifier orthicon for the ultimate in sensitivity.

The increased difficulty of adapting some of these devices for space operation has deferred their use, but only during the initial step of TV camera development.

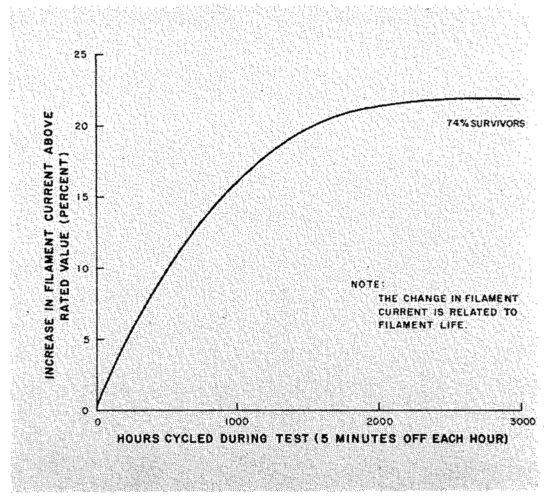


Fig. 6—Vidicon life as a function of filament cycles.

CONCLUSION

The use of space-borne TV in exploring distant portions of our universe will continue to be more and more intriguing because it permits man to thrust forth into these regions to discover new areas and obtain new knowledge without actually requiring him to risk his person in exploring it. This is one of the most persuading reasons among many that exist for continuing confidence in the growing future of television for space.

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TABLE II — Maximum Environmental Requirements for Space Cameras

TV System	*Model & Type*	*Random Vibration, g*	*Shock, g*	*Acceleration, g*	*Temperature Range, °C*
TIROS	Flight	10 (Thrust) 10 (Lateral)	—	—	55 to —10
	Proto	25	15 (Thrust) 10 (Lateral)	50 (Thrust) 20 (Lateral)	60 to —15
NIMBUS AVCS	Flight	11.7	—	—	50 to 0
	Proto	20	—	30	55 to —5
NIMBUS APT	Flight	11.7	—	—	50 to 0
	Proto	20	—	30	55 to —5
RANGER 3, 4, 5	Flight	12	—	7	55 to 0
	Proto	15	50	14	65 to 10
RANGER 6, 7, 8, 9	Flight	9	—	—	40 to 0
	Proto	15	100	14	50 to —10
OAO	Flight	4.5	—	—	40 to 0
	Proto	25	30	11.5	50 to 72 —10 to 36
APOLLO	Flight	2	—	—	—
	Proto	5	78	7	37.8 to —17.8

TELEVISION FOR STELLAR ORIENTATION OF THE ORBITING ASTRONOMICAL OBSERVATORY

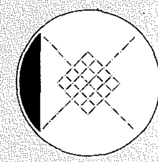

Fig. 1—Vidicon reticle pattern.

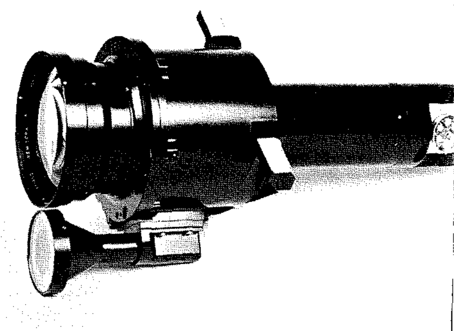

Fig. 2—Camera housing which includes the optics, shutter, vidicon, preamplifier, and heater.

Earth satellites offer many new opportunities to utilize television, such as the system described here that will indicate accurately the direction and brightness of target and reference stars relative to the Orbiting Astronomical Observatory (OAO) Satellite's coordinate axes. This system provides a TV-monitor presentation to an operator on the ground and serves as a back-up pointing method and visual check on the primary attitude-control system of OAO.

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VISUAL observation from a spacecraft lends itself to many varied applications, including reconnaissance, surveying, meteorological observations, navigation, and control of attitude (e.g., pointing the spacecraft *accurately* toward the earth, the sun, or other stellar body).

The television system described herein is being designed by the DEP Astro-Electronics Division for the ORBITING ASTRONOMICAL OBSERVATORY satellites (see *Background*). The system serves as a visual monitor and back-up pointing system for the spacecraft's boresight axis, and detects stars of second to fifth magnitude with sufficient clarity to allow the ground operator to recognize star patterns.

The general requirements for any satellite TV camera are extreme reliability; minimal power, size, and weight; unattended-operation capability; conservation of bandwidth; and the ability to withstand severe environmental stresses. Reliability is achieved by the use of worst-case design, the careful selection of proven components, appropriate "derating," suitable care in assembly and wiring, numerous inspections, and environmental testing. Components utilized in the TV subsystem of OAO are derated by a factor of 10:1, in most cases, in order to achieve a probable operating life of one year. Bandwidth conservation is accomplished by slow-scan techniques and a null system (described herein).

Final manuscript received June 8, 1964

METHOD OF OPERATION

The unique method selected for measuring the position of the stars relative to the OAO coordinate axes reduces the required bandwidth and makes the subsystem essentially independent of deflection linearity or drift.

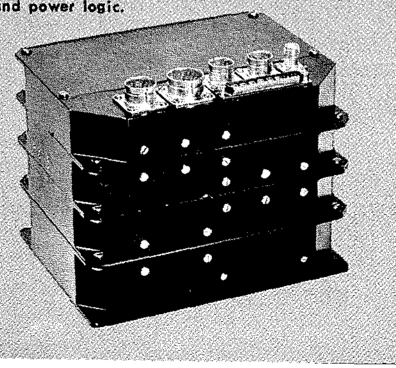
An opaque grid pattern is superimposed on the vidicon photoconductor (Fig. 1) the central intersection of the grid pattern indicating the reference axis direction for pointing purposes. When the lens images a star field on the vidicon photoconductor, a normal TV display of the star field results; but, when it images a star on one of the opaque dots or lines, no video signal will result. In conjunction with the optical system, the diameter of the reticle dots represents 30″ of arc, while a star represents approximately 8″ of arc. Thus, when the central reticle dot obscures a target star and thereby nulls the video output, spacecraft position can be established to within 30″ of arc. Other stars in the field of view can verify the pointing axis. The distance between the reticle dots is equivalent to 1° of arc, while the total field of view is 8.4° by 8.4°. The location of the remaining reference stars may be thus ascertained by comparison with a star map. A definite advantage of this null method of reference measurement is that lowering the electronic resolution *does not degrade the accuracy*, thus enabling reduction of the amplifier bandwidth.

The TV camera for OAO is initially aligned and boresighted so that the central dot of the vidicon reticle is within 15″ of arc of the optical boresight axes. The optical alignment deviates less than 30″ of arc as a result of environmental stresses. To achieve these requirements, stability of the vidicon and optical-system with respect to the three mounting pads on the camera is held to within several millionths of an inch.

The TV subsystem consists of two units: 1) the camera and optics (Fig.

Fig. 3—Electronic package.

Module A: vidicon control and DC-DC convertors.
Module B: horizontal deflection and erase logic.
Module C: vertical deflection and shutter logic.
Module D: video amplifier; blanking; black and white level references; waveform test points; telemetry; and power logic.



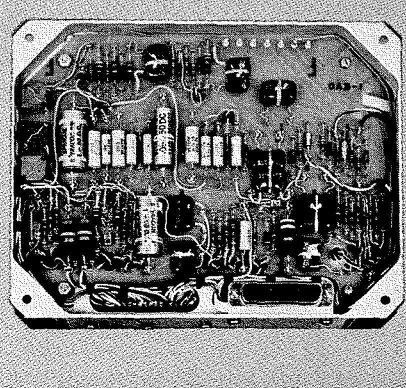


Fig. 4—Typical electronic module.

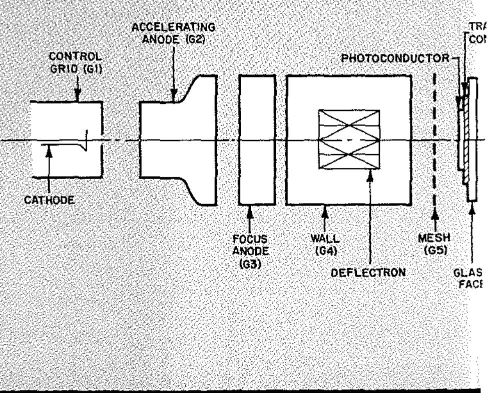


Fig. 5—Vidicon tube structure.

Background—The Orbiting Astronomical Observatory

Increased emphasis is being placed on astronomical observations to learn more about the birth and chemical composition of the planets, stars, and nebulae and to increase our understanding of the origins of the universe. Observations from the earth are limited to the visual and radio telescope spectrums. However, visual measurements are degraded by the shimmering effect of the earth's atmosphere, while measurements in the ultraviolet region below 3,000 angstroms are impossible because of atmospheric absorption. Satellite-borne observatories such as OAO are designed to overcome these limitations and permit clearer stellar views. They will make possible the ultraviolet mapping of the heavens now hidden by the earth's dust clouds.

NASA plans a series of three Orbiting Astronomical Observatories (OAO) to perform the following primary experiments:

1) The Smithsonian Astrophysical Observatory will map up to 50,000 stars. It will use an instrument called the *Celescope* which contains four ultraviolet-sensitive vidicons with an ultraviolet range of 1,200 to 2,900 angstroms.
2) The University of Wisconsin experiment, utilizing four photometers and two scanning spectrometers, will measure the stellar energy from bright stars and nebulae in the spectral range of 800 to 3,000 angstroms.
3) The Goddard experiment will use a 38-inch-diameter telescope in conjunction with Dr. J. Milligan's absolute scanning spectrophotometry equipment to map up to 14,000 stars per year with an initial resolution of 2 angstroms.
4) Dr. L. Spitzer's Princeton University experiment, using a 32-inch telescope in conjunction with a precision spectrometer, will determine the absorption features of interstellar medium.

The above experiments require a spacecraft pointing accuracy of $\pm 1'$ of arc and in some cases a fine pointing accuracy of $\pm 2''$ of arc. The spacecraft must be capable of maintaining this attitude within 15″ of arc for a time duration of 55 minutes. Later experiments will require a stability of 0.1″ of arc.

The OAO satellite, designed to fulfill these stringent requirements, is octagonal in shape, having a diameter across the flats of 7½ feet and length of almost 10 feet. The satellite will accommodate telescopes having diameters as great as 48 inches and lengths to 110 inches. The total payload weight will be 1,000 pounds, and the gross weight of the vehicle, including the payload, will be 3,600 pounds. Solar paddles with over 80,000 solar cells and covering an area of 111 square feet will generate 680 to 1,000 watts of electrical power to recharge the batteries. It will be launched into orbit by an ATLAS-AGENA D, and the orbit will be circular at approximately 500 miles (below the inner Van Allen radiation belt). During this orbit, the observatory will be in the sun for an average of 65 minutes and in the earth's shadow for 36 minutes.

Gas jets and inertia wheels provide attitude control of the spacecraft. The sensors for the stabilization and control system consist of rate gyros, solar sensors (eight course, eight fine), six gimbaled star trackers, a boresight star tracker, and the TV subsystem described in this paper, which serves as a visual monitor and backup pointing system for the boresight axis.

The DEP Astro-Electronics Division, Princeton, N.J., is designing the *OAO Stellar TV Subsystem* under NASA Contract NASA5-814 through a subcontract of the Grumman Aircraft Engineering Corporation.

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2); and 2) a four-module electronic package (Figs. 3 and 4).

VIDICON

An electrostatically deflected and focused vidicon (Fig. 5) minimizes weight, power, and magnetic fields. Magnetic-field reduction is of great importance, inasmuch as stray fields would interfere with the stabilization of the OAO—of prime importance in those OAO experiments requiring a stability of 0.1″ of arc for periods of 50 minutes. Weight is saved with the electrostatic vidicon, which does not require focus, deflection, or alignment coils. The vidicon deflection system is *not* of the conventional configuration (i.e., where the location of one set of deflection plates is closer to the photoconductor than the other), rather, all the plates are combined into an electrostatic yoke called the *deflectron.* As a result, the simultaneous vertical and horizontal deflection improves deflection sensitivity and minimizes astigmatism.

Measurements of the signal level at the ground allow calibration of stars of various magnitudes. To assist in distinguishing between stars, a reference level of 4 volts (electronically representing a second-magnitude star) is incorporated in the composite video signal. Comparing the amplitude of the video signal (corresponding to the star) with calibrated reference photographs determines star brightness to within a half magnitude.

PHOTOCONDUCTOR ILLUMINATION

A first-magnitude star has an apparent brightness, as seen on earth, of approximately 7.72×10^{-8} lumens/ft². Each succeeding stellar magnitude differs in brightness by a factor of 2.512. Therefore, the apparent brightness B_s of a fifth-magnitude star is:

$$B_s = \frac{7.72 \times 10^{-8}}{(2.512)^4} \sim 2 \times 10^{-9} \text{ lumens/ft}^2.$$

The 1-inch electrostatic vidicon has a useful photoconductor area of 0.44 by 0.44 inch; assuming equal resolution of 350 lines in the vertical and horizontal directions, the picture element area is $(0.44)^2 \div (350)^2 = 1.575 \times 10^{-6}$ square inch.

