OBJECTIVES

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.

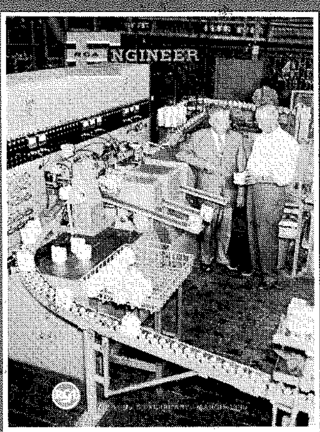
To serve as a medium of interchange of technical information between various engineering groups at RCA.

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.



OUR COVER

RCA Automatic Piston Inspection Equipment at the Oldsmobile Division Plant, General Motors Corp., Lansing, Mich. Harold Wright, Inspection Superintendent of the Engine Plant, and D. E. Straight, Gauge Development Engineer observe operation during production run. Inspection machine checks diameter of two "wrist-pin" holes in aluminum piston, automatically classifies and stamps each piston with classification number, checks piston skirt diameter in two places for proper taper, and classifies for 4 categories in $\frac{1}{10}$ increments plus "over-and-under" and 11 skirt classifications plus "over-and-under".

CREATIVITY

In the past few years, there has been much said and written concerning the need to develop creativity in engineers. There is a parallel need to develop an alertness for the recognition of ideas when they do appear. Anyone long associated with engineering has seen many good ideas go begging. Small ideas are readily adopted, but *big* ideas are hard to sell. It takes the same imagination to accept and implement an idea as is needed to conceive it. Those who have control over the means of implementing an idea often lack this essential imagination—and the larger the organization the more this factor comes to the fore. Where numbers of people are involved in the decision to act on an idea, the greater is the risk of its being suppressed by inaction or indifference. "NO" is always the safe short-term decision. Extensive sharing of decisions intended to dilute responsibility should be avoided.

Engineers as a class are competent workers and, day by day through the years, they advance their art through the generation of many small ideas that overcome problems of the moment. They gnaw away steadily on the frontiers of experience and, by their great numbers, bring a noteworthy evolution of techniques. Managements know this and encourage it, especially where competitive advantages result.

Big ideas—the kind that make a leap forward or a major breakthrough—are contributed randomly by only a tiny portion of those engaged in technology. When one comes along, its fate is questionable. This refers not only to that special idea that is so far in advance of its time as to appear preposterous in terms of present experience, but also to big ideas within present means and needs, which often die if they do not fit into existing organizational arrangements, or if they require special facilities, or if everyone is busy with something else.

Any advance starts with an *idea* by an individual, followed by a *response* that is so necessary in providing the encouragement and facilitations for its implementation. Big or small, ideas are worth little more than the sincerity of response they receive.

George H. Brown
Chief Engineer
Industrial Electronic Products
Radio Corporation of America

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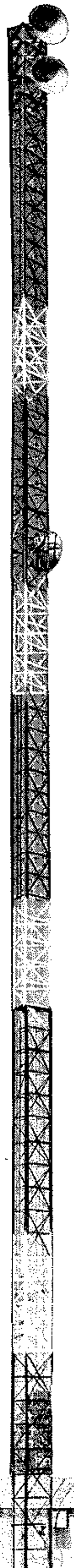
OUTLOOK: INDUSTRIAL ELECTRONIC PRODUCTS



by

T. A. SMITH

Executive Vice President
Industrial Electronic Products
Camden, N. J.

THE FIELD OF ELECTRONICS has been somewhat without an equal, not only for its rapid growth but also because it expanded both horizontally and vertically at the same time. While the early established areas grew in volume, new engineering developments made possible new uses and applications and these, in turn, became the foci for growth and business development.

There are new developments in the electronics field to be employed to advantage, among them—use of transistors, printed circuits, small module packages of components, ferrite and ceramic components, electro-luminescent materials and photo-sensitive and radiation-sensitive devices. We have new tubes to accomplish new functions, new uses for magnetic tape, new relays, new computers, new methods of measurement and a host of other research products, any one of which would have been considered revolutionary ten years ago. In fact, we are to some degree beset with riches and are faced with the problem of using them wisely.

Starting in the areas of communications and entertainment, electronics has branched into such diverse territories as navigation, instrumentation, industrial control and of course into the many uses for military purposes.

We are in an industry which is dynamic and expanding. It is growing rapidly in a number of areas, even while some are static. Electronics offers methods for reducing expenses when applied to industrial, business, educational and entertainment enterprises.

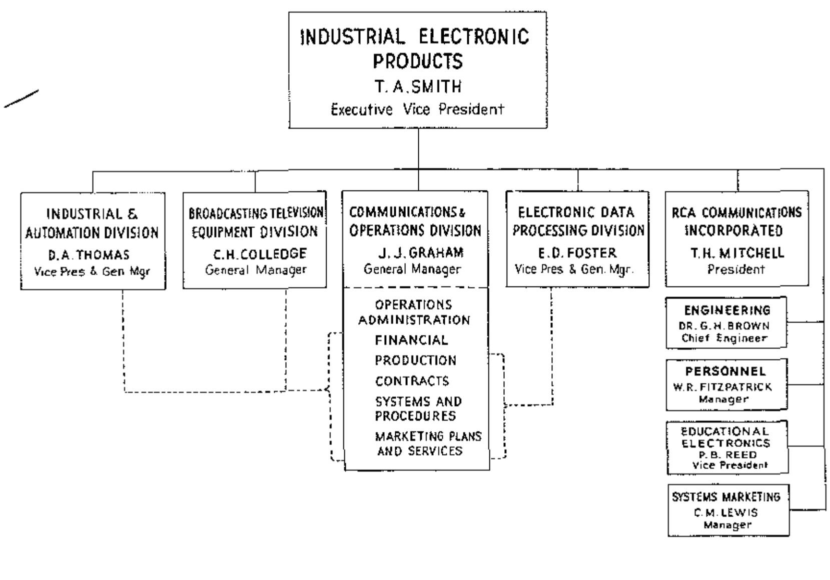
RCA's growth has been similar to that of the industry in that, while some of its interests such as entertainment and military electronics have grown substantially in volume, RCA has also branched out and grown horizontally into new fields. It is the goal of Industrial Electronic Products to grow in the commercial and industrial electronic equipment areas which many industry leaders believe will experience a marked and rapid expansion in the next ten years.

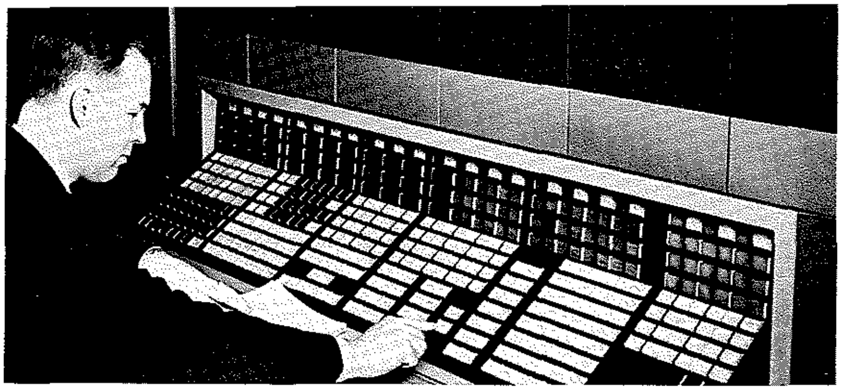
The major areas of Industrial Electronic Products lie in the fields of Communications, Industrial Controls and Electronic Data Processing, with Systems linking all three.

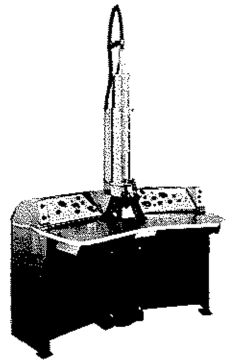
Communications, the original application of electronics, has advanced rapidly during the past fifteen years. Considering it in its broadest aspects, it has benefited from numerous technical developments which have improved long-distance transmission, increased the intelligence which can be sent and received and have made possible personal types of communications. The results are manifest in scatter transmission, in direct teletype (TEX) radio circuits, in improved closed-circuit television, in Personalfone communication sets, in improved mobile and sound equipment and in many other forms. Industrial Electronic Products is interested in developing new applications for commercial communications and in broadening the products and services which contribute to better communications.

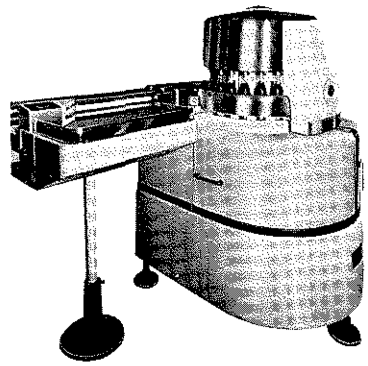
For a number of years, RCA has produced and sold industrial inspection devices such as beverage-inspection machines, metal-detecting equipment and the like. More recently, it has offered electronic gauging apparatus and associated work-handling equipment. Late in 1958, it was announced that there would be added to the line of industrial products electronically-controlled equipment useful in the field of newspaper printing. As described in this issue, a glass-flaw detection device has been developed and is being tested. Industrial Electronic Products is interested in expanding its line of products applicable to industry for inspection and for control.

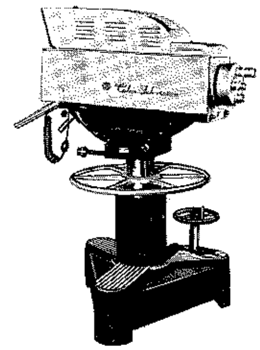
In 1951, RCA started an engineering program directed towards the design and production of electronic data-processing equipment. Having produced the Bizmac I system, a large computer, it has recently offered for sale the RCA 501 medium-size all-transistor data processing system. The first Bizmac I installation is now performing one of the largest business data-processing functions in the country. The RCA 501 has met with wide acceptance and a substantially augmented commercial group has been established to market it. Industrial Electronic Products is interested in











expanding its activities in the data-processing field and in offering new products in connection with this rapidly growing new field.

In the field of military electronics, it has been proved that integrated systems of electronic devices form a more powerful tool than separate equipments. Hence, Industrial Electronic Products has established an industrial systems and marketing activity. A pipeline reporting and controlling equipment development recently completed to the point of a prototype suitable for demonstration is an example of an integrated system linking the areas of communications, data handling, instrumentation and control devices. Other systems are being studied and it is expected that RCA's commercial systems activity will grow to link together the tools developed by its product activities.

In addition to these broad lines of endeavor, Industrial Electronic Products is interested in the use of its products for educational purposes, in high-power radio-frequency generators for various applications, in video systems, picture and sound recording, broadcasting apparatus, and many others.

Great progress has been made in harnessing electronics to serve the country's defense efforts. It seems reasonable to believe that similar advances will be made in increasing the contributions which electronics can make to American business and industry. This is the field in which Industrial Electronic Products is interested and in which it proposes to expand its activities. This is a field in which sound, well-conceived engineering will play a vital role in developing new products.

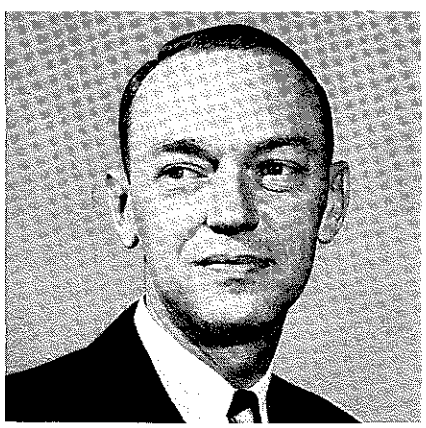
We have new techniques as well as physical devices. From military work have come methods for achieving greater reliability of complex devices, a field in which RCA has taken leadership. We have operational research methods for solving complicated problems. We have improved methods for handling paperwork through data-processing devices. We have system-engineering methods to accomplish broad results.

We have at our command RCA's great background in research and development and experience in many phases of electronics as well as, within the company, people who are expert in nearly every aspect of the electronic art—in marketing, engineering or production.

The Radio Corporation of America has reached the position it holds today because it is a forward-looking company. I have every reason to believe that we can play an important part in the industrial electronics era, just as we have in the vast and exciting eras which have preceded it.

This new task is not an easy one. It will require education and selling work by engineers and marketing people in the entire industrial electronics area. It will require a continuous survey of the technology of the entire industrial electronics industry. It will require the maximum in creative and imaginative ability.

We already have the inherent skills in our organization to accomplish the tasks ahead — tasks that will require more than an ordinary amount of creative engineering and marketing. With well-planned programs designed to earn reasonable profits, there should be excellent opportunities for the growth of individuals and of the business as a whole.



THEODORE A. SMITH was elected Executive Vice President, Industrial Electronic Products, on June 7, 1957. He is responsible for RCA telecommunications systems including RCA Communications, Inc., computer systems, industrial control systems and other commercial products. He is also a member of the Board of Directors of RCA Communications, Inc.

Associated with the company since 1925, Mr. Smith supervised the construction of RCA's pioneer television station W2XBS, New York, in 1928, and later held sales, engineering and administrative posts of increasing responsibility.

In 1942, he became Staff Assistant to the Manager of the Engineering Products Department. He was promoted to General Sales Manager of that Department in 1946 after serving for a year and a half as Manager of the Transmitter Sales Department. From 1951 to 1953, Mr. Smith was Assistant Manager of the Engineering Products Department. He then was elected Vice President and General Manager of the Department and became Vice President and General Manager, RCA Defense Electronics Products, in October, 1955.

Mr. Smith received a Mechanical Engineering degree from Stevens Institute of Technology at Hoboken, N. J. He holds a number of patents on television and other products, and is the author of several radio engineering papers.

A senior member of the Institute of Radio Engineers, he is past chairman of the Philadelphia Section; past chairman of the Technical Products Division, Radio-Electronics-Television Manufacturers Association; a member of the Armed Forces Communications Association and of the American Society of Naval Engineers.