The Super Farran lens utilized has an effective aperture of 3 inches. The effective brightness L_v of a fifth-magnitude star, as seen at the vidicon is:

$$L_v = \frac{\textit{lens area}}{\textit{element area}} \times B_s$$
$$= \frac{(\pi)(1.5)^2}{1.575 \times 10^{-6}} \times (2 \times 10^{-9})$$
$$\sim 9 \times 10^{-3} \text{ lumens/ft}^2$$

COMMAND MODES

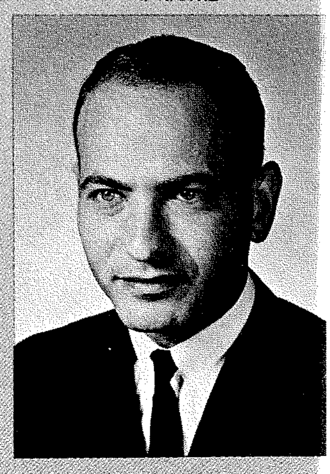
External commands, consisting of pulses

SENSENIG received certificates in Radio Tele-
on Electronics from RCA Institute (1942), Ad-
ced Electronics from Yale University (1943), and
F Techniques from the University of Connecticut
4). In 1943, he worked on airborne TV for the
ington Rand Corporation. From 1944 to 1946
from 1947 to 1957, Mr. Sensenig was employed
the Allen B. Dumont Labs Inc. in the develop-
nt of various TV and radio equipment. In 1946
1947, he worked on an airborne TV transmitter
the U.S. Air Force. In 1957, he was employed
Stavid Engineering Inc. as project engineer on
ransistorized airborne radar indicator, and on
development of a video scan-conversion unit
other radar and TV displays. He joined Philco
poration in 1959 as an engineering group super-
r on the SENTRY Satellite project. He joined
Astro-Electronics Division in 1961 as lead
ineer on the OAO Satellite Stellar TV Camera
ject. He is presently the lead engineer on the
RIS image-orthicon camera project. Mr. Sensenig has one U.S. patent and is a Member of the IEEE.

M. KRAVITZ received a BSEE degree from Newark College of Engineering in 1958, and he is presently studying toward a MSEE degree at the same institution. After graduation, Mr. Kravitz joined the National Security Agency, Ft. George G. Meade, Maryland, as a Design and Development Trainee before beginning a three-year active duty tour with the U.S. Air Force in Europe. As a Communications Officer, he was responsible for the maintenance and administration of nine radio relay stations which utilized Siemens and Henske microwave equipment. Mr. Kravitz joined the Astro-Electronics Division in September 1961. He was assigned to the TV Camera Observations Group where he has since been engaged in the design, development, and test of the OAO Television Camera Subsystem. Mr. Kravitz is a member of Tau Beta Pi, Eta Kappa Nu, and the IEEE.

W. Sensenig

M. Kravitz



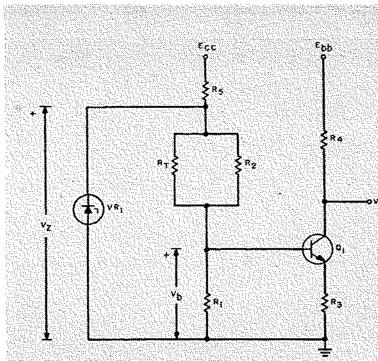


Fig. 6—Temperature transducer.

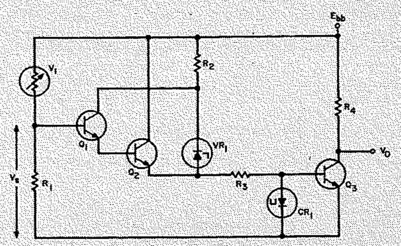


Fig. 8—Sun sensor preamplifier.

with a *0* level of 0 volts and a *1* level of 10 volts, are used in:

1) TV on	4) shutter open
2) standby	5) shutter closed
3) erase	6) shutter automatic

The purposes of the first two command modes are obvious. The *erase* mode rids the vidicon photoconductive surface of residual images if the camera is exposed to bright stars or planets. The erase procedure consists of uniformly illuminating the vidicon photoconductor for 0.5 second while increasing the sweep rates to 7-kc horizontal and 20-cps vertical (from 350-cps horizontal and 1-cps vertical) for a period of 1 second at a high beam current. (The shutter is closed during the erase procedure.) This process equalizes the photoconductive surface of the vidicon and allows the image to decay to the background noise level in less than 30 seconds. Many hours would be required without this erase procedure.

In the *shutter automatic* mode, the shutter remains open unless illumination from the earth, moon, or sun enters the acceptance cone of the photoconductive cell.

TEMPERATURE TRANSDUCER

In normal vidicon operation, a loss of signal occurs towards the edges of the vidicon target, attributable to electron-beam landing errors—referred to as *shading* or *porthole*. The dark current of a vidicon varies directly with temperature, approximately doubling for each rise of 10°C. As might be expected, the amplitude of the porthole will also vary directly with temperature. This change in signal with temperature will apply in a similar manner to the modulation of the reticle lines; however, this effect may be controlled by an inverse relationship between target voltage and temperature.

A unique method alters the voltage to the target of the vidicon, making use of the temperature dependence of a transistor. This transistor temperature-transducer causes the target voltage to vary inversely with temperature in a predictable and linear relationship by making use of the temperature-sensitive base-to-emitter voltage variation of the transistor in a simple circuit. In the basic temperature-transducer circuit (Fig. 6), a relatively small resistor R_1 makes voltage V_b stable with respect to changes in I_{CBO}. This voltage is independent of the transistor β, since:

$$(\beta + 1)R_3 >> R_1$$

A zener diode with a low coefficient of temperature keeps voltage V_z constant. The emitter current I_e is:

$$I_e = \frac{V_b - V_{be}}{R_3} \qquad (1)$$

The output voltage V_o is:

$$V_o = E_{bb} - I_c R_4 \qquad (2)$$

Assuming $I_c = I_e$, then:

$$V_o = E_{bb} - I_e R_4 \qquad (3)$$

Substitution of Eq. 1 in Eq. 3 yields:

$$V_o = E_{bb} - (V_b - V_{be}) \frac{R_4}{R_3} \qquad (4)$$

As seen from Eq. 4, the only variable is V_{be}, which will vary linearly at the rate of approximately −3.7 mv/°C for silicon transistors. Therefore, V_o is a linear function of temperature and can be utilized as the variable target-voltage supply. The slope of the curve may be changed by changing the values of R_3 and R_4, as indicated by Eq. 4. Resistor R_T is then utilized as a trimming resistor to provide the required output voltage at 24°C.

SUN SENSOR

The TV camera subsystem may be commanded to a *shutter-automatic* position to prevent damage to the photoconductive surface of the vidicon when exposed to a bright source. Fig. 2 shows the sun sensor located adjacent to the camera optical system. In this shutter-automatic mode, a signal activates a solenoid and closes the camera shutter if the sun, earth, or moon enters the field of view of the sun sensor.

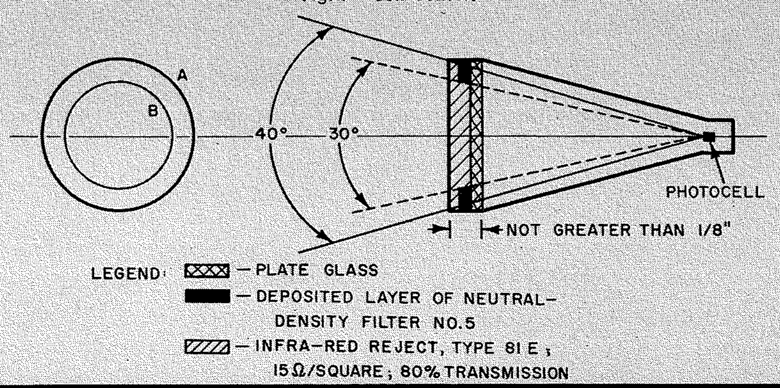
In the sun sensor (Fig. 7), the total field of view for diameter *A* is 40°, and for diameter *B*, 30°. A Clarix CL-605L photocell is located at the apex of the sun-sensor cone, or "funnel." The field of view between 30° and 40°, utilizing the No. 5, neutral-density filter, permits saturation of the photocell *only* from the illumination of the sun; illumination from the moon or earth will not saturate the photocell until it enters the 30° field of view.

The extremely fast switching of a tunnel diode initiates the automatic signal in conjunction with the photocell (Fig. 8). When the sun sensor is looking at dark space (no illumination), the impedance of photocell V_1 may be assumed as infinite. All three transistors are then in the *off* condition and the output voltage is E_{bb}. When the sun or moon enters the appropriate field of view, photocell V_1 saturates and the resistance of R_1 is much greater than that of V_1. The current required to switch the tunnel diode is found from the characteristic curve of the diode, enabling the calculation of the threshold value of voltage V_s sufficient to effect switching. It is then possible to calculate the resistance of V_1 that is required to obtain voltage V_s; let us call this resistance $(V_1)_s$. The amount of illumination necessary to obtain the resistance value of $(V_1)_s$ can then be determined from data obtained from the manufacturer and from experimental data.

CONCLUSIONS

The OAO television system described herein has the advantages over normal star trackers of a larger field of view and a real-time display. It detects a number of stars simultaneously, which greatly aids in immediate recognition of target stars—thus reducing the possibility of selecting a false target. Also, this TV subsystem acts a check on the OAO star tracker and boresight tracker; in the event of their failure, the OAO satellite can successfully complete its mission with the aid of the television unit.

Fig. 7—Sun Sensor.



AN/FSR-2 ... AN ADVANCED SYSTEM FOR PHOTO-ELECTRONIC DETECTION AND PLOTTING BEYOND RADAR RANGES

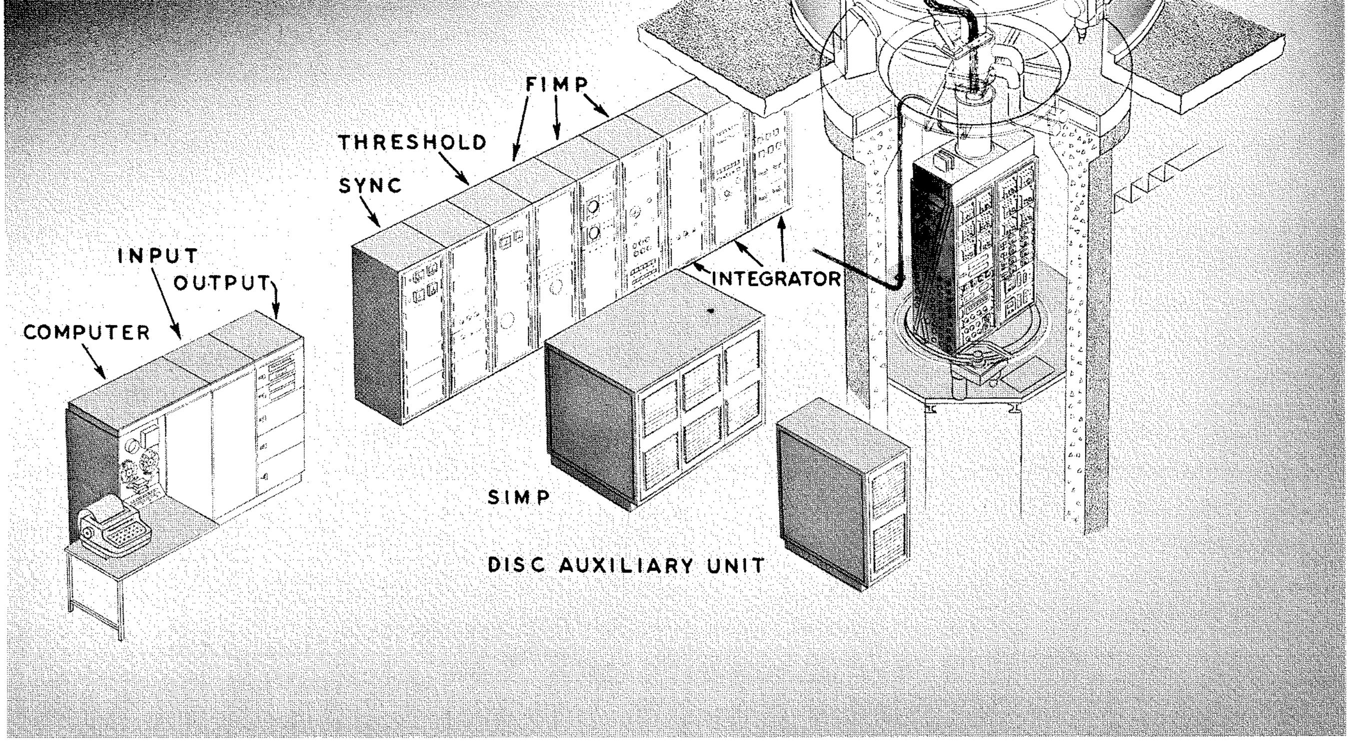


Fig. 1—Artist's view of the AN/FSR-2.

An 11-ton telescope having high-aperture, large-format, and photo-electronic detection has been designed for satellite surveillance at distances greater than radar slant ranges. Electron image integration enhances detection, and electron-image correlation provides moving-target discrimination. Electronic data processing yields detection confirmation and satellite plotting data in near-real-time. DEP-ASD, Burlington, is engineering the system, the most complete of its kind yet undertaken. It is highly automatic, and will become part of the Space Track network. Discussed here is the optical system (which involves 12 image orthicons, 24 electrostatic storage tubes, and state-of-the-art fiber optics), the telescope, and the observatory—all of which are in advanced stages of construction.

C. B. PARK

Electro-Optical Engineering

Aerospace Systems Division, DEP, Burlington, Mass.

LAUNCHINGS of high-altitude artificial satellites and space probes bring closer the need for developing an economical sensor capable of real-time surveillance of the regions beyond those covered by the already powerful radar. An optical system coupled with modern electronic pick-up devices and signal processing appears to fulfill the need.

STELLAR OBSERVATIONS

Efforts of astronomers throughout history have been made toward achieving a more perfect means of recording the physiography of the vast celestial sphere. Progress in recent years of electron imaging devices, signal processing, and data handling has led to the advent of a new field of specialization in stellar observation and real-time space surveillance.

Early development in electronic satellite detection included an Air Force sponsored "Facet-Eye Equipment"; it incorporated twenty-five individual 5-inch telescopes, each having an image-orthicon camera and a photographic recording of the resulting cathode-ray-tube image. This new art is in its early stage of development; however, the components and techniques that contributed to such advances are:

1) the image-orthicon tube with a sensitivity far exceeding photographic media, and a time-sequential information channel amenable to electronic real-time processing;
2) star cancellation, background suppression and signal integration, storage media and data processing.

The work of Dr. W. Livingston at the Kitt Peak National Observatory, that of Messrs. B. Aikens, G. Barton, W. Power at the Dearborn Observatory, that of R. K. H. Gebel at Wright-Patterson AFB, and that of M. Cantella and Dr. P. Nesbeda at the Aerospace Systems Division, Burlington, have contributed to the development of the technology and to the realization of a real-time optical surveillance system.

The Aerospace Systems Division, Burlington, Mass., under the sponsorship of the Electronic Systems Division of the USAFSC, is now engaged in building what is undoubtedly the most com-

Final manuscript received February 7, 1964.

plete system for ground-based automatic real-time optical space surveillance that has ever been undertaken (Fig. 1). It will become part of the Space Track network for detection and location of artificial satellites.

OPTICAL SURVEILLANCE SUBSYSTEM

The Optical Surveillance Subsystem (designated as AN/FSR-2) is a passive system; it uses sunlight reflected from the satellite as the source of energy and utilizes the motion of the satellite relative to the fixed-star background for its detection.

The AN/FSR-2 consists of: 1) a large-aperture, wide-field telescope, 2) a three-axis mount, 3) twelve image-orthicon cameras, 4) video processing channels, including 24 electrostatic storage tubes for signal integration and star cancellation, and 5) a general-purpose digital computer for data association and reporting. Except for initial program selection, *nowhere in the system is the human used in the direct detection and reporting process* either for control, inspection of gathered data, or evaluation of results.

Fig. 2 shows the major components of the system. The telescope-mounted camera heads contain integral video preamplifiers, with the remainder of the camera chains located in the rotary racks below (Fig. 1). Video signal integration for enhanced signal-to-noise ratio is accomplished in electrostatic storage tubes; these tubes and their associated circuits are located in the main operations room. Velocity filtering is done in a fast and a slow channel for expanded dynamic range. In the fast channel, electrostatic storage tubes are used in a unique *write-to-equilibrium* mode in which a single beam is used for simultaneous writing and reading; video comparison is performed directly on the tube and registration is automatic. The slow image-motion processor uses a 14-disc magnetic storage data file for large, long-time storage capacity; access time is 0.2 seconds. The computer interface unit provides buffering for signals entering and leaving the computer and for system timing, as well as the usual keyboard and tape input-output apparatus. A commercial general-purpose digital computer is used for system computation. The synchronizer provides system timing and assigns x and y coordinate values to video signals.

TELESCOPE

The telescope and mount are designed and built by the Perkin-Elmer Corp., Norwalk, Connecticut. The telescope is a Baker-Schmidt design having a spherical primary mirror with three corrector plates of relatively close spacing, optically located near the center of curvature of the primary mirror. The resulting spherical image surface normally embodied in this class of telescope is located midway between the primary mirror and the trio of corrector plates; in this instance, it is made available to complex detection apparatus in a form not previously employed, as far as we know. The optical path has been folded along a diagonal plane approximately through the primary focal surface by virtue of a flat mirror with a central hole. The spherical image surface is coherently conducted through this central hole, dissected into twelve equal, square formats—and then distributed still coherently to the several flat faceplates of the twelve conveniently separated image-orthicon camera heads. This image dissection, distribution, and flattening is done by a multiple fiber-optic bundle assembly.

The large size of the telescope together with a requirement for rapid indexing to desired pointing directions make necessary the use of lightweight materials and low rotary inertias about the rotational axes; the optical folding mentioned previously aids the second cause. Weight reduction is achieved in the primary mirror by use of fused quartz egg-crate construction; strips of fused quartz notched halfway through are overlaid both top and bottom by a solid slab of fused quartz. The whole assembly is fired once in flat form to fuse the joints; then, it is fired again, but over a hollowed-out graphite mold

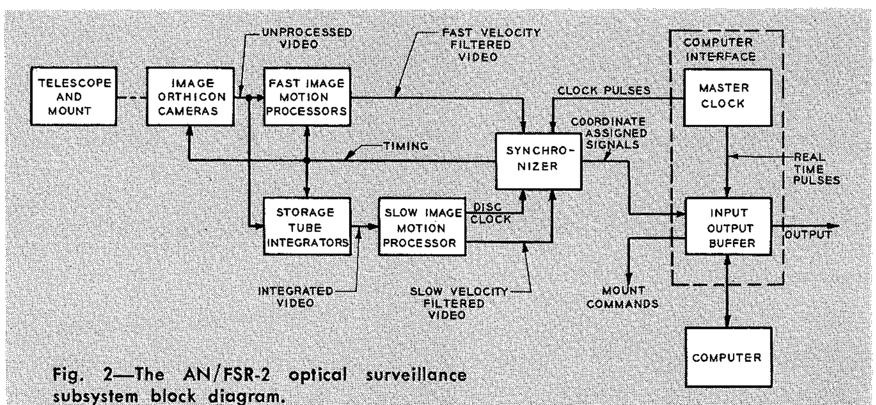
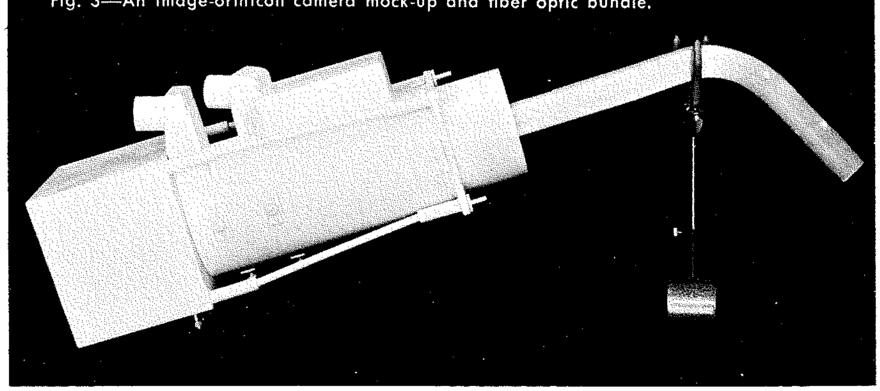
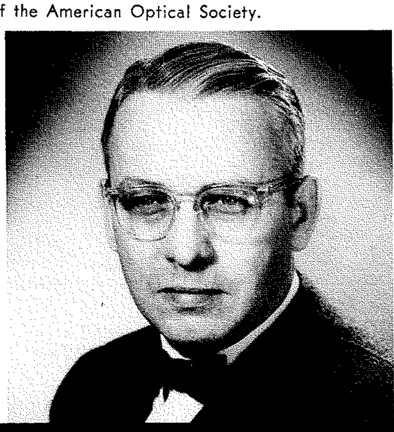


Fig. 2—The AN/FSR-2 optical surveillance subsystem block diagram.

Fig. 3—An image-orthicon camera mock-up and fiber optic bundle.



CHARLES B. PARK studied meteorology at U.C.L.A. and became an Air Force Meteorologist in World War II; he returned to study at Northeastern University and received his BSME in 1948, and took graduate courses in Electrical Engineering thereafter. Early engineering experience includes design of electromechanisms related to computer terminal equipment, high-speed page printers, cryptographic devices, and miniature card punchers and readers. In 1956 Mr. Park joined the Military Systems Division of the Electronics Corporation of America as Project Engineer on electro-optical and infrared equipment development programs. Since joining RCA in 1959, he has served as Senior Project Engineer in a program to develop long wavelength extrinsic infrared photo conductors and techniques for precision tracking of "cold" spaceborne targets over long ranges. He was assigned an engineering project to develop an infrared sea-surface tracking radiometer for the detection of small thermal gradients generated by sea-going vessels. He is currently an Engineering Scientist on the AN/FSR-2 development program and is responsible for the technical performance of the telescope and mount. Mr. Park is a member of the American Optical Society.



where it is allowed to sag into the spherical shape dictated by the mold. Then, the resulting blank is manipulated through the various finishing phases just as a solid blank; its weight is about a quarter of that of a corresponding solid blank. The mirror is mounted with gravity-actuated counterweights to maintain its figure.

In considering materials for the folding flat mirror, another problem arose: The flat mirror separates the principal volume of the telescope barrel with all of the optical elements operating at local outdoor temperatures (down to —11°F) from the area containing the twelve orthicon cameras operating at 72°F. Heat exchange was minimized by insulation and heat-reflecting panels; however, a residual rate of heat exchange from the cameras to the folding flat mirror was unavoidable. To limit the thermal gradients and, therefore, distortions induced in the flat mirror by the heat exchange, a material of high thermal conductivity was desirable. Of the very few metals that have been found at all suitable for optical applications, beryllium, proved to have the required characteristic. The most pertinent index of merit for judging materials in this case was the stiffness-to-weight ratio; beryllium proves to have a remarkably high value. Calculations showed that a flux of 800 watts of heat could be transferred by a beryllium mirror without exceeding tolerance limits on the flatness of the surface. Consequently, the mirror is fabricated from a solid slab of beryllium, lightened by boring multiple blind holes into the back side. The mirror is coated on the reflecting side with Kanogen, an amorphous coating of nickel-nickel-phosphorous composition. The reflecting surface is ground and polished much the same as on glass. This mirror is thought to be the largest optical element to be made of beryllium.

The telescope "barrel" is highly unconventional; it is similar to a triangular prism having the three main optical elements: corrector cell, folding-flat, and primary mirror, located one on each face of the prism. This housing is fabricated entirely of Invar for thermal stability. The optical portion of the telescope will be sealed and filled with dry nitrogen.

FIBER OPTICS

The image fiber-optic bundle assembly represents an advance in the art of fabrication of such devices with respect to total optical-path length and volume of glass used. The spherically polished input end is 2.8 x 8.4 inches in area. It is divided into twelve contiguous square areas from which individual bundles fan out to the twelve orthicon camera locations. The individual fiber bundles are 1.4 inches square and are fabricated from 400 hexagonally shaped sub-bundles; each sub-bundle contains about 18,000 individual clad fibers. The sub-bundles are laid up in a square, channel-shaped holding fixture and are fused in an oven to form solid glass bars 20 inches long; each bar contains about 7,000,000 fibers. These square glass bars are then reheated and bent against forming tools into predetermined shapes. The twelve individually shaped bundles are then epoxy-cemented into a single assembly and the spherical radius is ground and polished on the common end. The entire assembly has 234 inches of coherent optical path length, 460 cubic inches of glass and contains 83,000,000 individual fibers.

The final optical element in the system is the fiber-optic faceplate of the image orthicon. The tube itself is similar in every respect to the RCA 8093-A, except for the faceplate; it was selected after tests were performed on a large number of tube types under simulated operating conditions. The selection criteria were resolution and good performance with point images of low level in the presence of night sky background. A typical fiber optic bundle and image orthicon camera package mock up are shown in Fig. 3.

MOUNT

The telescope mount represents a departure from the several existing forms of large instrument mounts. It can be classed as an astronomical mount, since its lowest axis, a polar axis, rotates continuously at sidereal rate during operation. The bearing for this axis is a ball-joint formed by a single precision hemispherical shell nearly 5 feet in radius and by four hydrostatic oil pads supporting the 7 tons of moving mass. The hemispherical form allows rotation about any polar axis over a range of latitudes from 45° south to 45° north. For installation at a given latitude, it is constrained to rotate about the local polar axis by a non-load-carrying pivot bearing whose axis points northward through the center of radius of the main hemispherical bearing. Thus, we have a sidereal platform on top of which is supported a more conventional azimuth elevation mount. The azimuth platform is a steel weldment ring, 10 feet in diameter, supported by a hydrostatic oil bearing carrying 7,000 pounds. Two elevation uprights are mounted on the azimuth ring with a distance between uprights of 5½ feet; ball bearings are used on the elevation axis. The telescope scans continuously in discrete steps in azimuth and from 11° to 89° in elevation. The azimuth and elevation drive motors are hydraulic for rapid slewing of the telescope.

The telescope and mount are supported on a 20-foot-high reinforced concrete tower which is isolated from the building proper and is protected by a 16-foot astrodome. In a room within the tower, immediately below the telescope, are two racks of electronics circuits; these racks are supported on a rotary turntable and are rotated with the azimuth ring of the telescope through a servo-link. Electronics racks contain camera power supplies, common deflection amplifiers, camera controls, and output video amplifiers. Power inputs and amplified video outputs are done through an assembly of 72 slip-rings. A coaxial rotary air joint carries cooling air to and from the cameras; a two-way rotary hydraulic joint handles the supply and return oil for the hydraulic elevation drive motor.

Housing for the sysem is a modified FPS-16 radar building on a 9,000-foot mountain at Cloudcroft, New Mexico. Particular effort has been made to preserve good "seeing" conditions in the vicinity of the building by low-velocity diffusion of exhaust air from the air conditioning system into large volumes of ambient air for maximum mixing and minimum temperature gradient.

CONCLUSION

The AN/FSR-2 real-time optical-surveillance subsystem was originally to be comprised of off-the-shelf components; however, it is seen to embody many advances in device technology ranging from telescope and optical-component design to a new image-orthicon and advanced video data-processing techniques.

It is anticipated that the system will not only provide real-time surveillance, but will open a new era of automatic recording and processing for astronomical investigation.

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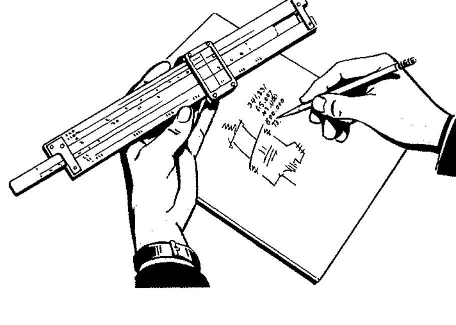
Engineering and Research NOTES

BRIEF TECHNICAL PAPERS OF CURRENT INTEREST



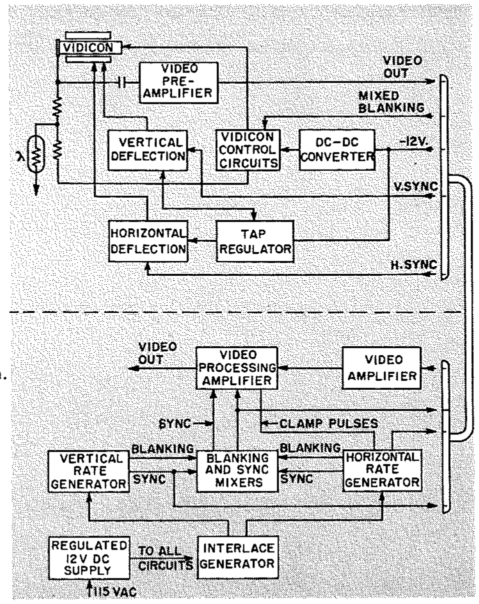


Fig. 2—Camera chain.