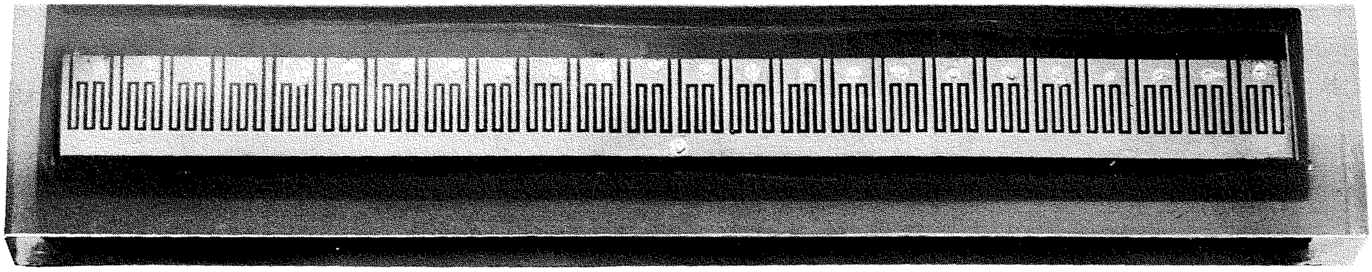


Fig. 1—Developmental photoconductive cell structure for use in continuous sheet flaw detection.

OPTICAL INSPECTION DEVICES FOR PRODUCTION PROCESSES

by

W. E. BAUER

Industrial and Automation Division
Industrial Electronic Products
Camden, N. J.

MANY ARTICLES HAVE pointed out that the planning of the development of industrial automatic control systems should fit the following framework:

1. Sensing and measurement of the quantity or property of interest.
2. Operation on this information to compare it to an established standard to decide what action is to be taken.
3. Performance of the necessary correction to eliminate the undesirable state.

As this thinking is applied to include greater portions of the complete process within control loops, the systems engineer soon contacts the inspection department or final quality control people. In accordance with the above framework, the first piece of apparatus needed is an automatic device for *continually measuring or monitoring the quality of the finished product.* Product quality is not as universal an entity as temperature or pressure, and is very often an ill-defined combination of several properties. This means that if a sensing or measuring device is to be designed, it must perform some computations and be provided with enough intelligence to present its output in the form which will fit a useful quality scale. Such a piece of apparatus is generally expensive. Also, since it stands alone in an incompleted system loop (i.e., it is just the transducer and in itself cannot correct poor product quality), the question is immediately asked whether the apparatus is worth the price. Such a question is fair, but the most advanced user recognizes that it would be foolish to design a complete system without first proving the capabilities of the primary element. In some applications, as discussed below, this first element with very little additional engineering can be used directly to perform the useful function of sorting good product from bad product where this is physically possible, or to sound alarms indicative of process malfunctions before large quantities of scrap material are produced.

In the paper manufacturing industry and the window glass industry, a significant portion of the quality control problem is related to the presence of *visual flaws* in the product. In each of these industries, the material is produced by a continuous process in which prepared raw materials are supplied at one end and the formed paper or window glass issues from the other end. The random occurrence of the flaws (which makes sampling quality control methods inadequate) together with the large volume of material handled, provide an ideal application for the high information handling capabilities of electronic apparatus. Three basic approaches which immediately suggest themselves are: (1) a scanning system using a television camera tube, (2) a flying spot system, (3) a series of photocells arranged across the web so that each cell is responsive to the presence of flaws in a narrow zone. The photocell approach was selected as the most promising.

The image storage properties of the television camera tube which make it ideal for converting the light image of a conventional television scene into an electrical signal are not realizable for observing flaws in a high-speed moving web. The television scene is substantially stationary during one frame interval; this is not so for the moving web in which a small defect might travel a distance equal to several times its own length in a few milliseconds. In order to immobilize the image therefore, narrow pulse-width stroboscopic lighting would have to be used. This would require high intensities in order to get the same image strength and the resulting lighting system for a wide web would be costly and unwieldy. By using the strip of photocells and constant illumination of the web, the full time interval of a pulse of light produced by a defect passing over the photostrip is effective in producing an electrical signal.

Flying spot systems would have corresponding limitations, in addition to being much higher in cost. From the optical standpoints then the photocell system offers a highly efficient method of converting the optical characteristics of the flaw into electrical signals.

From the standpoint of interpretation of the flaw signals, the photocell approach again has advantages over electronic scanning systems. The successive lateral scans of the television camera or flying spot system would require memory circuitry to reconstruct the actual flaw signal in order to determine its severity. With the photocell approach, the flaw signal appears only once and can be applied directly to the necessary logic or recognitive circuits in order to classify the flaw.

Finally from the standpoint of installation flexibility the photocell system is easily adaptable to the mechanical changes necessary to accommodate various web widths. It is merely necessary to make the length of the head suitable for the width required without being concerned with resolution for each installation.

The specific problems and merits of this system when applied to the paper and glass industries are discussed below.

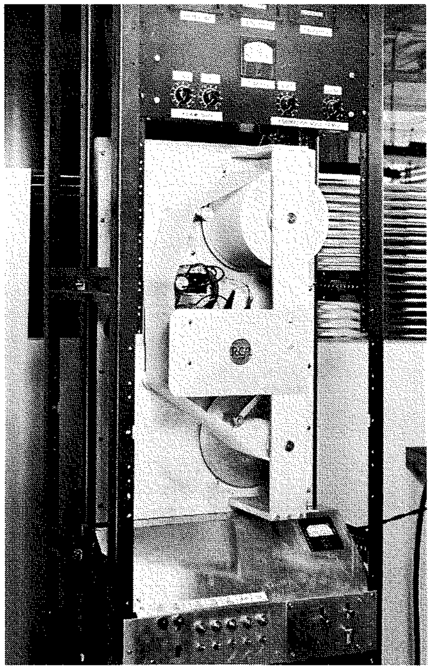


Fig. 2—Laboratory version of a flaw detector for use in the paper industry.

THE PAPER INDUSTRY

A typical paper making machine is 12 feet wide and turns out paper at a linear speed of 17 feet per second. The most modern machines double both these figures and will cost several million dollars. A significant portion of the quality control problem is related to the presence of flaws in the structure of the sheet. These defects consist of (1) holes which range in interest from .040″ diameter to several square inches in area, (2) thin spots or small areas where the paper fibers are separated sufficiently to increase the light transmission of the paper more than the normal mottled pattern of the good sheet, and (3) foreign material in the pulp which will appear as dark spots or dirt in the finished sheet. Since the paper is being produced in such tremendous quantities, it is impractical to check visually every square inch of paper. The development of sintered layer photoconductive materials possessing high electrical power-handling capabilities opened the way for reliable, low cost, continuous flow monitoring of this high speed web of material.

The Tube Division at Lancaster has been active in the development work of processing sintered layer photoconductive cells in the form of a mechanically continuous strip with an active surface 6 inches long and ¼ inches wide. An interleaved finger-like electrode structure is applied over the photoconductive layer in a manner which provides 24 electrically separate cells ¼-inch square, mounted as a unit. (See Fig. 1.) In its application to web or sheet flaw detection in the paper industry, these strips are mounted in a head which extends across the complete width of the machine. Each cell responds to changes in the amount of light transmitted through the element of paper which it sees. The benefit of the electrical separation of the cells becomes evident when one attempts to combine the outputs from individual cells in order to pass the defect signal through circuitry to grade or classify it. If the signals from each cell were caused to pass through a summing resistor directly (which would be like a single long, thin cell), the paralleled cells would load the signal cell, and the mottle noise from the combined outputs would add. Both these effects would result in poor signal-to-noise ratio. By passing the output of each cell through a diode before summing, the parallel loading effect is reduced, and the normal mottle noise can be blocked out, with resulting improvement in the overall signal to noise ratio and signal strength. The type of cell used makes direct diode action practical. The result is that it is possible to catch small local defects in the quality of the sheet.

Once the defect signal has been acquired, it is necessary to pass it through circuitry which will classify it or place it upon a meaningful quality scale. In this application, signal amplitude and polarity (light or dark) provides a sufficient degree of refinement for grading the defects. Since the majority of flaws of general interest fall into the category of thin spots or holes, two adjustable threshold levels are provided for signals of this polarity. Standard pulses are generated when the threshold level for a given flaw severity is exceeded. Similar threshold circuits and pulse generators are provided for areas which are darker than the normal mottle or formation pattern of the paper.

This basic approach with some detail modification is being applied for two separate purposes in the paper industry. When used at the output end of the paper making machine itself, it serves as a monitor on the quality of the paper being produced. The entire width of the web is divided into three zones. Defects occurring in a given zone are classified as previously described and recorded on separate counters for each of the zones. In this way, the machine operators are able to tell when the defect rate increases above normal, and approximately where across the width of the machine they should look for trouble. By means of this early warning, trouble is recognized and corrected before larger amounts of inferior quality paper are produced, which in order to be used would require expensive special handling. Fig. 2 shows a laboratory version of this apparatus which has been demonstrated to interested paper companies.

The second configuration of this machine (Fig. 3 and 4) is being applied to paper that is to be sold in sheet form. In this application, in order to catch and properly classify the small dirt spots which are important, it was necessary to have the sensing system monitor the reflected light from the sheet rather than the transmitted light. The defect signals require more refined processing in the form of integrating circuits which recognize

WILLIAM E. BAUER received his BS degree in Mechanical Engineering from Drexel Institute of Technology in 1943 and his MS degree in the same field from the University of Pennsylvania in June 1951. He spent three years with the Aviation Gas Turbine Division of Westinghouse Electric Corporation on the design and development of electro hydraulic power control systems for military jet aircraft. Following this, he spent seven years in the Research and Development Department of the Brown Instrument Division of Minneapolis-Honeywell Regulator Company on pneumatic and electric industrial control apparatus. Mr. Bauer joined RCA as a part of the Advanced Development section of Industrial Electronic Products in March 1957. In this activity he is engaged in the development of industrial inspection equipment for the Inspection and Control product line.

area. The processed signals are compared to adjustable threshold levels which when exceeded, trigger the appropriate pulse generating circuit. This pulse is of sufficient power level to operate solenoid-controlled air valves which operate diversion mechanisms to route the inspected sheet to any of three quality grades.

THE WINDOW GLASS INDUSTRY

In the flat-glass industry, the product is sold as either window glass or plate glass. The manufacturing method is quite different for these two forms, and the resulting price of plate glass is much higher than window glass. With continued improvement in the quality of window glass, this product is challenging the plate glass market. The potentialities of the increased market are stimulating interest in the quality control problems of window glass. Here, as in paper, a large portion of the quality problem is centered around the presence of visual flaws in the glass.

Window glass is produced by drawing vertically from a furnace, a continuous ribbon of glass 12 feet wide, at a rate of about 1.5 inches per second. The draw rises about 40 feet during which interval the glass cools sufficiently to be automatically cut into lengths about 5 feet long. The glass is then tipped into a horizontal position onto a belt conveyor which moves it to a stacking area for later cutting into finished window panes. The conveyor speed is about 8 inches per second and it is on this conveyor where a field evaluation model of an automatic glass inspection machine will be installed.

The flaws are of two types: (1) blisters, which are sliver shaped voids buried in the sheet and (2) stones, which may either be small pieces of refractory from the furnace or some other foreign inclusion. The length of the blister flaw is one of the factors which determine whether the resulting panes will be considered first quality, seconds, or rejects. The presence of any stone is sufficient to reject a pane containing it.

In order to incorporate automatic inspection into the processing and handling of the glass after drawing, considerable change would have to be made in the method of operation of the glass factory. Before making such a disrupting systems change therefore, it was necessary to prove the capabilities of a flaw detecting and grading device on a small scale. This was done by designing the equipment to cover only 8 inches of the entire width and incorporating a marking device arranged to place an ink mark upon the glass close to flaws which are outside the acceptable quality limits.

The detection system consists of a collimated beam of light which is directed through the glass to be inspected. The same photoconductive cell strip used for paper inspection is mounted in a light-tight enclosure on the side of the glass opposite from the light source. The collimated beam enters the enclosure through a narrow slit positioned close to the surface of the glass. The cell is positioned within the enclosure so that the entering collimated beam does not fall upon the sensitive area of the cell. In addition the inside of the cell case is flocked to absorb all internal reflections. The cell is therefore in darkness until a flaw in the glass passes through the light beam. The flaw is then detected as a result of the light which it scatters outside the direct beam, striking the photoconductive surface.

The flaw classifying circuitry must determine whether the glass is suitable for the desired quality. For blister flaws, it does this by measuring their length. Due to the nature of blister flaws their long axis always coincides with the direction of travel. Since the glass travels at constant speed the blister length can be determined by measuring the time interval during which the scattered light from the blister is striking the photoconductive surface. Whenever the signal due to scattered light from the glass exceeds a preset noise level, a ramp signal generator is turned on and remains on until the scattered light signal again drops below the noise threshold. If the voltage output from the ramp generator rises above a preset threshold determined by the maximum acceptable blister length, a monostable multivibrator is triggered which produces an output pulse of sufficient power level to actuate a solenoid operated air valve. This valve admits air to an air cylinder operated marking device placing a prominent ink mark on the glass in the vicinity of the objectionable blister.

The stone flaws are of such a nature as to produce a smaller high-intensity pattern of scattered light compared to the blister flaws. Since they are not classified in accordance with length, the ramp and threshold circuitry of the blister system is not applicable. Due to the nature of the scattered light pattern of the stone flaws, the electrical signal from the photocell has a steeper leading edge than the blister flaw signal. By using the proper size coupling capacitor, the stone signals with their higher frequency content can be processed by a separate amplifier. Blister signals cannot get through to this amplifier because of their lower frequency characteristics. The output of this stone circuit amplifier serves to trigger the same marking device as the blister circuit. In summary, then, stone flaws will always be marked but blister flaws will only be marked if they exceed the preset objectionable length.

As of this writing, the finished apparatus as shown in Fig. 5, has been accepted by the customer. It is shown mounted on a laboratory glass transport system on which it was demonstrated. After it has proven itself in the field, it is hoped that full-scale versions of this equipment will form a part of the customer's automation plans.

CONCLUSIONS

An important step toward automation in the paper and window glass industries is provided by the above devices for flaw detection and classification. Such equipment can be used to provide information which will permit more economical process operation as well as for final quality sorting of the product. The application of a line of sintered layer photoconductive cells with their high power controlling capabilities presents the flaw signal information in a form more amenable to interpretation by classifying circuitry, than signals from an electronic sweep scanning system would provide.

ACKNOWLEDGEMENTS

The creation, design and development work on this apparatus was the result of the joint efforts of Harold E. Haynes, A. S. Buchman, C. E. Reeder, R. L. Pryor and T. R. Mayhew as a part of Advanced Development, Industrial Electronic Products.

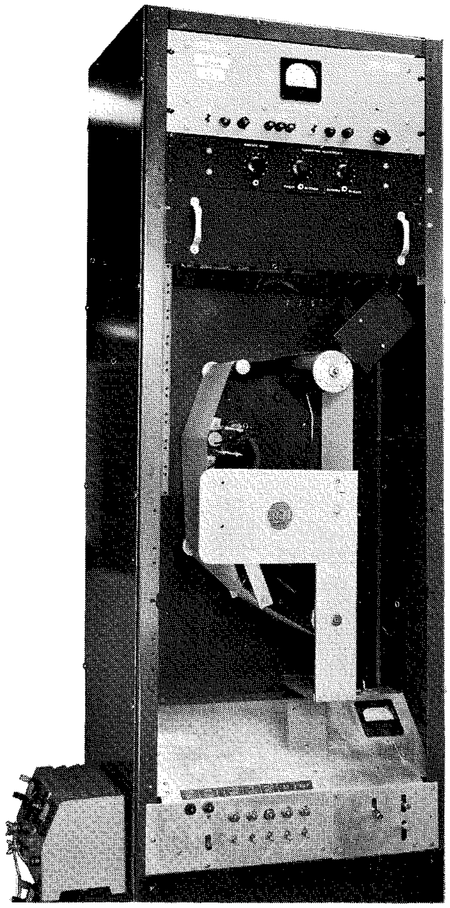


Fig. 3—Paper-sheet surface inspection machine.

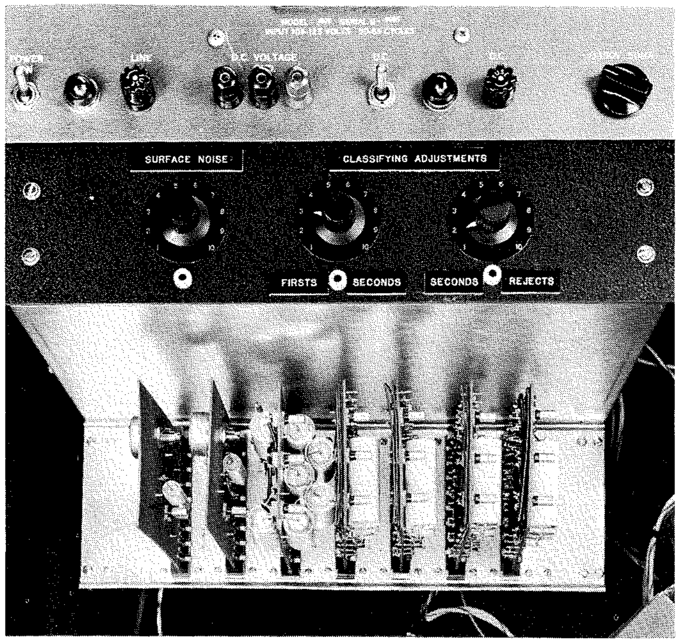


Fig. 4—Close-up of transistorized amplifiers and flaw-classifying circuitry in the paper-sheet inspection machine.

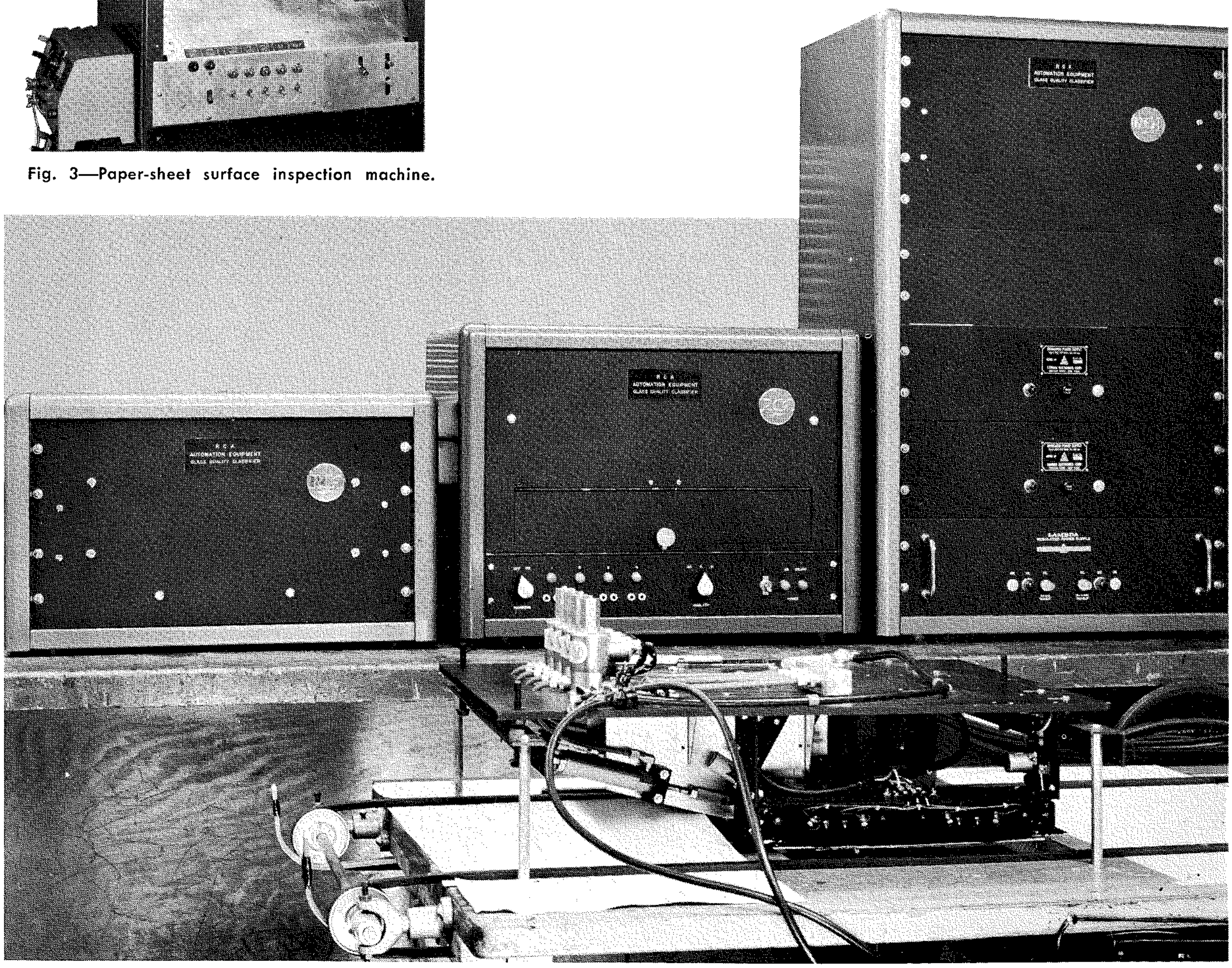
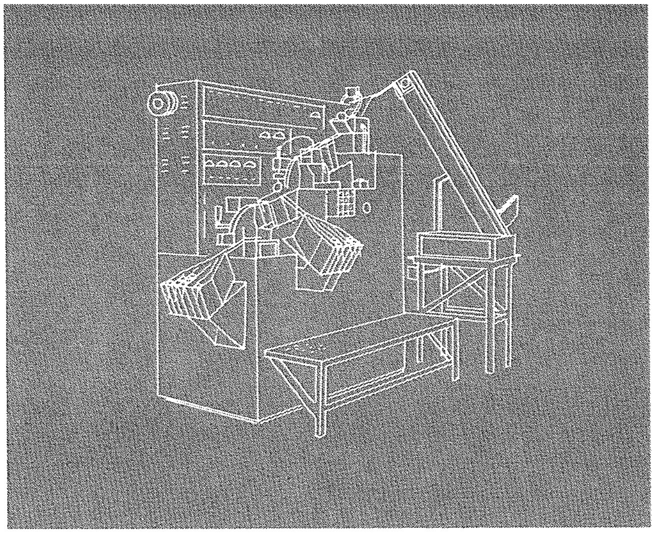


Fig. 5—Glass quality classifier.



THE RCA DETROIT STORY

by

M. A. MAURER,

Formerly Manager,
Industrial Machine-Tool Automation
Industrial Electronic Products
Detroit, Mich.

MORT A. MAURER studied Mechanical Engineering at Pratt Institute, Metallurgy and Aircraft Design at Rutgers, and Electronics at Temple University. During the summer of 1956, he attended the School for Management at Northwestern University.

Mr. Maurer has been successively employed by the Seversky Aircraft Corp., the Detecto Scale Co., and the Curtiss-Wright Corp. He joined RCA in 1948 as Parts Quality Manager, and in 1952 was made Plant Manager of the Detroit Plant. In 1957 he was transferred to Industrial and Audio Products Marketing, and with the acquisition of Arlin Products Company and the establishment of the Detroit Industrial and Machine Tool Operations, Mr. Maurer was appointed Manager.

More recently Mr. Maurer was appointed Manager of Production and Programming of the ATMAS project, DEP.

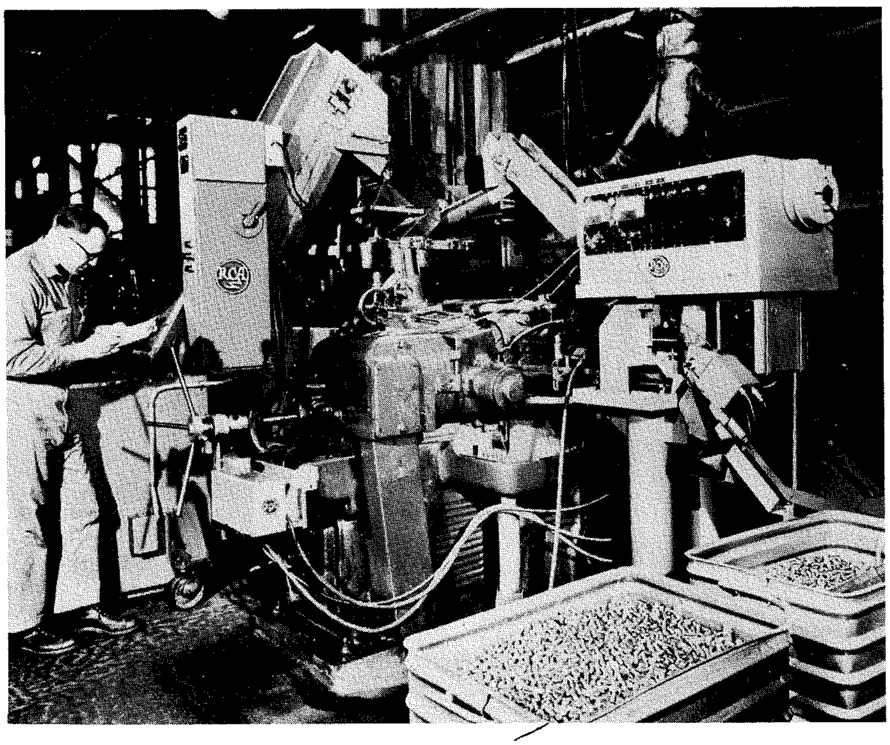


Fig. 1—RCA Grinder Control installation at Crucible Steel Company, Harrison, N. J. This unit gages and segregates magnets as they leave the centerless grinder. Production rate has doubled as a result of installing this control.

Whether you drive a Chevrolet, Ford or Chrysler, dab your face with Shulton's Old Spice After Shave Lotion, take your daily dose of Parke-Davis vitamin capsules, enjoy a glass of your favorite beer or soft-drink, or rinse your mouth with Listerine, you are already benefiting by the engineering skills of RCA's newly organized Industrial and Automation Division. Diverse as these products are, they illustrate the broad areas of industry in which equipments produced by this group are already in use.

The Industrial and Automation Division, under the management of Mr. D. A. Thomas, Vice President and General Manager, and Mr. Harold Emlein, Operations Manager, is charged with the task of establishing RCA as the leading supplier of electronic controls and automation systems in the industrial market. At present it consists of the Beverage Equipment and Control Section in Camden and two groups in Detroit—one for Industrial and Machine Tool Operations and the other for Graphic Arts Automation. The present article will be limited to the Industrial & Machine Tool Automation section, but the others will be covered at a later date.

ARLIN PRODUCTS ACQUIRED

This section was activated in February 1958, with the acquisition of the business of the Arlin Products Company, which was founded approximately twelve years ago on the basis of a development by Mr. Arlin of a novel electronic gaging system which utilizes a high-frequency oscillator to supply a signal to the gage head through a coaxial transmission line. The gage head functions as a variable capacitor and consists of two metal plates, one of which deflects when the gage tip or stylus is depressed. This causes voltage changes which are taken off and converted to a smoothly varying d-c current, proportional to the dimension being measured by the gage head. This d-c current may be applied to thyratron units which can be set to fire at the upper and lower dimensional limits as well as at intermediate points for the purpose of sorting and classifying parts.

A unique advantage of this gaging system is the extremely high voltage output of the circuit which can have a sensitivity of as much as 40 volts per 0.001 inch. Since this high output feature makes the use of signal amplifiers unnecessary, greater simplification and improved reliability result. Furthermore, the fact that the gage head itself is electro static rather than electro magnetic has the added advantage that it cannot generate spurious response due to external magnetic fields or magnetized parts.

This gaging system has been product-designed into plug-in modules which, when assembled as required by function and supplemented by integral material handling devices, can be made into a great variety of inspection and testing devices. These have proved technically useful when parts need to be segregated within extremely narrow limits for later selective assembly. For this reason these equipments have had wide acceptance in the automotive, appliance, bearing, and similiar industries where they are being used on such parts as pistons, piston pins, valves, valve lifters, bearing rollers, and races.