An Experimental Low-Power Vidicon Camera Chain

L. A. Boyer, F. L. Hatke, L. E. Flory, J. M. Morgan, and W. S. Pike, *RCA Laboratories, Princeton, N.J.*

Final manuscript received May 7, 1964

Fig. 1—(l. to r.) Authors W. S. Pike (holding monitor), L. A. Boyer, F. L. Hatke, J. M. Morgan, and L. E. Flory (holding camera). Control unit is in center of table.

The RCA 8134 Vidicon is a recent development in television pickup tubes. Using electrostatic focus and magnetic deflection, it requires no bulky focus coil and needs only about 25% of the deflection power required for a standard vidicon. These characteristics make possible the construction of a compact, transistorized camera chain with good resolution and very low power input (Figs. 1, 2, 3).

In Fig. 2, the blocks above the dotted line are in the camera; those below, in the control unit. The two units are interconnected by a cable comprising 4 coaxial cables and 6 wires. From the control unit, a single coaxial cable provides composite video to the monitor. In addition to the vidicon deflection circuits, the camera proper contains the video preamplifier, vidicon control circuits, and a DC-DC converter which provides the vidicon high voltage.

The control unit contains a regulated 12-volt DC supply, the main video amplifier, a video processing amplifier, interlace generator, horizontal and vertical rate generators and blanking and sync. mixers. Space is provided for a modulated oscillator to supply RF output on one of the VHF channels so that standard TV receivers may be driven directly by the chain, if desired. Use of the interlace generator is optional; if omitted, the horizontal and vertical oscillators run free at their proper frequencies.

The following objectives were set for the design of the camera chain: 1) *low input power;* 2) *500-line resolution;* 3) *a single camera cable;* and 4) *a reduced number of operating controls.* Power consumption of the camera is 7½ watts. The companion monitor requires about 30 watts. These low figures are possible partly because of extensive use of Class B deflection circuits. In the camera, both horizontal and vertical deflection circuits are of this type. In the monitor, only the vertical deflection is of this type. The horizontal deflection is generated by a switching circuit which also generates the ultor voltage (12kv) for the kinescope. This circuit follows a design by R. M. Cohen at RCA, Somerville. Adequate deflection and ultor voltage is provided while working in the safe operating range of the output transistor.

Exclusive of the power switch, the camera has only two operating controls; *video gain* and *black level.* All other controls are concealed screwdriver adjustment.

It is envisaged that in the industrial environment for which this camera has been developed, the simplicity of the controls will be attractive to unskilled personnel. The concealed controls will be used for set-up purposes only and adjusted by skilled service personnel.

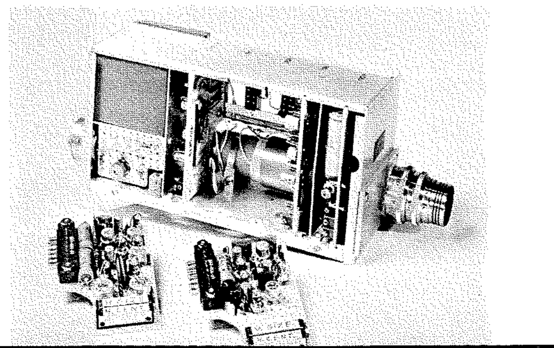
Certain novel circuit features may be of interest. Notable among these are the camera deflection circuits. Vertical and horizontal sawtooth voltages are generated in the control unit and fed to the camera via coaxial cables. In the camera a pair of Class B deflection amplifiers drive the yoke. Linearity is achieved by current feedback. The output stage of each deflection amplifier is direct coupled to its yoke winding. The low side of each yoke winding is returned via a current sampling resistor to a low impedance tapping point on the regulated 12-volt DC supply. The tapping point is established by an active circuit called the tap regulator. The latter is basically another Class B amplifier with a large amount of negative voltage feedback from its output to its input.

Electrical centering is readily provided by this arrangement. Each deflection amplifier includes a potentiometer which adjusts the DC level of its output terminal. In each amplifier this point may be made either positive or negative with respect to the tap regulator terminal to which the low side of each deflection coil is returned, thus providing centering in either direction. Another advantage of this scheme is that as the deflection amplifiers are aperiodic, the camera could readily be modified for nonstandard scanning rates.

A scene brightness sensing circuit is provided by a photoconductive cell located behind an aperture in the front plate of the camera. The cell adjusts the vidicon target voltage to a value appropriate to the average scene illumination. Correct compensation may be obtained over a variation in light level of at least 100:1. Optionally, the automatic target voltage control circuit may be disabled by means of a switch, if desired.

The question of video-amplifier noise in transistorized cameras is perennially raised whenever a new design appears. The original version of this camera used a silicon input transistor (2N2102) followed by a germanium "drift" transistor (2N1396) in a feedback

Fig. 3—Camera



circuit. This preamplifier was flat to 5 Mc. Noisewise, it was worse than a good vacuum-tube cascode preamplifier by no more than 2:1. More recently, field effect transistors of improved transconductance and low noise have appeared commercially. These units make possible performance equal to that obtainable with tubes.

The mechanical construction is shown in Fig. 3. Merely as a matter of laboratory convenience, printed wiring has not been used on the various circuit cards, although printed wiring would be attractive in a production version. Note the special shape of the camera cards which fit around the vidicon. As the DC-DC converter has stringent electrostatic and magnetic shielding requirements, it is not card mounted. It is in the enclosure at the extreme rear of the camera.

In conclusion, the RCA 8134 Vidicon coupled with modern transistorized circuits, permits the design of a very compact, low power TV chain of excellent performance equal in every way to that obtainable with magnetically focussed pickup tubes.

New Technique Measures Linearity to 0.1% in Nimbus TV System

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Final manuscript received May 15, 1964

The high performance capabilities incorporated in the Advanced Vidicon Camera System (AVCS) for the NIMBUS meteorological satellite exceeded state-of-the-art for television equipment in several areas. The design goal of a maximum sweep linearity error of ±0.5% was achieved. Because of this low value of maximum sweep linearity error, no equipments or techniques were available to measure that parameter to the desired accuracy of ±0.1%. The existing methods involved measurements made on a kinescope display. However, a technique for making linearity measurements using the video signal at the output of the camera was desirable to eliminate inaccuracies of the display device. Consequently a direct camera-output-measurement approach was selected.

Selection of Reticle: To obtain these measurements, a precise dimensional reference was placed in the image presented to the vidicon photoconductor, as shown in Fig. 1 (not including dimensions *A*, *B*, and *C*). The pattern is oriented parallel to the direction of sweep. The pairs of reticle marks on the faceplate were spaced with an error of no more than ±0.0001 inch in an overall reticle dimension of 0.384 inch on a side. The overall raster dimension of 0.440 inch on a side, slightly greater than the reticle geometry, is used as the reference for calculation of linearity errors. Thus the maximum spacing error for the reticle pattern is 1 part in 4,400 or better than 0.025%.

Linearity Measurement Technique: The technique selected for linearity measurement of the camera video output involves selective line sampling. In general, the method is to accurately measure the time interval between adjacent pairs of reticle lines in both the horizontal and the vertical direction as they appear in the video. A shift in the level of the video was to be introduced during the sample time in order to produce a marker in the kinescope display indicating the location of the sample.

The sampling scheme for horizontal linearity measurement is shown as dimension *C* of Fig. 1. A portion of a preselected line of video is gated to a time interval counter. As the vidicon beam passes the vertical reticle line, a pulse appears in the video rising toward "black." (The input image to the camera is a flat white field for all linearity measurements.) As the beam traverses the second reticle line a similar pulse is generated. The electronic time interval counter is then employed to measure the time interval between this pair of pulses.

The vertical linearity measurement is made in a similar fashion except a much shorter portion of a number of horizontal raster lines is selected as shown as dimensions *A* and *B* of Fig. 1. A "black" pulse is generated ideally only for those lines of video that traverse the horizontal portion of the desired pair of reticles and only during the sample period.

Equipment Function: The equipment setup shown in Fig. 2 was evolved to accomplish the measurement of time interval between reticle pairs in the camera video output. Camera video is fed into

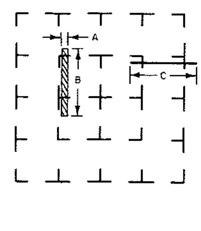

Fig. 1—Reticle pattern.

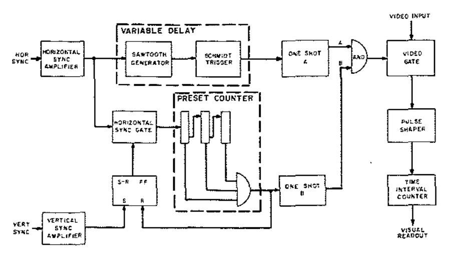

Fig. 2—Linearity Tester.

the video gate for the complete frame readout. The presence of an enable signal on both of the AND-gate inputs provides processed video to the interval counter for the desired sample time period.

Enable input A is generated for the time required to gate one pair of reticle spikes. This input is present for a selected portion of every TV line. Enable input B is present only during a predetermined raster line (line number 1 thru 999). Thus for only a portion of one preselected line in the raster are both inputs *A* and *B* present simultaneously.

Input *A* is generated by the one-shot *A* (monostable multivibrator) set to provide the desired gate pulse time (approximately equal to one-fourth of a TV line interval). The trigger is derived from delayed horizontal sync. The variable delay was provided as shown. A sawtooth generated at the horizontal rate from camera sync is directly coupled to a Schmidt trigger. Adjustment of threshold voltage for the latter varies the time delay for the sample gate trigger from the start of camera horizontal scan.

Input *B* is generated by the one-shot *B* set to provide the proper gate pulse time (equal to one horizontal line interval). The trigger is supplied by the *preset* counter output. The *preset* counter functions as a line selector by counting horizontal sync pulses until they are equal to the count set manually in the preset counter. On the *preset* count, a *reset* trigger is supplied to the *S-R (set-reset)* flip flop and one shot *B* is triggered. The *preset* counter resets automatically.

The *S-R* flip flop functions as a gating input to the horizontal sync gate. When *S-R* is in *reset* state, horizontal sync pulses are blocked by the sync gate. The *set* input to *S-R* is derived from vertical sync, indicating the start of a frame; and at that time horizontal sync is applied to the input of the *preset* counter. The video gate passes clipped video when an *enable* input is present. The video white excursion is limited by the clipper in order to eliminate noise riding on the signal. The time interval counter provides a visual readout of the time between the selected pairs of reticle spikes. Variation of the raster line number and the time delay along each selected line allows time-interval measurements for each of the 20 pairs of reticles in the horizontal direction.

For vertical linearity measurements, the horizontal sample time is reduced as shown in Fig. 1, by changing the pulse duration of input *A* (one shot *A* time constant). The pulse duration of input *B* is increased to allow gating of the selected portion of a number of horizontal lines that includes a pair of reticles in the vertical direction.

Special processing of the video is required in order to make use of the time interval counter for vertical measurements. Since at least two consecutive lines of video contain reticle information for each of the reticle marks, the interval counter would be gated on and would prematurely terminate the count almost immediately after being triggered, while still on the first reticle mark. To avoid this condition, a one-shot is switched in series between the video gate and the interval counter. The duration of one-shot pulse is adjusted for a period of several horizontal lines. Thus the first line of video containing the desired reticle information triggers the one-shot. Lines immediately following with the same information are thus rejected by the one-shot. However, the one-shot is reset and ready to be triggered by the first video line containing information from the second reticle.

Variation of the raster line number and the horizontal delay allows measurement of the time interval between each of the 20 pairs of reticles in the vertical direction.

The 20 horizontal and 20 vertical time measurements are then used to calculate percent deviation from an ideal linear sweep. It has been found that the error measurements are repeatable within ±0.1%.

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Off-Axis Feedback Modes in a 3-Mirror Laser System

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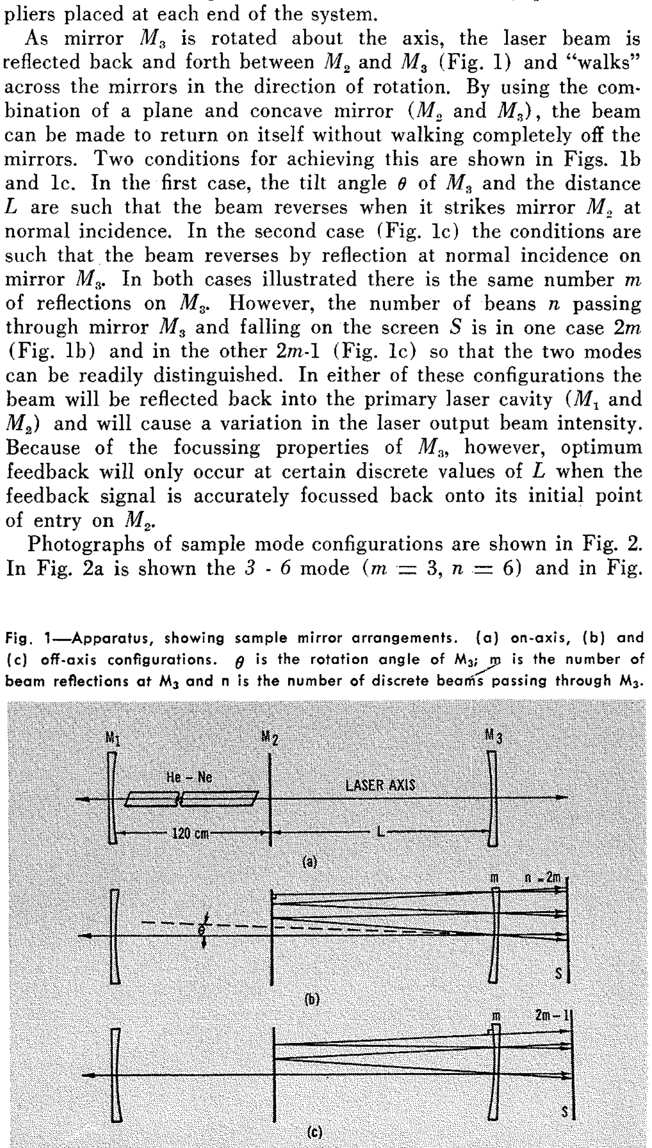
In the recent literature there have been several reports[1,2,3,4] on the use of helium-neon laser systems in which a third mirror is employed to reflect a portion of the laser output back into the laser. The usefulness of this technique for mode selection and modulation of the laser has been demonstrated and the potential advantages of this system for plasma diagnostics have been illustrated. In all of these investigations, the axis of the third mirror has been aligned along the axis of the primary laser (Fig. 1a). This *Note* shows that significant feedback effects can also be obtained for certain mirror configurations even when the third mirror is tilted at an appreciable angle to the laser axis.