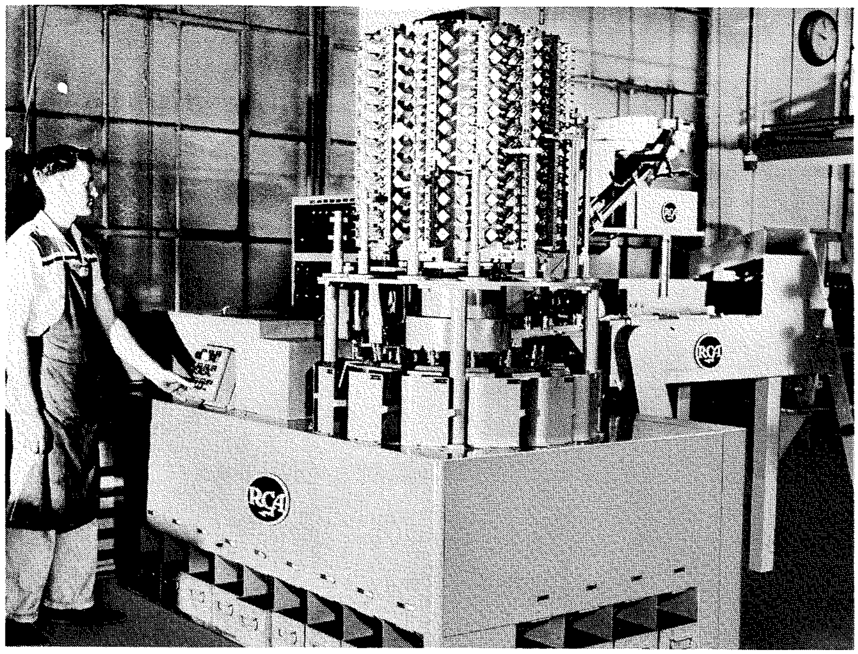


Fig. 2—Roller Bearing inspection machine is operating at the Aetna Ball & Roller Bearing Company in Chicago. This equipment inspects and segregates roller bearings into 8 OK categories in increments of 0.0001 inch. They are also classified in 4 NG groups—OD over and under, and length over and under. Rate is 20,000 pieces per hour. The unit shown to the right rear is an RCA Non-Mar Feeder which supplies the rollers to the inspection machine as required.

SUPPLEMENTARY PRODUCTS

Supplementing the RCA automatic equipment is a line of parts feeding, distributing, and orientating equipment used to supply parts automaticall to fabricating machines and processes as well as to RCA inspection and test machines. Because of space limitations the relative simplicity of this equipment and its similarity to other products of this type commonly used in the metal working industries we do not feel that further discussion of this is necessary. They do, however, account for a significant percentage of

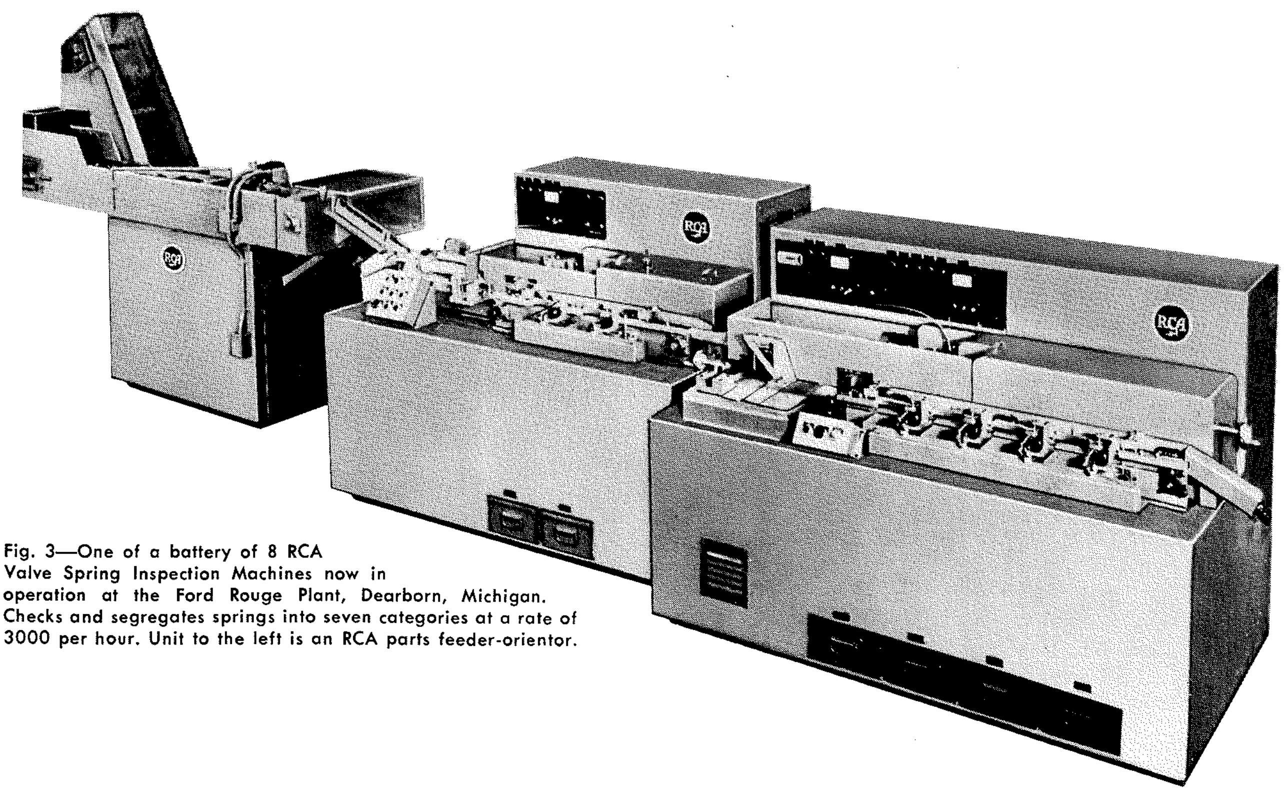


Fig. 3—One of a battery of 8 RCA Valve Spring Inspection Machines now in operation at the Ford Rouge Plant, Dearborn, Michigan. Checks and segregates springs into seven categories at a rate of 3000 per hour. Unit to the left is an RCA parts feeder-orientor.

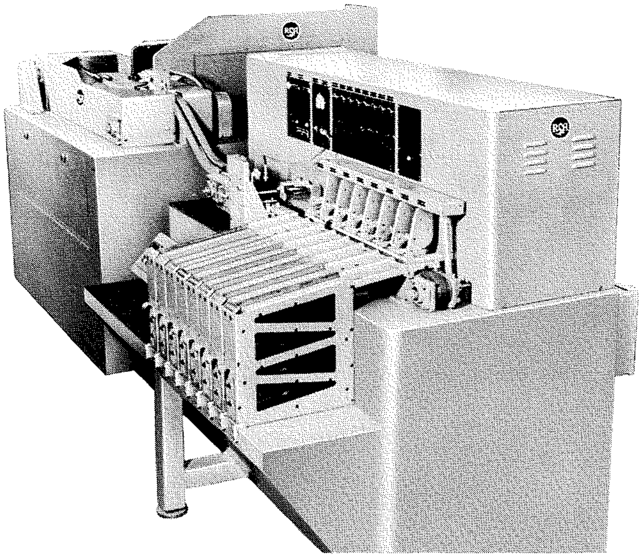


Fig. 4—RCA Piston-Pin Inspection Machines such as this one are now being used in Ford, Chevrolet, and Oldsmobile plants. These machines inspect and sort the pins into 8 OD classifications in increments of 0.000.05 inch. They also check and segregate the parts for length and true roundness. Rate is 3000 per hour. An RCA Non-Mar Feeder-Orientor is at left.

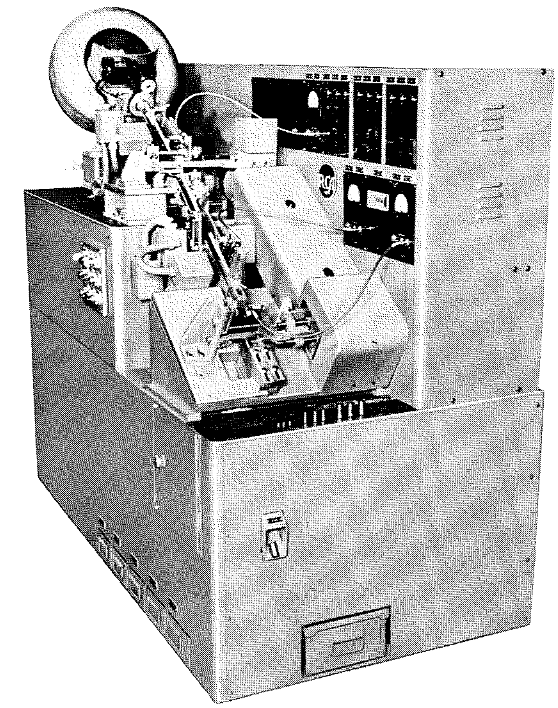


Fig. 5—This machine, now in operation at the Hughes Tool Company in Houston, Texas, tests roller bearings used in earth drills. It checks for hardness, length and OD and segregates the rollers into seven classifications at a rate of 4000 per hour. RCA Rotary Hopper mounted on top of unit feeds and orients the parts.

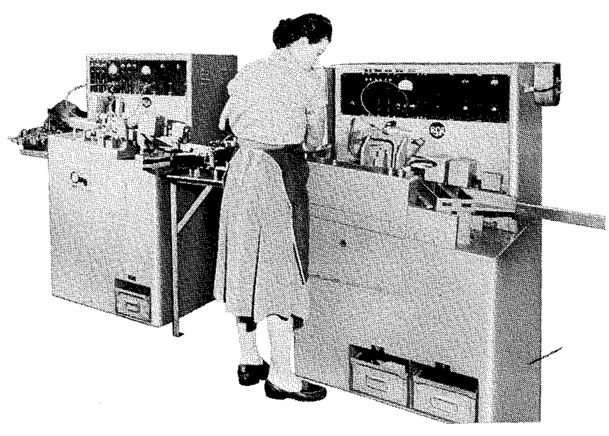


Fig. 6—Two more RCA machines in operation at the Aetna Ball & Roller Bearing Company. Unit at left checks width and OD of bearing races. That at the right inspects assembled roller bearings for radial clearance.

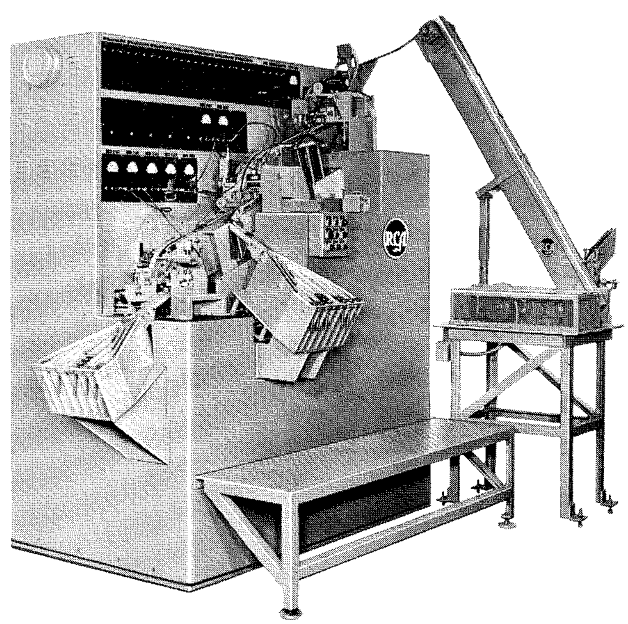


Fig. 7—RCA Automatic Valve Inspection Machine used in most of the automotive plants to inspect valves for concentricity, length, head thickness, stem and groove diameter and location of groove, and separates them into 11 classifications at a rate of 3000 per hour. An RCA automatic valve feeder is shown on the right.

our total sales. Several are shown in the photos illustrating this article.

The third principal type of equipment in the Industrial and Machine Tool Automation section is a newly developed through-feed centerless grinder control. This consists of a control panel, parts gage, segregator and bed advance mechanism. It automatically gages the parts as they leave the grinder and segregates them if out of tolerance. When, because of wheel wear or drift, a series of several oversize parts pass through the gage, the limit controls immediately set the bed infeed actuator in motion. This movement is controlled by a gage which automatically stops the advance when compensation has been made and resets itself for another correction cycle.

A number of these controls have been sold and acceptance is rapidly increasing. One system is in use in the DEP Camden Fabrication Plant where Ed Sharpe, General Foreman, reports little measurable variation in the diameter of parts produced in an eight-hour period. Already a proved success on through-feed centerless grinders, engineering is adapting these controls to infeed and crush-type centerless grinders, as well as ID and surface grinders.

The fourth type of equipment produced by this section is an interesting and widely varied group of custom-designed machines, several of which are shown here. The present trend in industrial automation indicates that this area may well provide our greatest potential in the immediate future.

FUTURE PLANNING

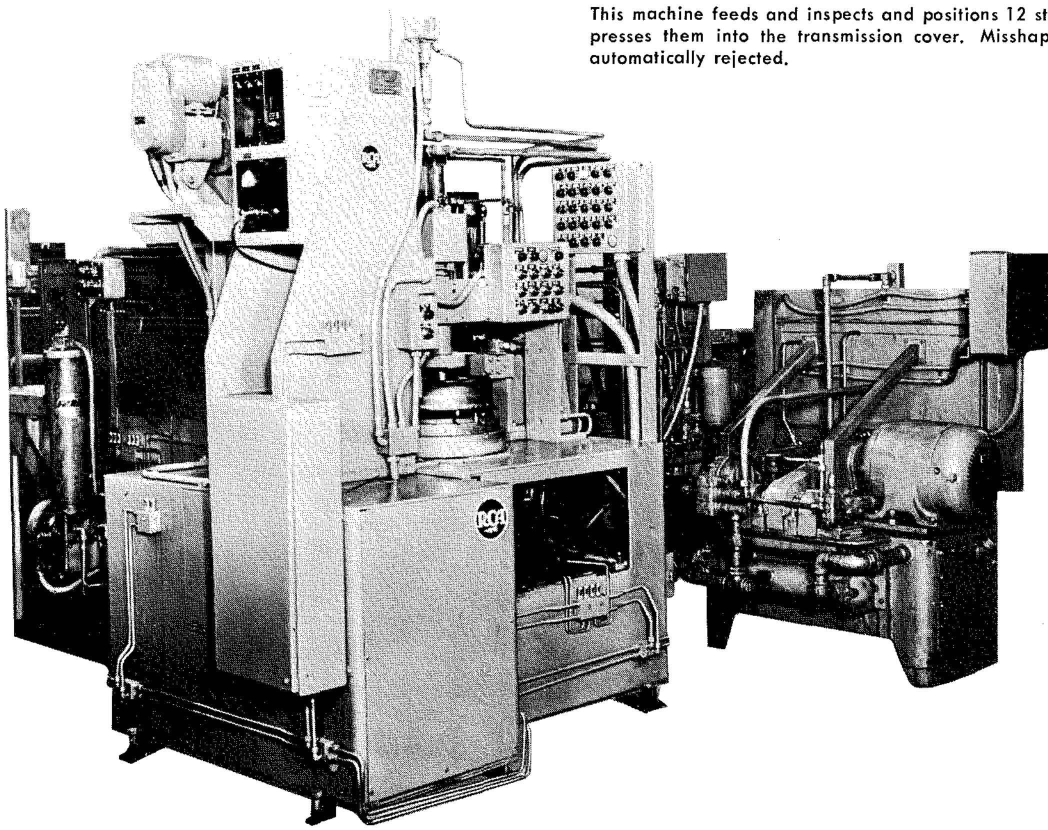
Our advance planning is ambitious in scope and concentrated in time. Our many custom-designed machines already in operation are being re-evaluated for possible modification to permit additional applications. A typical example are our automatic penetration-type hardness testers which have operating rates exceeding any other similar equipment now available. These are being studied to reduce manufacturing cost and to determine the feasibility of adding a direct readout. As another example, many of our automatic inspection machines contain gaging stations which in themselves may be engineered into bench type of production line products. Thus one of the stations in our Valve Inspection Machine checks true roundness within 0.00005 inch at high speed without introducing error due to diameter change from part to part—a technique which may well have many other applications.