The arrangement of the apparatus is shown schematically in Fig. 1. The three mirrors have reflectivities at 6,328 angstroms of about 99%. Mirrors M_1 and M_3 are spherical surfaces with a radius of curvature of 126 cm; M_2 is a plane mirror with an anti-reflection coating on the surface facing M_3 and the high reflectivity coating on the other. A He-Ne discharge tube (with Brewster angle windows) is aligned between M_1 and M_2 to provide the laser oscillation, and M_3 is mounted so that it can be rotated about an axis normal to the laser axis. Mirrors M_1 and M_2 are positioned so that the primary laser is operating in the lowest axial mode in an approximate hemispherical configuration. In the present experiments, the separation L of the third mirror could be varied between about 7 and 35 cm. The intensity of the output beam from either M_1 or M_3 could be monitored by photomultipliers placed at each end of the system.

As mirror M_3 is rotated about the axis, the laser beam is reflected back and forth between M_2 and M_3 (Fig. 1) and "walks" across the mirrors in the direction of rotation. By using the combination of a plane and concave mirror (M_2 and M_3), the beam can be made to return on itself without walking completely off the mirrors. Two conditions for achieving this are shown in Figs. 1b and 1c. In the first case, the tilt angle θ of M_3 and the distance L are such that the beam reverses when it strikes mirror M_2 at normal incidence. In the second case (Fig. 1c) the conditions are such that the beam reverses by reflection at normal incidence on mirror M_3. In both cases illustrated there is the same number m of reflections on M_3. However, the number of beans n passing through mirror M_3 and falling on the screen S is in one case $2m$ (Fig. 1b) and in the other $2m$-1 (Fig. 1c) so that the two modes can be readily distinguished. In either of these configurations the beam will be reflected back into the primary laser cavity (M_1 and M_2) and will cause a variation in the laser output beam intensity. Because of the focussing properties of M_3, however, optimum feedback will only occur at certain discrete values of L when the feedback signal is accurately focussed back onto its initial point of entry on M_2.

Photographs of sample mode configurations are shown in Fig. 2. In Fig. 2a is shown the *3 - 6* mode ($m = 3$, $n = 6$) and in Fig.

Fig. 1—Apparatus, showing sample mirror arrangements. (a) on-axis, (b) and (c) off-axis configurations. θ is the rotation angle of M_3; m is the number of beam reflections at M_3 and n is the number of discrete beams passing through M_3.



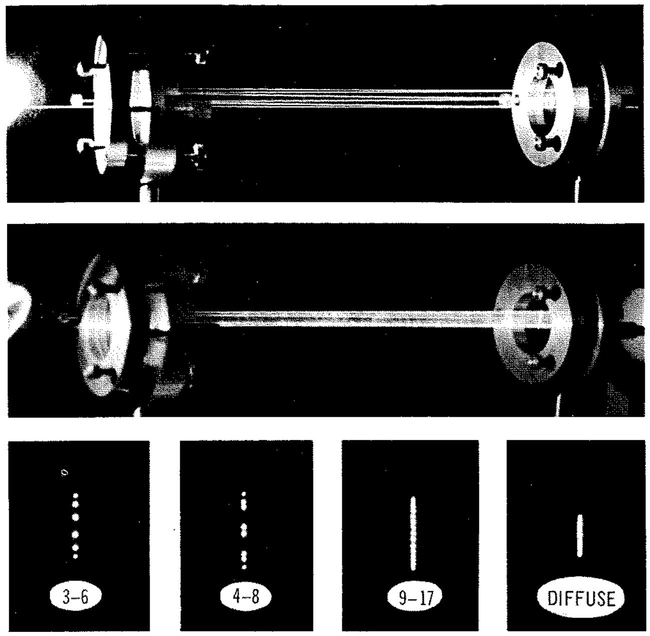


Fig. 2—Photographs showing (a) the 3-6 mode, (b) a "diffuse" mode for $L = 29.5$ cm and (c) sample multiple beam output configurations. (a) and (b) were photographed by introducing smoke into the M_2, M_3 cavity and (c) was obtained by photographing the images on screen S (Fig. 1). Note image of the diffuse beam on screen in (b).

2b, a *diffuse* mode. These diffuse modes appear to be very high order or defocussed modes of the system and their structure could not be resolved with the present apparatus. These off-axis modes have several features of importance. They offer a method of controlling the feedback level in the 3-mirror feedback system by a very simple angular adjustment of the third mirror. Since the mirror rotations involved can be fairly large (up to about ½° in the present experiments) the feedback adjustment can be made without the need of high precision control. The present results also show that even when it is desired to operate with $\theta = 0$ in the on-axis configuration, errors arising from mirror misalignment can be minimized by selecting an L value of a low order mode where the feedback varies only slowly with θ.

In addition, the off-axis modes provide a large increase in the volume traversed by the beam within the M_2, M_3 cavity (see Fig. 2a and 2b). This feature could be useful in plasma diagnostic applications or in making more efficient use of an active laser medium. It may be possible to improve the performance of a conventional 2-mirror laser cavity by employing such off-axis mode configurations thereby reducing the "saturation" effects. For this application two curved mirrors could be utilized so that off-axis modes are generated in two dimensions on the mirror surfaces—as compared with the linear arrays generated in the present system (Fig. 2c).

Finally, it is worth noting that with the off-axis feedback it is possible to obtain a multiple beam output through Mirror M_3. In Fig. 2c sample distributions are shown for several modes. These were photographed on the screen S (Fig. 1) and show that various beam configurations ranging from the single normal beam up to a "ribbon" type beam several centimeters wide can be produced. Also the focussing effects of M_3 are seen in Fig. 2c by the variations in the spot sizes. The component beams of the multiple output are all "locked" in both phase and amplitude by the feedback mechanism and this property could be of value for several applications.

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The Possibility of a High-Gain, Solid-State Microwave Amplifier

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Research on the properties of electron-hole plasmas in semiconductors has been underway for several years at the David Sarnoff Research Center, Princeton, New Jersey, and in Laboratories RCA, Inc., Tokyo. The ultimate objective has been the generation and amplification of microwave power. Several new types of plasma oscillations, extending in frequency up to about 100 Mc, have been discovered and studied. There has now been a major increase in the attainable frequency; radiation has been generated over a broad frequency spectrum extending to about 40,000 Mc. Furthermore, if our present concepts are correct, the new effect could ultimately provide broad-band, very-high-gain solid-state amplifiers at these gigacycle frequencies.

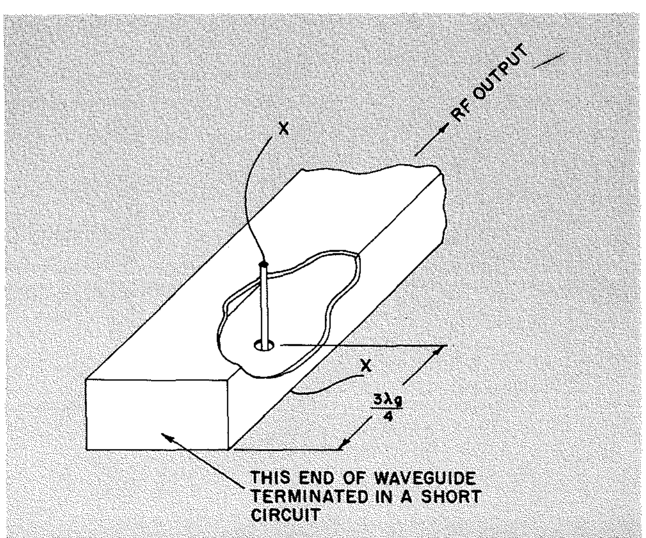
This radiation can be generated relatively simply. A bar of indium antimonide, about 20 mils square and ½-inch long, is cooled with liquid nitrogen and mounted in a waveguide used to carry the RF energy to a receiver. A pulse current of several amperes is passed through the semiconductor bar while it is subjected to a magnetic field of at least 3,000 gauss in the plane perpendicular to the axis of the waveguide. As a result, microwave energy is generated in a spectrum that extends from at least 2,000 Mc to above 40,000 Mc. The total power generated throughout the spectrum is approximately 10 mw.

The theory of the effect, while far from complete, accounts moderately well for the experimental observations. In brief, the device is basically an amplifier; the electronic noise in the plasma is amplified by an interaction with the pulse current. The calculated amplification is extremely high—about a billion times. When this amplification factor is applied to the plasma noise power (easily determined by conventional theory), the total output power is gratifyingly close to the 10 mw measured.

We are far from having a practical device. Above all, a way must be found for introducing an input signal into the semiconductor that is much larger than the plasma noise. If this can be done, both the original noise and the amplified noise should be negligible and the desired high-gain, broad-band, solid-state amplifier would be realized. Such an amplifier would probably be usable only in pulse applications, for it may not be practicable to cool the indium antimonide bar sufficiently to permit the continuous flow of the high currents required.

Even at the present stage of this work, it is very encouraging to have obtained power at 40,000 Mc and to have uncovered a new method of amplification at this frequency by use of a simple bar of semiconductor that has no critical dimensions.

Fig. 1—"Cut-out illustration" of the indium antimonide bar mounted as an inductive post in a dominant mode waveguide. One end of this waveguide is terminated 0.75 guide wavelengths away from the post position in a short circuit. When this post is placed in a DC magnetic field and a voltage is applied across the lead wires marked "X," microwave power is generated by the bar and propagates down the waveguide as indicated.



On The Optimization of Random-Access, Discrete-Address Communications

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Final manuscript received May 21, 1964

The concept of RADA communications is receiving increased attention. In such systems, a major cause of performance degradation is self-interference from random combinations of undesired signals fortuitously generating a desired address. In this *Note*, an optimum system parameter adjustment is determined such that, for a specified number of active subscribers and an allotted system bandwidth, the probability of falsely generating a desired address is minimized. A general result is then obtained.

An address code consists of a time-frequency matrix of n pulses arbitrarily distributed among p address channels (or wires) and placed in j time positions. In general, there are no constraints between the positive integers n, p, and j. Each pulse is assumed rectangular with width t, and the address code as an entity is transmitted with an average period T. Similarly, M interfering codes are transmitted asynchronously by active subscribers. At the receiver, the desired address code is recognized by introducing complementary delays in those channels utilized by the desired address and observing an n-fold coincidence of pulses at the delayed outputs. Phase cancellation of pulses is ignored. Thus, the analysis which follows is representative of carrier systems which employ a central transmitter, or cable systems which employ video pulses.

It is convenient to define a system load factor:

$$\lambda = \alpha n = \frac{Mnt}{pT} \tag{1}$$

The load factor λ is the mean number of interfering pulses per pulse width on each of the p channels. A measure of the over-all system bandwidth is:

$$B = \frac{p}{t} \tag{2}$$

Owing to the asynchronous nature of subscriber transmissions, the arrival of pulses on each of the p independent channels follows a Poisson distribution; i.e., the probability that, at any instant, no pulse is in progress on any single channel is $\exp[-\lambda]$. Thus, the probability that all n elements of the desired address appear simultaneously and thereby generate a false address is:

$$\varepsilon = (1 - \exp[-\lambda])^n = (1 - \exp[-\alpha n])^n \tag{3}$$

(This result is independent of j and the particular delays which are used). It is of interest to minimize ε with respect to n, a design parameter. Taking $d\varepsilon/dn = 0$, and then re-substituting $-\lambda$ for $-\alpha n$ results in:

$$\lambda \exp[-\lambda] + (1 - \exp[-\lambda]) \ln (1 - \exp[-\lambda]) = 0$$

Substituting $x = \exp[-\lambda]$ and $\ln x = -\lambda$ into the equation above:

$$-x \ln x + (1 - x) \ln (1 - x) = 0,$$

It is evident that the solution is $x = ½$. Thus, the minimum false address probability results if:

$$\lambda_o = \ln 2 \tag{4}$$

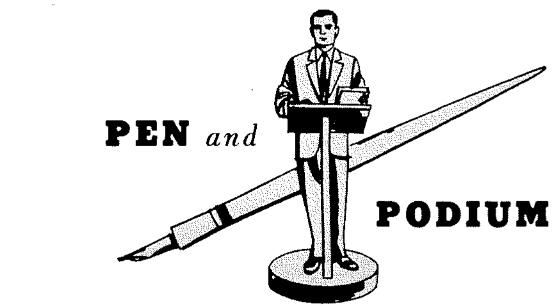
This is achieved when:

$$n = n_o = \frac{BT \ln 2}{M}$$

Physically, n is constrained to integer values, but by substituting Eq. 4 into Eq. 3, it is found that the minimum false address probability which is obtained through optimization is:

$$\varepsilon_o = 2^{-n_o} \tag{5}$$

This result leads to the interesting conclusion that *an optimized* RADA *communication system is one which is loaded such that each channel has a pulse in progress with probability of 0.5.* Intuitively, maximum information is transmitted when events are equi-probable. This suggests that, upon minimizing the false address probability, the mutual information exchange among the active subscribers has been maximized. *Can this be proven?*



A SUBJECT-AUTHOR INDEX TO RECENT RCA PAPERS

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3,142,765—Tunnel Diode Voltage Multiplier, July 28, 1964; C. M. Wine

3,142,766—Tunnel Diode Bipolar Pulse, July 28, 1964; C. M. Wine, J. C. Miller

3,142,823—Punchable Memory Card Having Printed Circuit Thereon, July 28, 1964; M. H. Lewin, J. A. Rajchman

HOME INSTRUMENTS DIV.

3,136,850—Television Receiver Cabinet, June 9, 1964; G. H. Blaker

3,140,444—Tuner, July 7, 1964; D. J. Carlson

BROADCAST AND COMMUNICATIONS PRODUCTS DIV.

3,141,065—Servo System, July 14, 1964; A. C. Luther, Jr., R. N. Hurst, J. R. West

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DATES *and* DEADLINES

PROFESSIONAL MEETINGS AND CALLS FOR PAPERS

Meetings

Sept. 17-18, 1964: SPECIALISTS CONF. ON INTEGRATED ELECTRONIC DEVICES, G-ED; Naval Post Grad. School, Monterey, Calif. *Prog. Info.:* J. A. Lesk, 6143 E. Exeter, Scottsdale, Ariz.

Sept. 17-18, 1964: 12TH ANN. ENG. MANAGEMENT CONF., IEEE-ASME, et al.; Pick-Carter Hotel, Cleveland, Ohio. *Prog. Info.:* J. Fox, PIB, 333 Jay St., Brooklyn 1, N.Y.

Sept. 22-24, 1964: ANTENNAS & PROPAGATION INTL. SYMP., G-AP; Intl. Hotel, Kennedy Intl. Airport, L.I., N.Y. *Prog. Info.:* Dr. H. Jasik, Jasik Labs., 100 Shames Dr., Westbury, N.Y.

Sept. 23-24, 1964: 13TH ANN. INDUSTRIAL ELECTRONICS SYMP., IEEE, PTG-IECI; Phila., Pa. *Prog. Info.:* IEEE Headquarters, Box A, Lenox Hill Station, N.Y. 21, N.Y.

Sept. 24-26, 1964: 14TH ANN. SYMP. ON BROADCASTING, G-B, Willard Hotel, Wash., D.C. *Prog. Info.:* S. Bergen, 103 Fairchester Dr., Fairfax, Va.

Sept. 25-26, 1964: 3RD CANADIAN SYMP. ON COMMS., Montreal Sec. IEEE and Region 7; Queen Elizabeth Hotel, Montreal, Que., Can. *Prog. Info.:* F. G. R. Warren, PO Box 802 Sta. B, Montreal, Que.

Sept. 25-26, 1964: 12TH ANN. CONF. ON COMMS., IEEE Cedar Rapids Sec.; Hotel Roosevelt, Cedar Rapids, Iowa. *Prog. Info.:* IEEE Headquarters, Box A, Lenox Hill Station, N.Y. 21, N.Y.

Sept. 28-29, 1964: 1ST INTL. CONGRESS ON INST. IN AEROSPACE SIMUL. FACILITIES, G-AS, AGARD; Paris, France. *Prog. Info.:* P. L. Clemens, VKF/AB, Arnold Air Force Sta., Tenn.

Sept. 28-30, 1964: ALLERTON CONF. ON CIRCUIT & SYS. THEORY, Univ. of Ill., G-CT; Conf. Center, Univ. of Ill., Monticello, Ill. *Prog. Info.:* Prof. W. R. Perkins, Dept. of EE, Univ. of Ill., Urbana, Ill.

Sept. 28-30, 1964: NATL. CONF. ON TUBE TECHNIQUES, Office of the Director of Defense, Research and Engineering; W. Union Auditorium, 60 Hudson St., N.Y. *Prog. Info.:* Program Sec'y, D. Slater, Advisory Group on Electron Devices, 346 Broadway, 8th Floor, N.Y., N.Y.

Sept. 29, 1964: NUCLEATION, GROWTH, AND STRUCTURE OF THIN FILMS, American Vacuum Soc. Thin Film Div.; Chicago, Ill. *Prog. Info.:* S. P. Wolsky, P. R. Mallory & Co., Burlington, Mass.

Sept. 30-Oct. 2, 1964: 11TH NATL. VACUUM SYMP., American Vacuum Soc.; Pick-Carter Hotel, Chicago, Ill. *Prog. Info.:* Dr. G. H. Bancroft, Bendix-Balzer Vacuum Co., Ind., 1645 St. Paul St., Rochester, N.Y.

Oct. 5-7, 1964: 10TH ANN. COMMS. SYMP., G-ComTech.; Utica, N.Y. *Prog. Info.:* J. L. Ryerson, Code EMC, RADC, Griffiss AFB, Rome, N.Y.

Oct. 5-7, 1964: RADIATION EFFECTS IN ELECTRONICS, American Nuclear Soc., American Soc. for Testing & Matls.; Syracuse, N.Y. *Prog. Info.:* T. J. Csermely, Carrier Res. and Dev. Co., Carrier Parkway, Syracuse, N.Y.

Oct. 6-9, 1964: INTL. SPACE ELECTRONICS SYMP., G-SET; Dunes Hotel, Las Vegas, Nev. *Prog. Info.:* Dr. O. L. Tiffany, The Bendix Corp., Ann Arbor, Mich.

Oct. 6-13, 1964: HAZARD AND RACE PHENOMENA IN SWITCHING CIRCUITS; IEEE, AIAA, ISA, ASME; Bucharest, Roumania. *Prog. Info.:* Prof. E. J. McCluskey, Jr., EE Dept., Monsanto Chem. Co., 800 N. Lindbergh Blvd., St. Louis 66, Missouri.

Oct. 11-14, 1964: 1964 FALL URSI-IEEE MTG., URSI-IEEE; Univ. of Ill., Urbana, Ill. *Prog. Info.:* Prof. E. C. Jordan, Dept. of EE, Univ. of Ill., Urbana, Ill.

Oct. 12-14, 1964: ENTRY TECHNOLOGY, American Inst. of Aeronautics & Astronautics; Williamsburg, Va. *Prog. Info.:* AIAA, 500 5th Ave., N.Y. 36, N.Y.

Oct. 12-14, 1964: INTL. LASER PHYSICS AND APPLICATIONS, Institut fur angewandte Physik der Universitat, Bern, Commission Suisse d'Optique Photonique et d'Optique Electronique; Bern. *Prog. Info.:* R. Dandliker, U. of Bern., Dept. of App. Physics, Sidlerstrasse 5, Bern, Switzerland.

Oct. 12-15, 1964: 19TH ANN. ISA CONF.; New York City. *Prog. Info.:* H. Tyler Marcy, Vice Pres., Intl. Business Machines Corp., White Plains, N.Y.

Oct. 14-16, 1964: GASEOUS ELECTRONICS, American Physical Soc., Army Electronics Res. and Dev. Lab.; Atlantic City, N.J. *Prog. Info.:* S. Schneider, Hq., AERDL, Ft. Monmouth, N.J.

Oct. 14-16, 1964: 1964 SONICS AND ULTRASONICS SYMP., IEEE; The Miramar Hotel, Santa Monica, Calif. *Prog. Info.:* R. L. Rod, Acoustical Assocs., Inc., 5331 W. 104th St., Los Angeles, Calif.

Oct. 15-16, 1964: SYSTEMS SCIENCE CONF., SC-TC, Univ. of Pa.; Univ. of Pa., Phila., Pa. *Prog. Info.:* A. R. Teasdale, Martin Co., Friendship Intl. Airport, Md.

Oct. 19-21, 1964: NATL. ELECTRONICS CONF., IEEE, et al.; McCormick Pl., Chicago, Ill. *Prog. Info.:* Dr. W. B. Boast, EE Dept., Iowa State Univ., Ames, Iowa.

Oct. 21-23, 1964: E. COAST CONF. ON AEROSPACE & NAVIG. ELEC. (ECCANE); Emerson Hotel, Baltimore, Md. *Prog. Info.:* R. Allen, Martin Co., Mail #683, Baltimore 3, Md.

Oct. 21-24, 1964: ACOUSTICAL SOC. OF AMERICA; Austin, Tex. *Prog. Info.:* C. P. Boner, Univ. of Tex., Univ. Sta., Austin, Texas.

Oct. 27-29, 1964: FALL JOINT COMPUTER CONF., AFIPS (IEEE-ACM); Civic Center, San Francisco, Calif. *Prog. Info.:* D. R. Brown, Stanford Res. Inst., Menlo Park, Calif.

Oct. 28-30, 1964: 11TH NUCLEAR SCIENCE SYMP.—INSTRUM. IN SPACE & LABORATORY, G-NS; Phila. Sheraton, Phila., Pa. *Prog. Info.:* W. A. Higinbotham, Brookhaven Natl. Lab., Upton, L.I., N.Y.

Oct. 29-30, 1964: ELECTRON DEVICES MTG., G-ED; Sheraton-Park, Wash., D.C. *Prog. Info.:* R. W. Peter, Watkins-Johnson Co., 3333 Hillview Ave., Palo Alto, Calif.

Calls for Papers

Dec. 21-23, 1964: AMERICAN PHYSICAL SOC.; Berkeley, Calif. **Deadline:** Abstracts, **10/16/64.** *TO:* W. Whaling, Regional Sec'y, Calif. Inst. of Tech., 1201 E. Calif. St., Pasadena, Calif.

Jan. 5-8, 1965: SOLID-STATE PHYSICS; Inst. of Physics and Physical Soc.; U. of Bristol. **Deadline:** Abstracts, **11/20/64.** *TO:* D. A. Greenwood, H. H. Wills Physics Lab., Royal Fort, Bristol 8: Administration Assistant, IPPS, 47 Belgrave Sq., London, S.W. 1, England.

Jan. 6-8, 1964: 13TH ANN. INDUSTRIAL ELEC. AND CONTROL INSTRUMENTATION CONF., PTG IECI, ASME-ISA, Phila. Section; Phila., Pa. **Deadline info.:** IEEE Headquarters, Box A, Lenox Hill Station, N.Y. 21, N.Y.

Feb. 3-5, 1965: 6TH WINTER CONVENTION ON MILITARY ELECTRONICS, G-MIL, L.A. Sect.; Ambassador Hotel, Los Angeles, Calif. **Deadline Info.:** IEEE L.A. Office, 3600 Wilshire Blvd., Los Angeles, Calif.

Feb. 17-19, 1965: INTL. SOLID STATE CIRCUITS CONF., IEEE, G-CT, Univ. of Pa.; Univ. of Pa. & Sheraton Hotel, Phila., Pa. **Deadline:** Abstracts, **10/26/64.** *TO:* G. B. Herzog, RCA Labs., Princeton, N.J.

March 22-25, 1965: IEEE INTL. CONVENTION, All Groups TOC Committees; Coliseum & New York-Hilton, New York City, N.Y. **Deadline:** Abstracts, **10/16/64.** *TO:* Dr. E. L. Harder, IEEE Headquarters, Box A, Lenox Hill Station, N.Y. 21, N.Y.

Apr. 13-15, 1965: NATL. TELEMETERING CONF., IEEE, AIAA-ISA; Shamrock Hilton, Houston, Tex. **Deadline:** Abstracts, approx. **10/1/64.** *TO:* R. W. Towle, Philco Corp., Western Dev. Labs., 3825 Fabian Way, Palo Alto, Calif.

Apr. 14-15, 1965: 1965 ELECTRONICS & INSTRUMENTATION CONF. & EXHIBIT, IEEE & ISA, Cinc. Sect.; Cincinnati Gardens, Cincinnati, Ohio. **Deadline Info.:** IEEE Headquarters, Box A, Lenox Hill Station, N.Y. 21, N.Y.

Apr. 21-23, 1965: SOUTHWESTERN IEEE CONF. AND ELEC. SHOW (SWIEEECO), Region 5; Dallas Memorial Auditorium, Dallas, Tex. **Deadline:** Abstracts, approx. **10/1/64.** *TO:* E. F. Sutherland, Genl. Radio Co., 2501-A Mockingbird Lane, Dallas, Tex.

Apr. 21-23, 1965: 1965 INTL. NONLINEAR MAGNETICS CONF. (INTERMAG), IEEE; Sheraton Park Hotel, Wash., D.C. **Deadline Info:** E. W. Pugh, IBM Components Div., Poughkeepsie, N.Y.

May 5-7, 1965: 1965 MICROWAVE THEORY & TECHNIQUES SYMP., G-MTT; Jack Tar Harrison Hotel, Clearwater, Fla. **Deadline:** Abstracts, **11/15/64.** *TO:* J. E. Pippin, Sperry Microwave Elec. Co., Box 1828, Clearwater, Fla.

May 5-7, 1965: ELECTRONIC COMPONENTS CONF. (ECC), IEEE-EIA; Marriott Motor Hotel, Wash., D.C., **Deadline:** Abstracts, approx. **10/9/64.** *TO:* IEEE Headquarters, Box A, Lenox Hill Station, N.Y. 21, N.Y.

May 10-12, 1965: NAECON (NATL. AEROSPACE ELECTRONICS CONF.), G-ANE, AIAA, Dayton Section; Dayton, Ohio. **Deadline:** Abstracts, approx. **12/15/64.** *TO:* IEEE Dayton Office, 1414 E. 3rd St., Dayton 2, Ohio.

May 13-14, 1965: SYMP. ON SIGNAL TRANSMISSION AND PROCESSING, G-CT; **Deadline Info.:** IEEE Headquarters, Box A, Lenox Hill Station, N.Y. 21, N.Y.

May 24-29, 1965: IFIP CONGRESS '65, IFIP; New York Hilton, New York City, N.Y. **Deadline:** Abstracts **9/1/64.** *TO:* Dr. A. Householder, Oak Ridge Natl. Lab., Oak Ridge, Tenn.

June 7-9, 1965: INTL. SYMP. ON GLOBAL COMMS. (GLOBECOM VII), G-ComTech Denver, Boulder Section; Univ. of Colo. and NBS Labs., Boulder, Colo. **Deadline Info.:** R. C. Kirby, NBS, Boulder, Colo.

June 20-24, 1965: AEROSPACE TECH. CONF., G-AS, Houston, Section; Shamrock-Hilton, Houston, Tex. **Deadline:** Abstracts, **9/30/64.** *TO:* T. P. Owen, 635 20 St., Santa Monica, Calif.