The Parts Feeders are being modernized and a number of new types are planned, the first being a newly designed Rotary Feeder which is priced below any comparable unit on the market.

Concurrent with our program of developing standard products, we are organizing our manufacturing facilities so that plant #1, which is the original RCA location, will produce all standard automation equipment, while plant #2, the former Arlin location, will produce custom-designed equipment. The facilities and organization of plant #1 continue to lend themselves to the manufacture of precision electro-mechanical devices and this skill is being left intact as a service to DEP and other RCA divisions.

Although most of the equipments thus far described have been designed

Fig. 8—RCA Automatic Transmission Cover Assembly Machine installed at the General Motors Transmission Plant at Willow-Run. This machine feeds and inspects and positions 12 studs and then presses them into the transmission cover. Misshapen studs are automatically rejected.



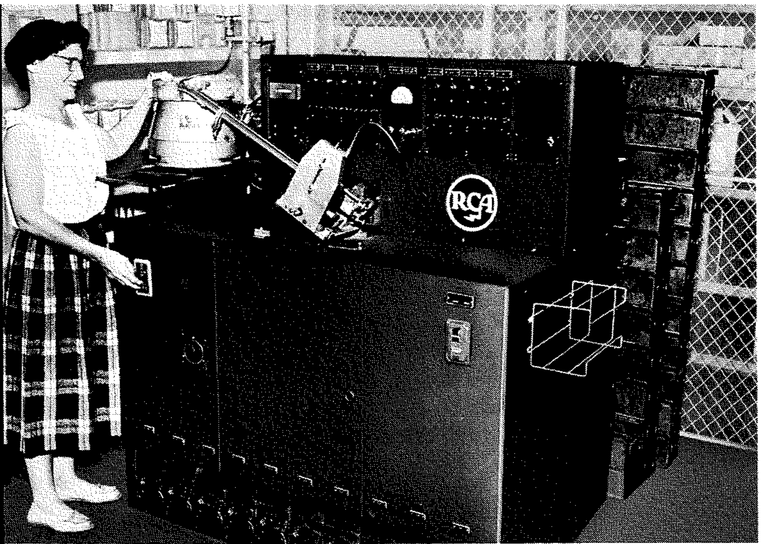


Fig. 9—RCA Roller Bearing Inspection Machine at Shafer Bearing Company, Chicago. This unit inspects hour-glass shaped roller bearings at rate of 6000 per hour (as much as 30 inspectors formerly produced in the same period.

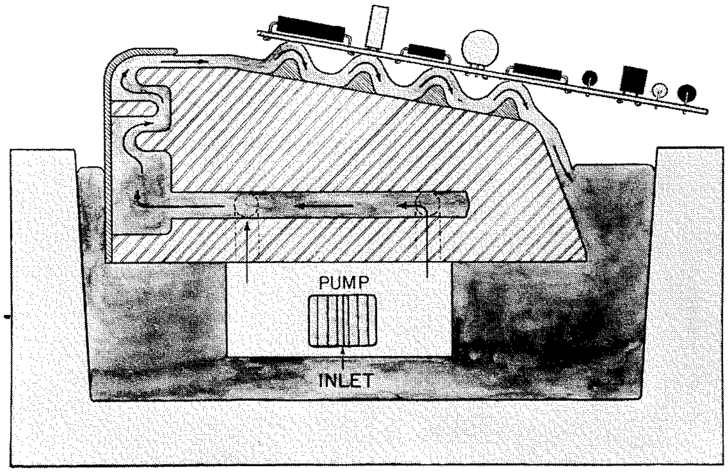


Fig. 11—Cascade Multi-Wave Solderer. Simplified sketch of RCA Cascade Multi-Wave Solderer. Height of solder wave is controlled by the pump.

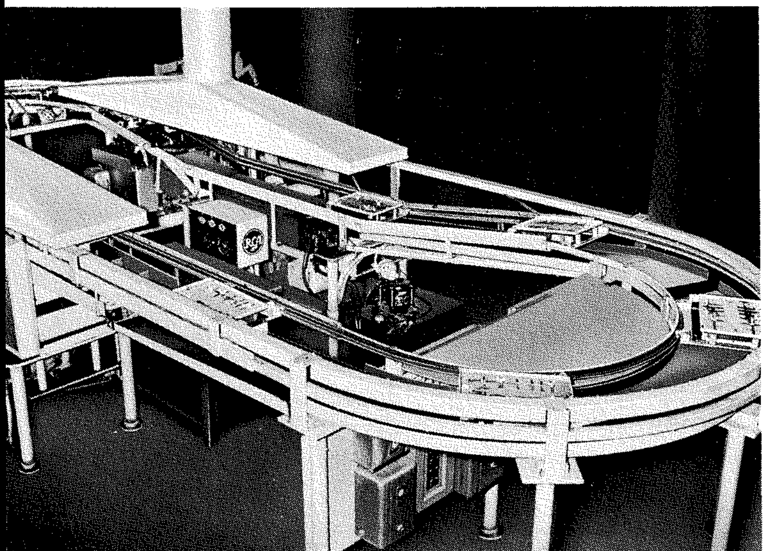


Fig. 10—RCA Automatic Circuit Board Soldering System Pallet loading and unloading station is in left foreground. Exhaust hood in rear hangs over the Foam Fluxer, Pre-Heater and Cascade Multi-Wave Solderer. Cleaning station is at far left.

for the metal working industries, we have also undertaken a number of promising new programs in other areas. One machine we are now building for the DEP Moorestown Plant is a two-axis device which positions an optical comparator along a chassis by reference to a drawing. It inspects the chassis by reference to a drawing dimension with the direct read-out furnished by our inspection equipment. We are already planning a further application of this positioning technique to punch press operations so that the layout operation usually required to produce templates or small lot products can be eliminated.

We have completed the initial design and are now fabricating a Packaging Machine which automatically feeds RCA Victor records into a four-flap carton, seals the carton and attaches a mailing envelope. Although this machine is being built for the Record Department of the Indianapolis Plant, the skills thus acquired will be generally appropriate to the handling of many other products packaged in four-flap cartons.

We have recently been awarded a contract by the Shulton Company to furnish them with a conveyorized automatic assembly machine which will assemble the orifice, shroud, and cap onto a bottle of after-shave lotion at the rate of 9,000 per hour. Our successful bid on this unit has already resulted in an opportunity to quote on another assembly operation for Shulton.

HIGH CUSTOMER ACCEPTANCE

It is becoming increasingly apparent to us that when we succeed in furnishing a new equipment to a customer he becomes interested in utilizing our skills for more of his projects. A good example of this process is the Chrysler Corporation where, because of the proved performance of our custom-designed machines we now have the opportunity to automate their entire Valve Lifter operation. In addition, we are able to exploit our success with a company in a particular industry with other companies in the same industry. Thus a conclusion that can be presently drawn is that in substantial measure our growth depends on the success of our products. The more successful the products, the greater and faster the growth.

It would seem obvious from the above that one of our most important prospecting areas for new products, new applications and ideas should be right within our own corporation. We are sure that many problems throughout RCA's widespread plants have been solved by ingenious devices and techniques which might easily have much broader applications in industry and, as such, could substantially increase the product line of our Industrial and Machine Tool Automation section. In fact, we have already found two such products: one, a Hot-Melt Gun developed by the Findlay Plant and the other, a Cascade Multi-Wave Solder Applicator developed by DEP. We will describe the latter as an example of RCA ingenuity that is developing an excellent market potential.

AUTOMATIC SOLDER APPLICATOR

RCA's new Automatic System for Soldering Single-Sided Printed Circuit Boards provides a reliable, economic means of mechanizing a normally tedious and costly manual operation. Special advantages of this system are: high speed—up to 600 finished assemblies per hour; wide range of board sizes which can be handled; ability to solder even warped panels, and complete absence of bridging or tailing. This system can handle a wide range of board sizes and even those which have lugs or connectors protruding as much as 3/4″ from the underside.

Requiring only one operator to load and unload the assemblies, this system applies flux, preheats the board, solders the assembly and cleans off the excess flux.

The complete unit utilizes a one track conveyor system around which the carriers or pallets move, spaced at regular intervals. Loaded pallets, which are pulled around the conveyor track by connecting links attached to a continuous chain drive, first pass through a foam of flux which thoroughly covers the copper circuits as the pallet passes across the bath. Controlled air jets in the liquid flux cause the foaming. This method has been found far more efficient than brushing, etc., since every portion of the circuit receives the proper amount of flux, regardless of the number of crimped lead wires, etc.

The pallet then moves over an electric heat-controlled radiant plate so the flux becomes hot and tacky, a condition which improves the operation speed and quality of the soldering process.

Next, the heated pallet advances over the soldering unit at an angle of 10°, the bottom of the circuit board coming in contact with four successive waves of solder. It then moves through the cleaner which removes excess flux from the board and the pallet. The boards are then unloaded, and new boards inserted in the pallets for the next cycle.

The Multi-Wave Cascade Solderer consists of a wedge-shaped block whose bottom surface is normally one inch below the solder level of a large capacity thermostatically controlled pot. Solder is pumped through a cavity in the block so that a steady stream emerges from the orifice slot and flows downward in smooth uniform waves over four ridges on the surface of the block. This is sloped at 10° and has side plates which prevent spillage over the edges. Since the fluxed boards pass over the block at an angle of 10°, they are always parallel to the block slope and are lapped by each of the four wave crests successively. This makes 100% coverage certain and permits flux gasses to disperse.

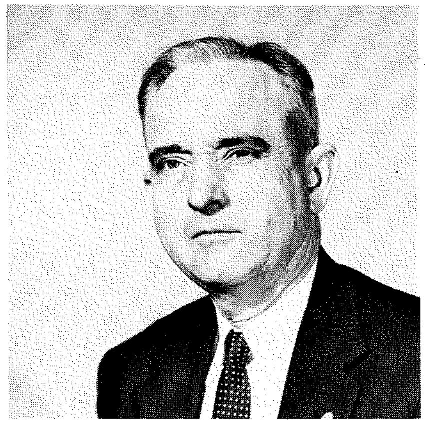
This method offers a number of important advantages. The 450 lbs. pot capacity gives a very stable heat reserve. Dross never comes in contact with the circuit board, but accumulates over the bulk supply which it protects against further oxidation.

It is our hope that this and the succeeding articles on the functions and development of the Industrial and Automation Division will encourage every RCA engineer to call to our attention all such ideas, techniques or products which may have outside applications in the field of industrial automation.

Figs. 12 & 13—Plant #1 showing facilities used for manufacturing of precision electromechanical components and assemblies.

HIGH-SPEED CONTINUOUS-MOTION BEVERAGE INSPECTION MACHINE

By **JOHN J. SYMES**
Industrial and Automation Engineering
Industrial Electronic Products
Camden, N. J.



JOHN J. SYMES was graduated in 1927 with a BS degree in EE from Purdue University, and became associated successively with a theatre chain in a managerial position, a commercial sales engineer for a firm in Cuba, and a manufacturing engineer for the Pan American Mfg. and Supply Corporation.

In 1943 he accepted a position as mechanical engineer with RCA Victor in Indianapolis and was assigned to the Beverage Inspection Engineering project. He moved to Camden in 1946 and set up an expanded engineering activity for beverage inspection of which he became a group leader in 1947.

Mr. Symes was made engineering supervisor of the Beverage Inspection Group in 1950. In 1955 his engineering activity was expanded to include the Metal Detector line.

QUALITY CONTROL HAS become an essential consideration in almost every mechanical activity in this modern day and age. Its importance in the food and beverage industries cannot be too greatly stressed. As processing speeds increase, the personal touch is gradually lost and automatic machinery takes over the tasks once performed by people. Thus the need for planned quality control increases.

When the bottling of beverages was largely a hand operation with a speed of 20 to 30 bottles per minute, inspection of the bottles was a comparatively simple task for the operator to include as one of his multiple responsibilities. On the modern bottling line, however, where one hundred thirty bottles per minute is now considered slow, visual inspection of the product is virtually impossible, unless the line is divided into multiple lines with an inspector on each. This system is both inefficient and expensive. The Coca-Cola Company early recognized the need for automatic inspection to guard the quality of their product of which they are exceedingly and justly proud.

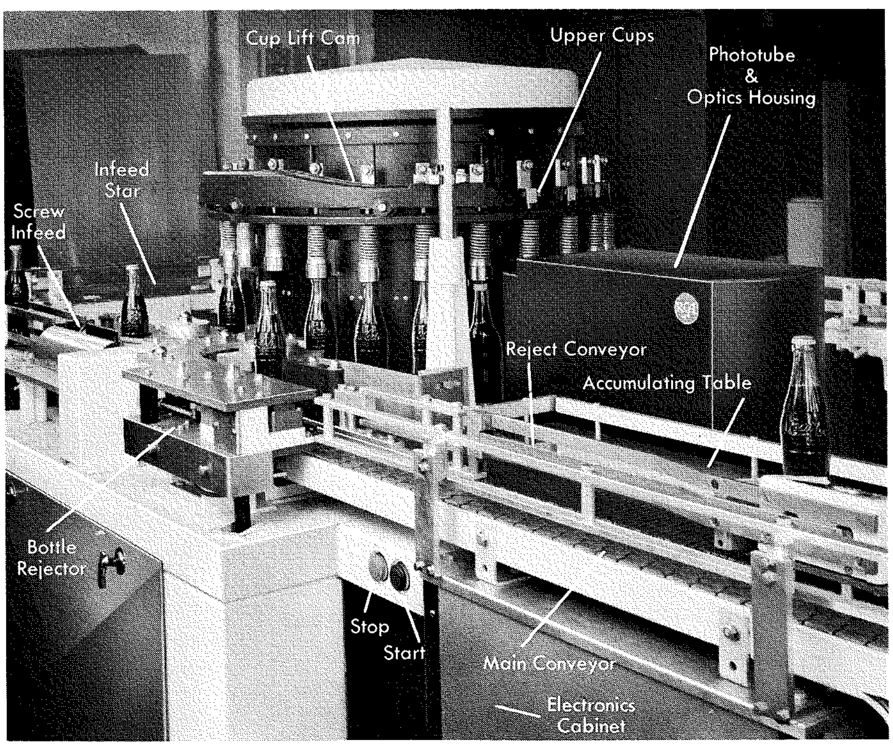
The RCA Electronic Automatic Inspector owes its conception and early beginning to developments carried out by the Coca-Cola Company. For over twelve years, RCA has produced the EIM5A Beverage Inspection Machine with a top speed of 150 bottles per minute. One thousand of these machines are now in daily operation. They are scattered throughout the nation with installations also in Mexico, Canada, Belgium, Holland, Cyprus and Uruguay.

BASIC PRINCIPLE OF OPERATION

The RCA Beverage Inspection Machine automatically inspects transparent beverages put up in round bottles. The recent addition of a bottled antiseptic solution to our growing line of inspected products broadens our field to include liquids other than beverages.

The inspection operation is accomplished by transferring the crowned and filled bottles from the plant line conveyor to a revolving turret of the RCA Beverage Inspection Machine and then causing each bottle to spin on its vertical axis for a brief period. The rotation is brought to an abrupt stop coincidently as the bottle enters the inspection position. Vertical beams of light are projected through the revolving liquid and are focused on the light-sensitive cathode plates of banks of photo tubes. If a foreign particle is moving in the liquid so that it can pass through the light beam, the amount of light falling on the photo tubes will be slightly changed and the resulting change in their electrical output will result in an impulse to a relay which in turn registers the presence of the particle on a mechanical memory. The memory device controls the bottle rejector system. The actual rejection of the bottle occurs when a deflecting barrier is put across its path as it emerges from the turret onto the main conveyor. The barrier directs its travel onto a secondary reject conveyor which conveys the bottle to an accumulating table for rejects.

Fig. 1—Type "S" Beverage Inspection Machine in operation.



HIGHER SPEED NEEDED

With bottling lines now operating as high as 500 bottles per minute and with a tendency to increase speeds still further, the Beverage Inspection Machine speed of 150 bottles per minute was no longer satisfactory. The higher speed lines required three or four machines which was not desirable from the customer's view point. He had to consider initial cost of the machines, conveyor costs, maintenance and service costs and also increased space requirements. Space limitations frequently prevented the installation of beverage-inspection equipment, even though the plant management was eager to provide the automatic quality control afforded by the RCA electronic beverage inspector.

The need for a higher speed machine was known long before a practical solution to the technical problems was found. The speed problem was easily met by the manufacturers of other bottling line equipment by increasing the size of the turrets of their fillers or by widening their washers to accommodate more bottles at a time, but the inspection machine problem was not that simple. The oscillating mechanical system required to provide a time interval in the inspection position to allow time for the particle to make a complete revolution inside the bottle was the major handicap. Fortunately an optical method of obtaining the time delay of the bottle in the inspection position was discovered by Roger E. Schell, development engineer for the Inspection and Control group. With the speed barrier removed, the way was opened for the design of a machine to operate at double the speed of the original.

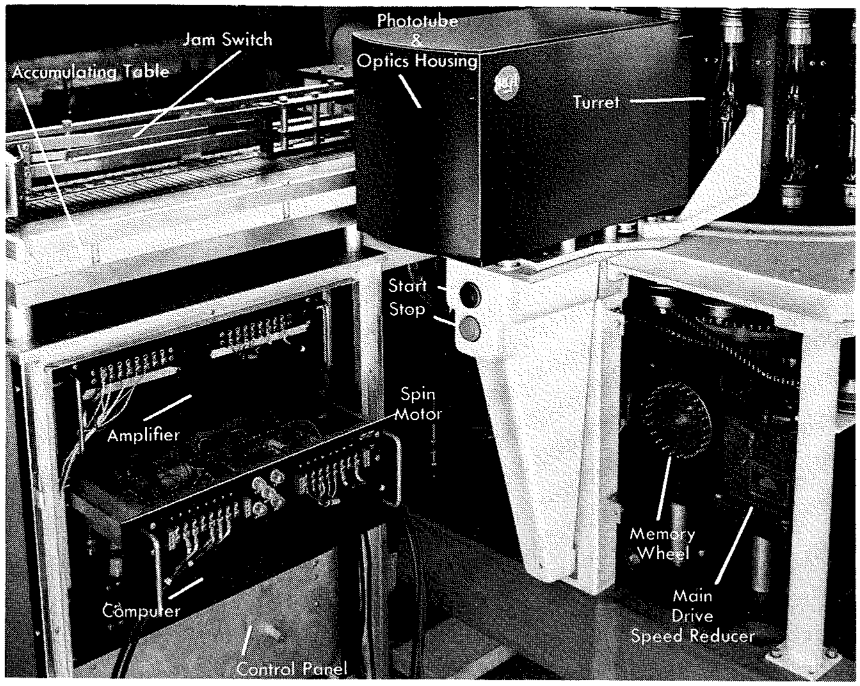


Fig. 2—Side view of the type "S" B.I.M. showing the electronics cabinet on left (pulled out for service); black box houses the optical and phototube system; at right is the main drive gear reduction unit.

TYPE "S" BEVERAGE INSPECTION MACHINE

The new machine now in production has been designated as the type "S" and incorporates many new features, besides increased speed, to give the customer the utmost in reliability and inspection efficiency. The bottle size range has been extended to include the quart bottle.

While the basic principle of inspection has been retained, entirely new optics and data handling circuitry has been designed expressly for the type "S" machine. Special attention has been given to mechanical features aimed at improving the reliability, and simplicity of operation, so necessary in the modern high speed plant where twenty-four hour operation is common practice in the large breweries; and where many different people must be taught to operate and maintain the machine with a bare minimum of instruction.

MECHANICAL OPERATION

The bottle infeed to the turret employs the reliable feed screw system which is used on most first class bottling machinery, and is capable of feeding bottles at speeds in excess of 500 per minute. The screw spaces the bottles into an indexing head called a star wheel. This wheel guides the bottle into the revolving turret where it is clamped immediately between rotatable upper and lower bottle cups. The turret mounting ring for the twenty-four upper cups can be adjusted vertically, through a jack screw mechanism, to accommodate a range of bottle heights from five inches to twelve and a half inches. The entire set of cups can be raised or lowered as a unit in about two minutes. The adjustment is calibrated on an arbitrary numerical scale. Four sizes of lower cup assemblies cover the range of bottle diameters from two inches to three and three-fourths inches. These cup assemblies are complete with their bottle lifting platform and mounting collar. Each cup can be exchanged quickly by simply loosening and tightening one set screw. It takes about ten minutes to replace the full set. The size range has been selected so that the most popular sizes of bottles can be accommodated without having to change cups. The lower bottle cup drive assembly incorporates a self-contained brake and a slipping clutch. The brake is applied to halt the bottle rotation as it enters the inspection position. An adjustable cam applies the brake. A slipping clutch is also a feature of the cup drive assembly. The clutch reduces the wear on the spin belt as it absorbs the shock when the belt engages the spin pulley to start the bottle to spinning. It also absorbs the shock to the belt when the brake is applied. The use of the clutch eliminates a free coasting period, thereby guaranteeing that the particle will be traveling at maximum speed when it modulates the light beam to generate the signal that will eventually cause the bottle's rejection.

When liquids are spun in a bottle, a definite time delay is experienced while the liquid comes up to speed. This delay establishes the time that the bottle must be spun to cause the particle to move freely. The size of the turret and speed of operation are both linked to this time interval and these factors were balanced in arriving at the turret size of twenty-four bottle positions. The inspection position is located three-fourths of the way around the machine from the infeed. This location allows enough time to optically scan the bottle, electronically handle the information and physically reject the bottle while it is still in the control of the inspection machine.

ELECTRONIC INSPECTION

The light beam through the bottle originates from a low-voltage lamp located on the exact center of the turret. Power for the light is d-c in character and is obtained from a three-phase rectifier. A three-phase supply is used to minimize the unfiltered ripple in order to improve the signal-to-noise ratio. A lens system is used to orient the light to vertical narrow twin beams that are projected through the bottle, which is traveling radially around the light source. Stray light is gathered by special cylindrical lens sections and focused on the bottom of the bottle where maximum light intensity is needed to seek out the smallest particles, such as tiny bits of glass and other relatively heavy objects. The twin beams are focused on the phototube cathodes and remain so focused even though they are projected through a moving bottle. Spherical lenses accomplish this optical feat which is the prime reason for the success of the continuous motion inspection principle. Actually there are four light-gathering lens systems each with its own phototube bank. These are arranged one above the other so as to cover the full range of bottle heights in steps. The uppermost lens system is used only for quart size bottles. An adjustable mask is provided to select the lens area required for each height of bottle to be inspected.

The method of connecting the phototubes divides the bottle into two inspection zones. Means are provided for individual control of the sensitivity of each of these zones. This control flexibility allows a high degree of inspection sensitivity in the bottom zone where the majority of the particles are found. These include high density items such as glass, pins, nails, paper clips, stones, bottle caps, etc. A somewhat lesser degree of sensitivity is maintained in the upper inspection zone where bubble and foam disturbances may be found and produce reject signals if the sensitivity is set too high.

BOTTLE REJECT

An inspection rate of three-hundred bottles per minute allows only one fifth of a second for the inspection of each bottle. Part of this time must be used for halting the rotation, the remaining part of the fifth of a second is required for the particle to travel through the light beam on its orbit around the inside of the bottle. No time is available for making use of the information received by the phototube amplifier when the light beam is modulated by a particle orbiting through it. This situation was met by incorporating an electric memory system which records and stores the signal until the bottle has left the inspection position; then the stored information is used to operate a mechanical memory device. This mechanism, through solenoid action, positions a pin in the periphery of a wheel traveling in synchronism with the bottle in the turret. As the bottle is about to emerge from the outfeed starwheel, and again be deposited on the conveyor from whence it was taken upon entering the machine, a barrier, which is controlled by the pin in the memory wheel, shunts the bottle onto a reject accumulating table. The barrier is made up of two arms which are powered by solenoids. The solenoid action is synchronized so that the barriers move into position in a progressive operation ahead of the bottle to be rejected. The progressive action is another feature designed into the machine to make possible the physical rejection of the bottle in the fraction of a second available. A single arm would strike the bottle preceding the reject. The slight lag of one section of the barrier behind the other allows time for the advance bottle to move out of its reach. The reject barrier prevents the bottle leaving the outfeed star until it reaches the reject conveyor. This conveyor is driven by the inspection machine and serves to convey the rejects onto the accumulating table where they are held for the operator's attention.

SAFETY FEATURES

The handling of five bottles every second is bound to result in some jams and other mishaps which could seriously damage the machine were it not amply protected against these conditions. Five bottle-operated switches are located at strategic points along the path the bottles take through the machine. Any one of these switches can open the control circuit and stop the operation through the medium of an electro-magnetic brake on the turret drive motor. The first switch is attached to the bottle guide and protects against bottles being jammed at the infeed screw. The next switch is located in the bottle spin position so that a bottle which behaves abnormally in the spin position, such as one with the neck broken off, will trip the safety gate and actuate the switch. The third switch is located at the outfeed bottle guide; the fourth at the reject bottle guide and the fifth on the accumulating table. This last switch controls a relay which supplies the necessary time delay to restart the machine, after the jam is cleared. This type of jam is caused by an obstruction down the line, possibly at the case packer. The jam interrupts the flow of bottles on the conveyor, causing them to squeeze sideways under the continuous thrust of the conveyor chain which slides under the stalled bottles. The sideways pressure operates the switch through a lever action.

A second type of safety device is a relay-operated overload which opens the control circuit should an abnormal condition arise such as a wedged bottle in the turret or star wheels. This overloads the drive motor thus causing it to draw more current. The increase in current is used to operate the relay through the action of a trigger tube which has been made conductive by an amplified change in the current obtained from a tapped resistor in one leg of the three-phase motor winding.

The time delay required to restart the machine referred to above is necessary to allow a centrifugal mechanism time to accelerate and close another switch which is also in the control circuit. A temporary shunt is placed around this switch by the relay if the machine has been stopped by the switch on the accumulating table, or it is shunted by a push button if manually started. The centrifugally operated switch is a fail-safe feature which stops the machine in case the spin is slowed down or stops through belt failure. The spin system must be up to speed or the centrifugal switch will not close the control circuit. By means of this feature our customers are assured that all bottles inspected have been properly prepared for inspection.

When the machine has been stopped and restarted, bottles in the spin position may not all have been properly spun therefore an electronic circuit causes the first three or four bottles through the inspection position, after a shut down, to be automatically rejected. This is one of the features contributing to the reliability of performance.

Another of the fail-safe features, which has characterized the current model and the new high-speed continuous motion machine, is the rejection of all bottles if the solenoid coil fails in either the mechanical memory or the bottle rejector mechanism.

One of the most unusual features peculiar to the RCA Beverage Inspection Machine is a self-checking cycle occurring after each bottle is inspected. A synthetic signal is imposed on the system which causes rejection of the bottle just inspected regardless of its freedom from foreign particles, unless the effect of the signal is nullified by a balanced bridge circuit which can only exist if the timing switch, the exciter lamp and the phototube amplifier system are all functioning normally. Thus these features are automatically checked up to 300 times per minute and bottles are accepted as good only if the machine is in good inspecting condition.