June 22-25, 1965: JOINT AUTOMATIC CONTROL CONF., IEEE-ASME, AIChE, ISA; Rensselaer Polytech. Inst., Troy, N.Y. **Deadline:** Abstracts, **11/15/64.** *TO:* Prof. James W. Moore, Univ. of Va., Charlottesville, Va.

Be sure deadlines are met—consult your Technical Publications Administrator or your Editorial Representative for the lead time necessary to obtain RCA approvals (and government approvals, if applicable). Remember, abstracts and manuscripts must be so approved BEFORE sending them to the meeting committee.

Engineering NEWS *and* HIGHLIGHTS

RCA PROFITS AND SALES FOR FIRST HALF 1964 REACH ALL-TIME HIGH

RCA earnings during the second quarter of 1964 increased 32% over the same quarter last year to establish an all-time record for the period. RCA's operating earnings for the first six months of 1964 also established a record for the period, rising 28% over the first half of 1963. The second quarter was the 13th consecutive quarter in which profits were higher than those in the comparable period of the preceding year.

Sales for the 6-month period reached a record level of $899,100,000, up about 2% over the 1963 first-half total.

Operating earnings per common share for the first half were 69¢ after taxes, as compared to 53¢ for the same period last year. Per share operating earnings for the second quarter were 29¢, against 21¢ for the second quarter of 1963.

In addition to these net profits from operations, there were two special sources of non-recurring net income during the first 6 months. One was a refund of Federal excess profits taxes, amounting to approximately $6,800,000 after the deduction of applicable expenses and taxes. The other was a net capital gain of $4,600,000, after deducting applicable expenses and taxes, from the sale of 141,747 shares of common stock of the Whirlpool Corporation. These two non-recurring items added 22¢ to the per-share earnings.

Principal highlights of RCA's operations in the first 6 months of 1964 were:

1) New record sales and profits in RCA home instruments, led by a 25% rise in factory sales of RCA Victor color television sets.
2) A 30% rise in domestic orders for RCA electronic data processing systems, and a continuing flow of new orders achieved in direct competition with the latest systems announced by competitors.
3) An increase of about 20% in profits of the National Broadcasting Company over last year's all-time first-half record.
4) Record sales and earnings of RCA Electronic Components and Devices.
5) Further contracts for space systems which are part of the APOLLO lunar landing program, bringing to more than $100 million the value of contracts for RCA's participation in space projects directed at the moon.

The record performance of the second quarter and first half has more than offset a persistent decline in government business associated with the continued drop in production contracts awarded to the electronics industry. RCA's government sales for the first six months of 1964 were about 10% below those for the comparable period of 1963.

RCA has now delivered or taken orders for more than 730 electronic data processing systems, and the production capacity of the company's data processing plant at Palm Beach Gardens, Florida, is being increased to meet the continued influx of new orders.

COMSAT CONTRACT SET FOR RCA-AT&T TEAM

An RCA-AT&T team has received one of three satellite contracts to be awarded by the Communcations Satellite Corporation. COMSAT has awarded 6-month engineering design contracts for three different types of communication satellites. Relying on these studies, COMSAT will decide on the type of satellite to be used in the initial global system that will go into operation in 1966-67.

The RCA-AT&T project calls for the design of medium altitude satellites to be placed in random orbits 6,000 miles high, with 18 satellites in the system. Space Technology Laboratories and AT&T are to design a medium altitude satellite to be placed in a controlled orbit, i.e., the satellites keeping the same position relative to each other, and requiring 12 satellites in the system. Hughes Aircraft will work on an improved version of a synchronous satellite orbiting 22,800 miles high and remaining over the same spot.

The DEP Astro-Electronics Division, Princeton, N.J., will receive $1.3 million and AT&T $1.08 million. The RCA-AT&T proposal called for design of a satellite that can handle 530 two-way telephone circuits or two TV broadcasts. Based on RCA's experience with the RELAY satellite and Bell's with TELSTAR, the two companies feel that they could design a satellite with a 10-year lifetime—far longer than COMSAT officials had expected. However, because of the tight time schedule, a 5-year operating lifetime will be used as the objective for a guarantee formula.

NEW JERSEY BELL TO USE THREE RCA 601 AND 12 RCA 301 COMPUTERS

The New Jersey Bell Telephone Company recently announced plans for a three-fold expansion of its present multi-computer billing system serving nearly 2 million customers. The complete electronic complex, among the world's most powerful, will be based on three large-scale RCA 601 computers and 12 medium-scale 301 computers. The telephone company has successfully operated its first large-scale data processing center at Teaneck, N.J. since last spring using one RCA 601 and four satellite RCA 301 computers. (See RCA ENGINEER, Vol. 8, No. 6, April-May 1963 for pertinent articles.) Similar installations will be made at computer centers being established at Trenton to handle the central and southern parts of New Jersey and in Cranford to handle the metropolitan north-east section of the state.

AVINS WINS "BEST PAPER" PRIZE

At the 1964 Chicago Spring Conference of the IEEE Broadcast and Television Receivers Group, **Jack Avins** was awarded a $200 prize for the best technical paper in the Group's *Transactions*. The paper, "Sound Signal-to-Noise Ratio in Intercarrier-Sound Television Receivers," appeared in the July 1963 issue. Mr. Avins is a Staff Engineer for the RCA Victor Home Instruments Division, Indianapolis. When he wrote the paper, he was Manager of the Home Instruments Advanced Development Laboratory at RCA Laboratories, Princeton.

APPLIED RESEARCH OPERATES SEMICONDUCTOR-COOLED LASER TO ACHIEVE FIRST ALL-SOLID-STATE LASER SYSTEM

DEP Applied Research, Camden, recently announced the first successful operation of an all solid-state laser system—one which employs a semiconductor laser and semiconductor cooling. The experiment, first marriage of lasers and thermoelectric cooling, could lead to an operational laser complete with cryogenics and circuitry enclosed in an evacuated package the size of a soup can, according to **Donald J. Parker**, Manager, DEP Applied Research. The new development has achieved a major step toward operational semiconductor laser devices by eliminating cumbersome and impractical liquid nitrogen systems. Asemiconductor laser beam is easily modulated simply by modulating the current, a significant advantage over lasers which are pumped with high intensity light. The gallium arsenide injection diode laser was mounted on a three-stage cascade thermoelectric refrigerator and operated at —130°F.

Paul E. Wright, under whose direction the thermoelectric system was developed, said that the semiconductors used in the thermoelectric laser refrigerator are bismuth telluride. The high-temperature stage employs ten pairs of semiconductors, the intermediate stage three, and the low-temperature stage has one pair. The complete thermoelectric module requires 30 watts of DC power. **William J. Hannan**, engineer responsible for the laser system, said that the laser was pumped with pulses of current by discharging a capacitor through it. The pulse duration was 200 nanoseconds. At —130°F, the measured laser threshold was 40 amperes.

USAF LOGISTICS COMMAND WILL USE 14 RCA COMPUTERS

The USAF Logistics Command and RCA announced recently that 14 electronic data processing systems will be installed in pairs at seven strategic centers to handle on a priority basis the flow of some two million materiel items. The new systems are in addition to the 30 RCA 301 systems being installed at 10 key sites in the United States to provide AFLC with more comprehensive management reporting and faster response to the needs of command aircraft and missile units in every part of the world.

The RCA 301's to be employed in the AFLC Priority Distribution System can be linked directly to the Air Force AUTODIN computerized high-speed communications network which uses specially-designed RCA electronic equipment. Data flows over the AUTODIN net between AFLC units, Air Force bases, commercial suppliers and nine Air Materiel Area headquarters.

TECHNICAL MANAGEMENT CHANGES ANNOUNCED AT MOORESTOWN

In the DEP Missile and Surface Radar Division, Moorestown, three key technical management appointments have been announced by **J. H. Sidebottom,** Division Vice President and General Manager: **R. A. Newell** as Chief Engineer, **Dr. M. Handelsman** as Chief Scientist, and **A. L. Hammerschmidt** as Manager, Program Operations.

R. A. Newell was appointed Chief Engineer in a move which also involves reorganization and reorientation of the Engineering Department. Technical and scientific capabilities will be enhanced and centralized, and a new Systems and Advanced Technology group has been created in Engineering to provide leadership in development of new techniques and product lines.

Mr. Newell joined RCA in 1952 as a design engineer after three years with the Eastman Kodak Company. In ensuing years he managed a number of RCA's major radar programs—the AN/FPS-16 tracking radar, the DAMP Ship, and the TRADEX-PRESS program. His most recent assignment was as Deputy Director and Chief Engineer for the AADS-70 program. A graduate of Rensselaer Polytechnic Institute with a BME in 1949, Mr. Newell was doing graduate work in EE at Drexel Institute when he received a *Sloan Fellowship* for a 12-month executive development program at MIT, where he received a Master's degree in Industrial Management.

Dr. Handelsman, in the newly created position of Chief Scientist, will advise Mr. Sidebottom and the M&SR engineering staff of current and projected scientific developments which will enhance M&SR's military and space program capabilities. Dr. Handelsman received his BEE from the College of the City of New York in 1939, his MEE from Ohio State University in 1946 and his Ph.D. (EE) from Syracuse University in 1955. He has headed microwave research groups at Wright-Patterson Air Force Base, Watson Laboratories at Red Bank, N.J., and was chief of the Radar Laboratory, Rome Air Development Center from 1953-1956. In 1956, he became Director of Advanced Systems, RADC. In 1959, he joined RCA-DEP Advanced Military Systems, at Princeton, N.J. In 1961, he was named Associate Director, AMS. Dr. Handelsman has taught at Syracuse University as an Adjunct Associate Professor in the EE Department and also at New York University.

The newly created post, Manager of Program Operations, has been filled by Mr. Hammerschmidt, who was formerly Chief Engineer, M&SR. He will have responsibility for management of all major contract programs which are carried out in the Moorestown Plant.

In another move, **Avrel Mason,** formerly Program Manager for Strategic and Defense Systems, has been named Chief Engineer of the AADS-70 Program, a separate organization at the DEP Moorestown facility which, under **Harry R. Wege,** Vice President, is carrying out a series of study contracts on a future air defense weapons systems for the Army.

DEGREES GRANTED

N. Selantino,	DEP-MSR	MS, Physics, Drexel Institute of Technology
C. E. Mehl,	DEP-MSR	BSEE, Drexel Institute of Technology
E. P. Damon,	DEP-MSR	MS, Eng. Mgmt., Drexel Institute of Technology
C. C. Custer,	DEP-MSR	BS, Electronic Physics, LaSalle College
M. Cherry,	DEP-MSR	BS, Electronic Physics, LaSalle College
G. D. Chin,	DEP-MSR	MSE, University of Pennsylvania
R. G. Waddell,	DEP-MSR	MSEE, Drexel Institute of Technology
L. R. Allain,	DEP-MSR	MSEE, Villanova University
T. Simmer,	DEP-MSR	BS, Electronic Physics, LaSalle College
J. E. Courtney,	DEP-MSR	MSEE, University of Pennsylvania
L. W. Martinson,	DEP-MSR	MSE, University of Pennsylvania
A. J. Lisicky,	DEP-MSR	MS, Systems Eng. and Ops. Res., University of Penna.
S. Elfand,	DEP-MSR	MSEE, Drexel Institute of Technology
R. M. Greco,	DEP-MSR	BSEE, Drexel Institute of Technology
E. P. Irzinski,	DEP-MSR	MSEE, University of Pennsylvania
J. J. Lavoie,	DEP-MSR	MSEE, Villanova University
R. J. Mason,	DEP-MSR	MSME, Villanova University
A. F. Sciambi,	DEP-MSR	MSEE, Drexel Institute of Technology
J. E. Trimble,	DEP-MSR	MSEE, Villanova University
C. M. Vammen,	DEP-MSR	MSEE, Villanova University
H. P. Henderson,	DEP-MSR	MSEE, University of Pennsylvania
D. W. Janz,	DEP-MSR	MSEE, University of Pennsylvania
J. O. Santacroce,	DEP-MSR	MSEE, Drexel Institute of Technology
J. S. Frank,	DEP-MSR	MSEE, Villanova University
R. A. Stophel,	DEP-MSR	MSEE, University of Pennsylvania
W. W. Weinstock,	DEP-MSR	Ph.D., University of Pennsylvania
J. Liston,	DEP-MSR	MSEE, University of Pennsylvania
C. R. Phillips,	DEP-MSR	MSEE, Drexel Institute of Technology
R. D. Bachinsky,	DEP-MSR	MSEE, Villanova University
K. L. Farber,	DEP-MSR	MEE, Drexel Institute of Technology
V. F. Hoskins,	RCA HI	MBA, Indiana University
O. E. Toole,	RCA HI	MBA, Indiana University
S. W. Liddle,	RCA Victor Ltd.	MS Eng., Purdue University
R. T. Fedorka,	DEP-CSD	MSEE, Moore School of Electrical Eng., Univ. of Pa.
J. N. Yelverton,	DEP-CSD	MSEE, Moore School of Electrical Eng., Univ. of Pa.
R. L. Giordano,	DEP-CSD	MSEE, Moore School of Electrical Eng., Univ. of Pa.
O. J. Hanas,	DEP-CSD	MSEE, Drexel Institute of Technology
M. Wolf,	DEP-CSD	MSEE, Brooklyn Polytechnic Institute
B. S. Perlman,	DEP-CSD	MSEE, Polytechnic Institute of Brooklyn
J. J. Davaro,	DEP-CSD	MS, App. Statistics, Villanova University
J. T. Molieri,	DEP-CSD	MS, Eng. Mgmt., Drexel Institute of Technology
J. S. Becker,	DEP-CSD	BS, Drexel Institute of Technology
R. Magyarico,	DEP-CSD	MSEE, Drexel Institute of Technology
T. A. Knappenberger,	DEP-CSD	MS, Bus. Admin., University of Arizona
A. J. Banks,	BCD	MS, Moore School of Electrical Eng., Univ. of Pa.
A. B. Litwak,	BCD	MSEE, Drexel Institute of Technology
C. B. Davis,	RCA Labs	MS, Electro-Physics, Polytechnic Institute of Brooklyn
L. J. French,	RCA Labs	MSEE, Polytechnical Institute of Brooklyn
D. H. R. Vilkomerson,	RCA Labs	MSEE, University of Pennsylvania
G. S. Kaplan,	RCA Labs	MSEE, Princeton University
J. J. McCormick,	RCA Labs	MSEE, Princeton University
Y. Shaham,	RCA Labs	MSEE, Princeton University
A. Waxman,	RCA Labs	MSEE, Princeton University
D. W. Woodard,	RCA Labs	MS, Physics, Rutgers University
F. Heiman,	RCA Labs	Ph.D., Princeton University
S. Hofstein,	RCA Labs	Ph.D., Princeton University
K. Zaininger,	RCA Labs	Ph.D., Princeton University
N. Almeleh,	RCA Labs	Ph.D., Physics, Polytechnic Institute of Brooklyn
K. R. Kaplan,	RCA Labs	Ph.D., Electrical Eng., Polytechnic Institute of Brooklyn
R. L. Novak,	RCA Labs	Ph.D., Metallurgy, University of Pennsylvania
M. Y. Epstein,	RCA Labs	LL.B., Seton Hall Univ., School of Law
G. E. Gottlieb,	RCA Labs	MBA, Rutgers University, School of Business
H. P. Smith,	RCA Comms	BSEE, Lehigh University
H. Ackerman,	ECD	MS, Mgmt., Newark College of Engineering
M. Fomin,	ECD	BSEE, Fairleigh Dickinson
M. F. Kaminsky,	EDP	MSEE, Moore School of Electrical Eng., Univ. of Pa.
W. McGuckin,	EDP	MSME, Drexel Institute of Technology
J. L. Miller,	EDP	MSEE, Drexel Institute of Technology
A. J. Torre,	EDP	MS, Eng. Mgmt., Drexel Institute of Technology
G. J. Waas,	EDP	MSEE, Moore School of Electrical Eng., Univ. of Pa.
J. R. Oberman,	EDP	MSEE, Moore School of Electrical Eng., Univ. of Pa.