DESIGN CONSIDERATIONS

Long experience in operating electronic equipment in bottling plants has taught lessons influential in the design of model "S" machine. Still remembered are the "headaches" experienced in the early days of electronic inspection from sporadic signals causing bottles to be rejected for no apparent cause. After a considerable amount of work in damp and crowded bottling rooms, the trouble was traced to the random parading of insects across the high-impedance signal terminals on the phototube amplifier. This experience has led to the careful sealing of all openings in the electronic equipment to prevent the entrance of house-hunting intruders into the snug and warm confines of an amplifier chassis.

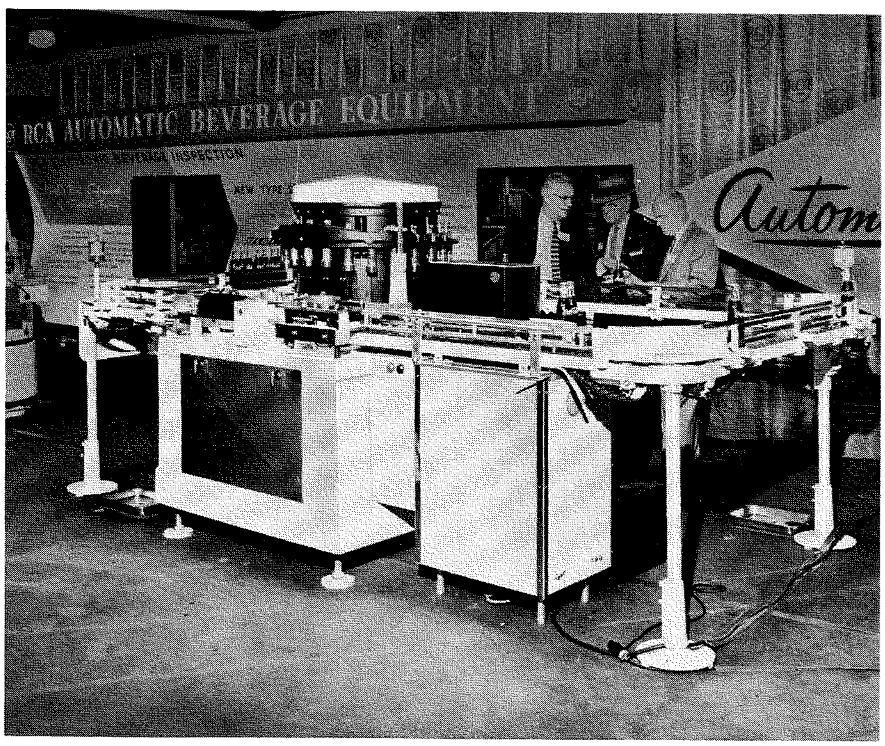
Corrosion has always been an enemy of switch contacts, especially when the circuits interrupted carry very light currents. The atmosphere in bottling plants is a very corrosive source of trouble. The delicate switching operations on the "S" machine are performed by transistor switching circuits, thus eliminating completely all mechanical contacts handling light currents. The actual inspection timing is controlled by a simple three-contact switch which sets up the inspection cycle each time that a bottle enters the inspection area. The switch is located in a protected spot under the turret and is directly actuated by a roller attached to each bottle position. It carries sufficiently heavy currents to avoid contact problems.

The phototube amplifier has dual channels, one for the top inspection zone and the other for the bottom zone. This permits the sensitivity of each zone to be selected in accordance with bottling conditions. Maximum inspection efficiency can be obtained when bubbling and foaming in the bottle is non-existent.

The inspection of beer in the familiar amber bottle has been made feasible by providing the amplifier with an automatic gain control which adjusts the gain in accordance to the transmitted light. The gain is inversely proportional to the light transmitted which varies from bottle to bottle. A light amber bottle may pass as much as twenty times the light from the same light source that will pass through a dark amber bottle. The adjusted gain assures the same degree of inspection in the dark colored bottle as that received by a light bottle.

Serviceability has been given a great deal of attention in the "S" machine. Electronic equipment, rectifier, motor controls and safety circuits have been concentrated in one cabinet which forms a base for the accumulating table. The amplifier and signal handling chassis are the slide-out type arranged so that all wiring and small components face up, with the tubes and large components hanging down. This allows the service man to test circuits without having to turn the unit over. A d-c voltmeter has been provided for control of the exciter lamp supply. This control is used by operating personnel to adjust the light intensity to conform to the product density. Orange soda requires a high intensity light while some colorless beverages require a minimum intensity. All control switches have been put within easy reach and a 110-volt convenience outlet which has been provided for a soldering iron, trouble lamp, meter, etc. The optical and phototube assemblies and the memory system are all close at hand.

View of complete beverage inspection machine as displayed at a recent National Convention.



ELECTRONIC INSPECTION IN THE BOTTLING PLANT

Electronic inspection has been firmly established in the bottling industry. It serves a useful purpose of untold value in preventing contaminated products from reaching the consumer. Not only does the "BIM", as it has been nicknamed, locate and segregate bottles containing foreign material visible to the eye but it also detects contaminants such as caustic, grease, etc., which may give the product an "off taste" but not be readily recognized. This type of detection results from a secondary effect. A foreign substance such as caustic or grease carried over from the bottle washer causes tiny gas bubbles to form and rise in the liquid. The electronic inspector "sees" these bubbles and causes the bottle to be rejected. One enthusiatic bottler confided that, were it not for the watchful "Electric Eye" ten thousand cases of product with a caustic taste would have been shipped to his customers. He found that the bottle rinsing mechanism was not doing its job and all bottles coming from the washer had a coating of caustic on the inside. Many cases similar to this have been brought to our attention and are further reasons why "BIM" has had a wide acceptance and why the engineers responsible for its design and production are enthusiastic about their charge.

Did you say, "Why call it the type 'S'?" The answer is simple—when you have Schell, Schuler, Seabert, Shoffner, Simonsick, and Symes all with a hand in its engineering, what else? And as for Webster and Wyche who were also on the team, the "S" is silent, of course!

PERSONALLY CARRIED COMMUNICATIONS EQUIPMENT

by **LIONAL BROWN**

Mobile Communications Engineering
Industrial Electronic Products
Camden, N. J.

SOME TIME AGO, the Mobile Communications Group of the Communications Engineering activity was presented with the problem of designing and producing a complete two-way radio system that was to be as small as possible and still would maintain a high degree of performance and reliability. In addition, it had to be completely compatible with existing mobile communications equipment systems. Specific sizes and performance specifications were established. As a result, the company is now in production on a complete line of high- and low-band personally carried communications equipment, small and light enough to be carried comfortably on a belt around the waist. Some compromises with the ultimate were necessitated, of course, due to technical and economical considerations, but the equipment to be described does represent an excellent compromise and incorporates many changes found to be desirable after months of field testing on prototype models. Fig. 1 indicates an actual application of the complete equipment in use. Normally, both transmitter and receiver are worn by the same person; however, certain requirements are fulfilled by the use of either one when utilized separately.

THE "PERSONAL FONE" RECEIVER

The receiver is completely transistorized and its physical size is 6½ inches long by 2¾ inches wide by one-inch thick, and its weight is ten ounces. The case is of non-breakable plastic.

At present, there are four different versions of the receiver in production. Two models, which are designated as the CPC-R2 and the CPC-R3, operate in the frequency range from 148-174 mc, and the CPF-R2 and the CPF-R3 which operate in the low band from 25-54 mc. The CPC-R2 and the CPF-R2 were designed for voice operation with a noise-operated squelch, while the other models, the CPC-R3 and the CPF-R3, provide selective calling and contain a decoder with 66 separate combinations, in addition to a buzzer

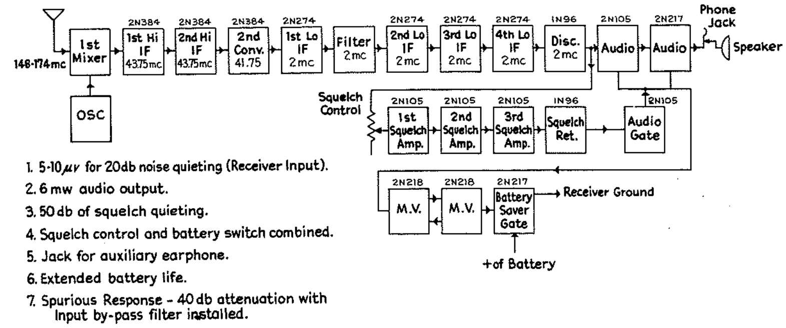


Fig. 2—Block diagram of high-band receiver indicating the various circuit functions and path sequence.

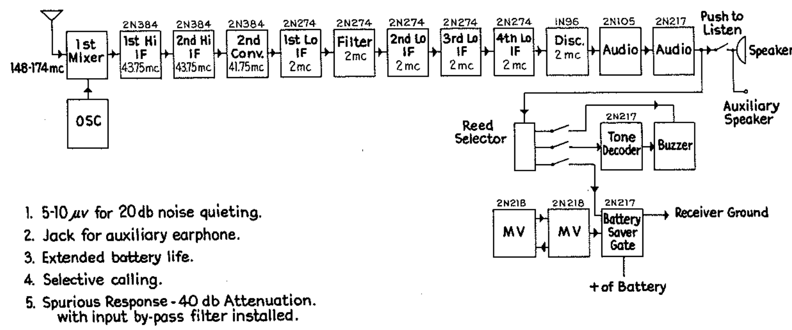


Fig. 3—The 148-174 mc selective calling model showing the squelch function replaced with a multi-reed resonant relay.

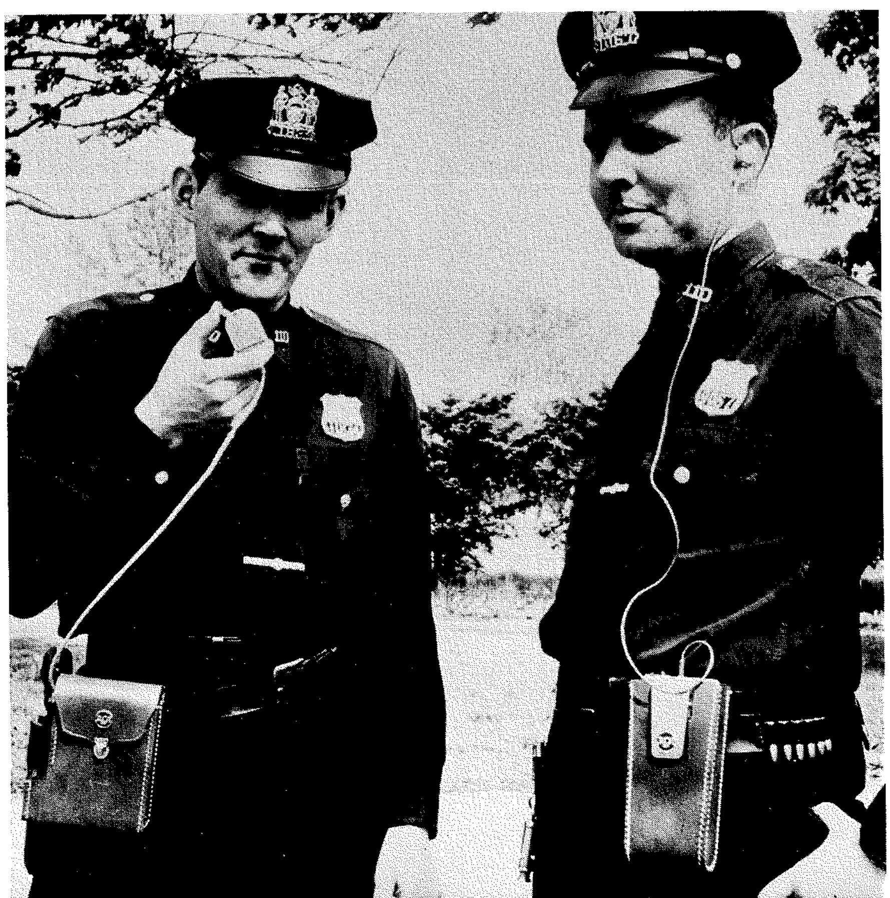


Fig. 1—New York City Patrolmen demonstrate the two-way radio system which will enable them to become walking radio stations as they patrol the city's sprawling 34,000-acre park system.

which notifies the user when the properly coded call has been received. A visual signal is also recorded which serves the purpose of notifying the user if the receiver has been called during his absence. Voice communications can be received by pushing a push-to-listen switch.

The circuitry of the units is modular in construction, and each primary circuit function is an individual module in itself. Each module connects to a common base module or "mother board." A module consists of one or more printed circuit boards on which the active and passive circuit components are assembled.

Fabrication of the printed boards and the punching of component mounting holes is an entirely automatic process. Components, for the time being, are hand assembled. After the components have been assembled onto the board, the wiring side of the assembly is solder dipped.

The CPC-R2 receiver is basically a double superheterodyne type, using a separate crystal-controlled oscillator as the source of injection voltage for each of the two mixers. A total of fifteen transistors are used to achieve a high order of performance and to maintain this degree of performance with time. Fig. 2 shows a block diagram of this particular unit.

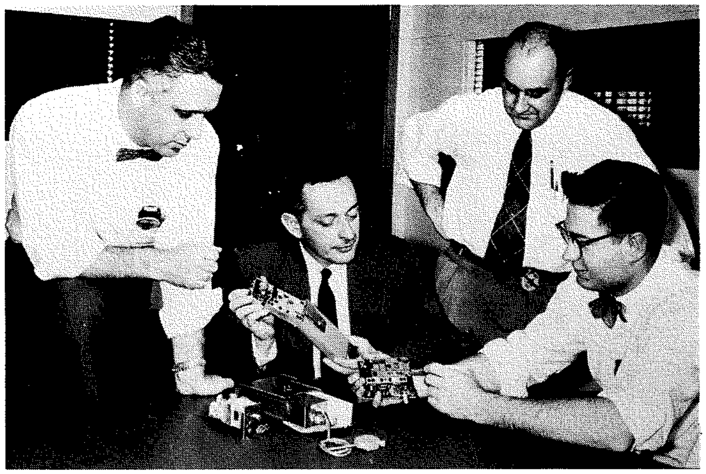
The received signal, in conjunction with the first crystal-oscillator high-frequency multiplier injection voltage, is fed into a first mixer. The difference frequency of 43.75 mc is then sent through two stages of high i-f amplification into a second converter in addition to the voltage of a second crystal oscillator. This difference frequency of 2 mc is fed through four stages of low i-f amplification in addition to a fixed-tuned bandpass filter inserted between the first and second stages. After detection in the discriminator, the detected signal is separated in accordance to frequency spectrum and directed into two separate paths. The voice bandpath is fed to a common collector stage which transforms the high-impedance discriminator to match the low impedance input of the audio output amplification stage which drives the speaker. Frequencies in the range beyond the voice band spectrum of approximately 3 kc are directed to the noise amplifier to provide audio squelch. This section consists of three separate stages of amplification. The noise signal is rectified and the resultant d-c voltage is used to control the bias of a switch transistor whose function is to turn the primary power "on" and "off" to the two audio stages in accordance with the presence or absence of a desired signal. With no signal, the last i-f limiter stage is saturated with noise. The rectified noise voltage is of a high value and the transistor switch is biased "off." When a signal is received, the noise output reduces considerably and the rectified noise voltage becomes nil, allowing the transistor switch to conduct and to apply voltage to the audio output transistors, which in turn permits signals to be heard from the speaker. In the absence of a signal, no audible sound is heard.