R. A. Newell

Dr. M. Handelsman

A. L. Hammerschmidt

A. Mason

PROFESSIONAL ACTIVITIES

RCA MAJOR PARTICIPANT IN GLOBECOM VI

Dr. Richard Guenther, Chief Scientist, CSD, 1-3, Camden, served as Program Chairman of the GLOBECOM VI Symposium where over 120 speakers from this country and abroad—France, Germany, England, Netherlands, Japan, and Ethiopia—delivered 90 technical papers at the University of Pa., June 2-4, 1964.

The papers accentuated the close ties between computers and communications networks. RCA was represented by the DEP Communications Systems Division and SEER; Electronic Data Processing; RCA Communications, Inc.; RCA International; David Sarnoff Labs; and the Broadcast and Communications Products Div. **T. H. Mitchell,** President, RCA Communications, gave the banquet address on Tuesday evening, June 2.

Papers were presented by: **W. A. Levy, A. C. Dupont, M. R. Winkler, E. L. Hillman, J. H. Wolff,** and **E. King**—all of CSD; **A. E. DiMond** of CSD with **R. K. Andres** of RCA Communications; **B. Silverman** of EDP and **T. M. Johnston** of SEER, Moorestown. Other participants were: **W. McGlaughlin,** Advisory Committee Chairman; **J. Acunis,** Advisory Committee Secretary; **F. Assadourian,** panelist; and **H. Guerber,** Panelist.—*C. W. Fields.*

MALCARNEY ASSUMES DIRECT MANAGEMENT OF DEP

On July 1, 1964, the divisions and staff activities of Defense Electronic Products began reporting directly to **A. L. Malcarney,** Group Executive Vice President. **W. G. Bain,** Vice President, will be assigned to special projects reporting to Mr. Malcarney.

DEP-Applied Research, Camden, N.J.: **T. B. Martin** and **M. B. Herscher** are teaching summer graduate courses in bionics at Drexel Institute of Technology, Graduate School of Biomedical Engineering. **Dr. J. Vollmer,** Manager of Applied Physics, discussed modern physics on the 10-minute radio program "Why" at 6:20 p.m. on *WRCV*, Philadelphia, Saturdays, June 13-July 11.—*M. G. Pietz.*

DEP-CSD Systems Lab., N.Y.: **J. L. Vossen** is Chairman of the Education Committee, IEEE, N.Y. Section, 1964-1965. **M. Frankfort** and **G. Aaronson** recently completed course (lecture series) on Computers given by the IEEE N.Y. Section on Communications & Electron Devices.—*M. P. Rosenthal.*

RCA Communications, N.Y.: **Carl G. Dietsch** was reappointed Chairman of the IEEE Radio Transmitters Committee for 1964 and liason member of the IEEE Standards Committee in April 1964, after serving as a member of the Radio Transmitters Committee #15 of the IRE from 1957 to 1963. He was elected Chairman of this IRE committee in early 1963 and continued as Chairman when the IRE merged with the IEEE.

At GLOBECOM, **E. D. Becken,** Vice President and Chief Engineer of RCA Communications, Inc., was Chairman of technical session #9 Data Transmission Systems of the 1964 International Symposium on Global Communications held at the University of Pennsylvania in Philadelphia from June 2nd to the 4th.

J. C. Hepburn was appointed Chairman of the Telegraph Sub-Committee of the U.S. Preparatory Committee for Study Group III CCIR. The Preparatory Committee met in California on June 16 to study documents from the Geneva Plenary Meetings of the CCIR and to outline procedures for generating revisions or new documents for the next International Meeting to be held in 1965. **J. C. Hepburn** was a guest Resource Leader at a Seminar on Data Communications and Systems sponsored by the American Management Association in New York, June 17-19, 1964.—*C. F. Frost.*

DEP-CSD, Tucson, Ariz.: **A. M. Creighton,** Tucson Plant Manager, was appointed Chairman of the Industrial Electronics Committee of the Tucson, Arizona Chamber of Commerce.—*J. F. Gibbings.*

DEP-CSD, Burlington, Mass.: Seminars on Work Statement Preparation are being given to all management in Burlington. **J. Tabor Bolden** is spearheading the effort.—*D. B. Dobson.*

RCA Victor Record Div., Indpls., Ind.: **M. L. Whitehurst** was elected Chairman Indiana Section of the Electrochemical Society for 1964-65.

RCA Victor Company, Ltd., Montreal, Can.: **Dr. J. R. Whitehead,** Director of Research, RCA Victor Co., Ltd., has been appointed Chairman and Organizer of the session "Materials: The Foundation of New Technology" which is one of the Engineering Institute of Canada's sessions at the American Association for the Advancement of Science annual meeting in Montreal, Dec. 1964. He has also been elected a Member of the AAAS local Exhibits Committee for the Annual Exposition of Science and Industry to be held in Montreal, Dec. 1964.—*H. J. Russell.*

TIROS VII SETS MARK FOR TV PICTURE TRANSMISSIONS

A record-breaking 72,000 television pictures of global weather occurrences have been transmitted by the TIROS VII weather satellite which on June 19, 1964 became the second consecutive TIROS to operate satisfactorily for a year in space. TIROS VII, built by DEP-AED for NASA, broke the record established by TIROS VI last year. Each TIROS weather satellite had a mission requirement of 90 days. The TIROS series has established an unprecedented record of eight successes in eight orbit attempts. These satellites combined have transmitted more than 360,000 TV weather pictures.

RCA LICENSED PROFESSIONAL ENGINEERS

Listed below are recently received additions to the "Directory of RCA Licensed Professional Engineers," which was published in the RCA ENGINEER, June-July 1964 issue, Vol. 10, No. 1, page 5. If your license has not yet been listed in that "Directory" or in the list below, send your name, PE number and state in which registered, RCA division and location, to: RCA ENGINEER, Bldg. 2-8, Camden, N. J.

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NEW SEMICONDUCTOR APPLICATIONS DISCLOSED TO DESIGN ENGINEERS AT RCA SEMINAR

Approximately 400 design engineers from the military, industrial, computer and communications equipment manufacturing fields attended RCA's Solid-State Device Applications Seminar on June 24, 1964 in an all-day meeting in Des Plaines, Ill. The Seminar covered a wide range of new applications for semiconductor devices and ferrite products. Among the subjects discussed were power transistors for audio, VHF and UHF; silicon controlled rectifiers; high-speed power-switching transistors; microwave power sources using varactors; MOS field-effect transistors; computer switching transistors; and high-speed magnetic memory systems.

Dr. R. B. Janes, Manager, Advanced Materials and Development, Electronic Components and Devices, presided at the seminar, which included papers presented by ten RCA engineers:

"Power Transistors for Audio-Frequency Applications" by **H. M. Kleinman**
"Transistor Circuit Design for 450 Mc and Above" by **P. E. Kolk**
"Design of Large-Signal VHF Transistor Power Amplifiers" by **R. Minton**
"Current Considerations for Silicon-Controlled Rectifier Circuits" by **D. E. Burke**
"High-Speed Power-Switching Applications" by **R. L. Wilson**
"Design of Microwave Power Sources Using Varactors" by **A. H. Solomon**
"The MOS Field-Effect Transistor" by **D. M. Griswold**
"Wide-Operating-Range Computer Switching Transistors" by **A. J. Bosso**
"Wide-Temperature Cores" by **H. P. Lemaire**
"High-Speed Magnetic Memory Systems and Their Applications" by **B. P. Kane**

RCA COMMUNICATIONS TO DOUBLE ITS PACIFIC COMMUNICATIONS NETWORK

RCA Communications, Inc. is more than doubling its communications facilities in the Pacific this year, through the new Transpacific Cable System which now links the U.S. mainland with Hawaii, Midway, Wake, Guam, and Japan. RCA Communications has acquired 30 new wideband circuits in various segments of the cable system from the U.S. Mainland to Japan, and will acquire 27 circuits in the new Philippine segment. Each of the new wideband circuits is 3-kc voice-grade capable of being subdivided into 22 telegraph channels. Participating in the Transpacific Cable System, in addition to RCA, are AT&T, Kokusai Denshin Denwa Company, Ltd. of Japan, and the Hawaiian Telephone Company.

RCA ENGINEER BINDERS AVAILABLE

Wire-rod-type, brown, simulated-leather binders are available for binding back issues of the RCA ENGINEER. The binders are 9¼ x 12 x 3¼, and will hold about 10 issues each. (Six binders will house all issues since Vol. 1, No. 1). RCA ENGINEER copies (or similar size magazines) are held in place by wire rods (supplied) that run along the center fold of the magazine and snap in place (no need to punch holes or otherwise mutilate the issue). These binders may be ordered directly for two-week delivery as follows: Order by stock number and description *exactly as below;* make check or money order payable *directly to the vendor,* and specify method of shipment:

Binder, rod type, No. 1584, price $3.66 each.
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Seymour Klein

CORRECTIONS TO JUNE-JULY 1964 ISSUE, VOL. 10, NO. 1

In the paper by Y. L. Yao, on Page 77, the chart appearing with the Fig. 5 caption is actually Fig. 6; conversely, the chart appearing with the Fig. 6 caption is actually Fig. 5. Also, the Fig. 6 caption should be corrected to read: "Shmoo plot based on hysteresis of *Fig. 5.*"

In the paper by Miller and Klein, on Page 47, the photo appearing above the biography of S. Klein is *not* that of coauthor Seymour Klein (formerly of EDP and now with ASD Burlington). The photo printed here is correctly that of coauthor Seymour Klein.

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NEW ED REPS NAMED: WALTZ FOR CSD-TUCSON, AND PHILLIPS AT AED

K. H. Waltz has been named RCA ENGINEER Editorial Representative for the DEP-CSD Systems Laboratory in Tucson, Arizona, succeeding **J. F. Gibbings.**

John Phillips has been named as an additional RCA ENGINEER Editorial Representative for the DEP Astro-Electronics Division, Princeton, N. J. Mr. Phillips will handle Equipment Engineering, while **Irv Seideman,** who had been the only Ed Rep at AED, will concentrate on Advanced Development and Research.

All three serve on **F. W. Whitmore's** DEP Editorial Board.

Kenneth H. Waltz studied Radio Engineering at John Brown University in 1955-56. In 1958, he received an AAS degree in Electrical Technology from Erie County Technical Institute, Buffalo, New York. His military training includes three years (1951-54) in the Coast Guard as an aviation electronicsman and a current assignment as a radio operations supervisor in the Air Force Reserve. He has held technical positions with Sylvania Electric, Bell Aircraft and Cornell Aeronautical Labs provided a varied background in the electrical manufacturing and research fields. Experience in technical publications was obtained by association with Westinghouse Electric Corporation, 1960-64. He joined RCA in April as a lab assistant in the Communications Systems Division, Tucson, where he also acts as the technical librarian. Interests outside of RCA include activity in amateur radio and membership in the STWP.

John Phillips has been with the Astro-Electronics Division since May 1962, and has been closely associated with publications for most of the major AED space programs. For two years preceeding, he was a technical writer at the Bendix Corporation, where he advanced to the position of group leader. He presently is majoring in mathematics at Rutgers University, after completing two years of evening school at Newark College of Engineering. John was on active duty with the U.S. Navy from 1956 to 1960, and during this time took advanced courses in radar, sonar, and communications. He was assigned the responsibility for maintenance of all types of submarine electronic equipment, including a complete prototype missile guidance system for the REGULUS missile. In addition, he taught courses in basic electronics and electronics equipment.

SEPTEMBER 1964 "RCA REVIEW" TO FEATURE PAPERS ON SUPERCONDUCTING Nb_3Sn

RCA's advances on superconducting niobium stannide are the subject of the entire September 1964 issue of *RCA Review,* copies of which will soon be available in RCA Libraries. Materials synthesis, basic measurements and properties, and applications are described in detail—including fabrication of Nb_3Sn-coated ribbon for extremely powerful magnets. [*Ed. Note:* For background on superconducting Nb_3Sn magnets, see paper by N. S. Freedman, RCA ENGINEER, *9*-3, Oct.-Nov. 1963.]

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