If desired, an additional feature may be incorporated into the unit which we choose to call a "battery saver." The function of this module is to prolong the life of the battery. It consists of two transistors in a "flip-flop" circuit functioning to control the operating condition of a second transistor switch, whose purpose is to "turn-on" the entire receiver for a fraction of a second in order to ascertain if a desired signal is available to be received. If there is no desired signal available, it "turns-off" the receiver and waits for approximately two seconds to sample the channel again. When it finds a desired signal, the squelch switch transistor will "turn-on" and connect a signal to the multivibrator, which places the second transistor switch in the "on" state as long as a signal of sufficient magnitude is received to produce noise quieting. When the signal is removed, noise appears, which "turns-off" the first switch and causes the cycling to continue. This feature results in considerable user economy, as battery life is prolonged in the order of eight to ten times.

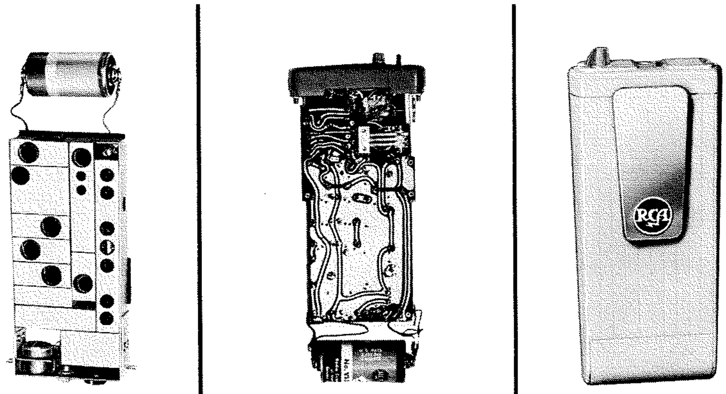
The CPC-R3 selective calling model is very similar to the voice receiver, with the differences indicated by the block diagram of Fig. 3. The only difference, you will note, is that the squelch function has been replaced with a multi-reed resonant relay and that information of a different nature is used to activate and de-activate the battery saver.

The battery saver causes the receiver to sample the channel to which it is tuned in the same manner that the voice-squelch receiver does. The presence of a signal on its channel will not, however, cause the transistor switch to operate. This function is selective and is activated only when the signal is modulated with a specific tone frequency. When this specific tone frequency is received, one of the reeds on the multi-resonant reed relay, which is generally the same frequency on all receivers, vibrates. This results in a small current being applied

"TALKING SATELLITE" USES RCA "PERSONALFONE"



President Eisenhower's speech broadcast from an Atlas missile circling the Earth was eloquent proof of this country's continuing progress in space technology. A modified "Personalfone" transmitter and receiver were used to provide the first two-way radio link with outer space. From the left, G. A. Robertson, R. A. Beers, Leader (holding "Personalfone" receiver), Lional Brown, and C. A. Michel (holding modified "Personalfone" receiver used in Atlas missile).



(a) (b) (c)

Fig. 4—(a) View of CPC-R3 receiver showing the layout of the various modules which house the component compliment of each particular circuit. (b) Back-side view of (a) depicting the connection of the modules to the "mother board." (c) Packaged view of the CPC-R3 receiver.

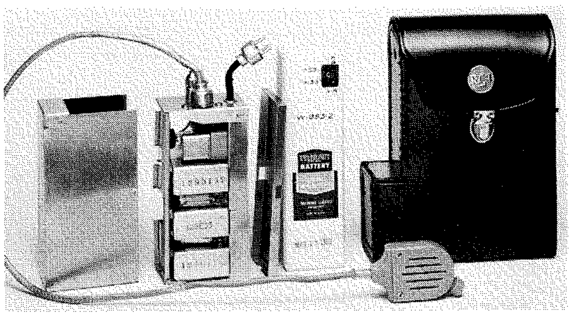


Fig. 5—View of CPC-T1A with transmitter exposed.

through its contacts to the transistor switch. The transistor switch remains conducting as long as this voltage is present and causes the receiver to remain in the continuous operate condition. In order to operate the "buzzer" the correct combination of two other simultaneous tones are required. When the proper tones are received, the other two reeds on the multi-reed relay will also vibrate, causing a small current to pass through the reed relay contacts. This current activates a second transistor switch which unlatches the buzzer. The buzzer will operate for several seconds. A red indicator also moves into position beneath a transparent plastic window in the case to provide visual indication that the receiver has been called. If a voice message is to be received, the "push-to-listen" switch is then activated manually to connect the speaker to the audio amplifier. Resetting the indicator flag automatically rewinds the mechanical buzzer. The buzzer has a capacity of several dozen calls on one winding.

Fig. 4, a front and back view of the unit, giving an indication of the modular construction and their connection to the "mother board," and a completely packaged view of the receiver.

The operation of the 25-54 mc receivers is similar to those of the high-band receivers, except that a total of 13 transistors are used in a superheterodyne circuit of the single conversion type, as compared to double conversion for the 150 mc receivers. Two stages of radio-frequency amplification replace the high i-f amplifiers, which gives a big assist in increasing the sensitivity down to one microvolt for 20 db of noise quieting.

The CPF-R3 employs the same circuitry with the exception that the squelch circuits are replaced by the decoder as shown in Fig. 3.

At present, there are two types of batteries available for the receivers. The first type is pictured in Fig. 4 and is a type of LeClanche cell with a special formulation and will operate the set for approximately 40 hours on an eight-hour duty cycle. The other is a rechargeable nickel cadmium cell which can power the set for approximately 7-8 hours continuous operation before a recharging cycle is necessary. As mentioned previously, these operating times can be increased considerably by the addition of the "battery saver" multivibrator circuit.

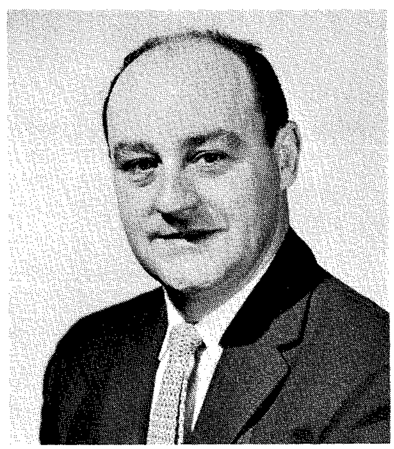
THE "PERSONAL FONE" TRANSMITTER

The associated transmitter is housed in a matching leather case which serves the combined purpose of tying the separate units together in addition to providing protection and being a carrying case as well. Overall dimensions are $6\frac{1}{2}$ inches long by 4 inches wide by $1\frac{3}{4}$ inches thick and the weight is 28 ounces.

Fig. 5 shows the transmitter and its major component parts. A brief description of each is included.

Fig. 6 is a block diagram of the CPC-T1A high-band transmitter (148-174 mc). This unit utilizes seven sub-miniature type tubes in a conventional crystal-controlled, phase-modulated, frequency multiplier type of circuitry. A Pierce oscillator operating in the region of 10 mc is multiplied 16 times in order to achieve the required operating frequency.

The output of a carbon microphone is transformer coupled to the phase modulator and this output is of sufficient amplitude to modulate the transmitter ± 5 kc when the microphone is held approximately two inches away from the mouth and modulated with a normal talking voice. Four frequency doubler stages follow the modulator, with the fourth stage driving a 6397 sub-miniature power amplifier which will deliver a minimum of 250 mw over the above mentioned frequency range into a 50 ohm load. A pi-network is used to couple the output of the power amplifier to the antenna



LIONAL BROWN received his BEE degree from the University of Virginia in 1948 and studied toward his Master's degree at the University of Pennsylvania. From 1948 to 1953 he was employed in the Instrument Research Division of the National Advisory Committee for Aeronautics at Hampton, Va.

Mr. Brown joined RCA in 1953 and is presently a design engineer in the Mobile Communications group of the Communications Engineering Department of IEP. He is a Senior Member of the IRE.

and to further attenuate the higher order spurious frequencies.

Although the transmitter is composed entirely of tubes, the total power consumption is less than 3 watts at 0.9 initial battery voltage. The battery used to power the transmitter is composed of high-capacity LeClanche type cells. Its capacity can be expressed in a variety of ways. However, the one that meets the most practical approach is to say that it will power the transmitter for a minimum of 2000 ten-second transmissions based on a 2% duty cycle, with the criterion of cutoff based on a 3 db drop in power output.

In the near future, a d-c to d-c converter powered by a rechargeable battery will be available as an optional or replacement item in place of the dry cell battery.

As might be expected, one very difficult requirement of the unit was to find a satisfactory antenna that did not protrude or hinder the operator in any manner. Obviously, the most efficient configuration for this type of service would be a quarter-wave vertical whip, mounted in such a way as to be least affected by the operator. As this could not be the case, resultant field tests indicated that satisfactory performance could be obtained if the microphone cord itself could be used in some manner to radiate the r-f energy. As a result of these tests, the antenna consists of a single piece of wire, which is machine woven in a wide mesh fashion over the microphone cord. This wide mesh weave has the tendency of reducing the capacitance between the antenna and microphone cable and also exhibits greatly reduced variations when held close to the body.

The CPF-T1A low-band transmitter fits in the same carrying case as the higher-frequency version. Fig. 7 is a block diagram showing the tube line-up and multiplication sequence. The Pierce oscillator operates in the frequency range from 2-3 mc and the multiplication is 24 times. The same number of tubes are used but the power consumption is less, mainly due to the lowered filament drain. Power output is in the order of 500 milliwatts when tuned into a 50 ohm load.

Antenna efficiency is somewhat lower than that of its higher-frequency counterpart, but the higher power output in addition to the increased sensitivity of the receiving equipment helps to compensate for this deficiency.

APPLICATIONS

As mentioned previously, one of the primary requisites in the design of this equipment was that it be completely compatible with existing mobile communications equipment. This, of course, means that a very useful extension to existing services can be provided. As an example, consider the foot patrolman whose duty it is to cover a certain area at regular intervals. A roving patrol car is usually assigned to an area covered by several patrolmen. Should a disturbance occur in any one of the several "beats" and assistance is required, the patrolman must go to the nearest call box and call the main station; the main station in turn notifies the patrol car and the patrol car must then go to the scene of the disturbance. When Personalfone is added, the patrolman contacts the patrol car directly and the car can then contact the main station while on its way to the required destination. The several minutes saved could conceivably make a great deal of difference in the obtained results. This is but one of several examples that could be cited which indicate the versatility that can be added to any existing system.

Another mode of operation should be mentioned and that consists of the use of a "booster" station which serves the purpose of extending the operating range between personally carried units themselves and, in addition, ties in all existing mobile units to a common control base station. The only disadvantage is that it requires the use of two frequencies.

In this mode of operation, a standard base station is slightly modified by the addition of a carrier-operated relay panel whose purpose is to automatically trigger the transmitter when a signal of sufficient level is received. This signal is normally determined by the sensitivity of the receiver. Any signal thus received is rebroadcast by the transmitter and is available for reception by any other receiver within its range.

If the base station receiver is on frequency F_1 and the transmitter on frequency F_2, and all mobile and personally carried receivers are on frequency F_2 and their associated transmitters are on frequency F_1, this means that all transmissions must go through the main station to be rebroadcast. All conversations can thus be monitored and controlled at the central point.

CONCLUSION

The equipment just described is expected to be a forerunner of a complete line of microminiature products for all of the land-mobile communications bands. Some day in the foreseeable future, it should be possible for one person to talk to any other person, almost regardless of where he may be, with convenient pocket-carried, two-way radio communications equipment.

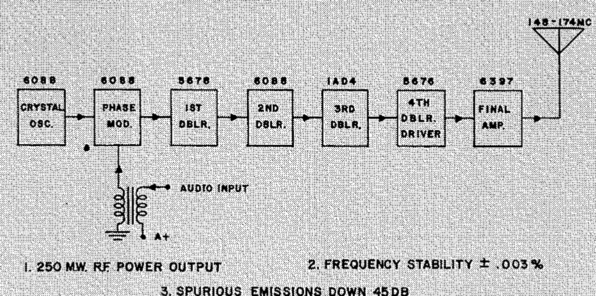


Fig. 6—Block diagram of the high-band transmitter indicating the functions of the several subminiature tubes.

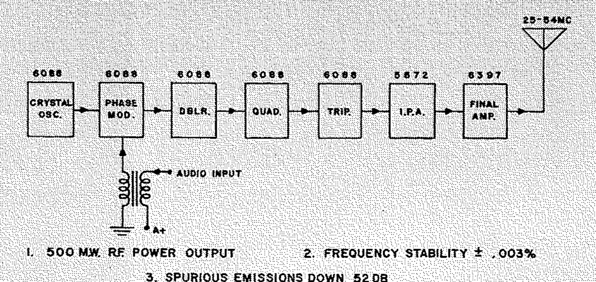


Fig. 7—Block diagram of low-band transmitter.

ENGINEERING IN RCA COMMUNICATIONS, INC.

by

D. S. RAU

Vice President & Chief Engineer
RCA Communications, Inc.
Industrial Electronic Products
New York, N. Y.

High-Power Transmitting Station, Rocky Point, Long Island (antennas shown have since been replaced).

RCA COMMUNICATIONS, INC., being an operating company, devotes its engineering effort primarily to the operation, improvement, and expansion of its communications services. These services consist of the transmission and reception of radiograms, addressed program material and radiophotos, and the furnishing of leased channel and TEX facilities to subscribers.

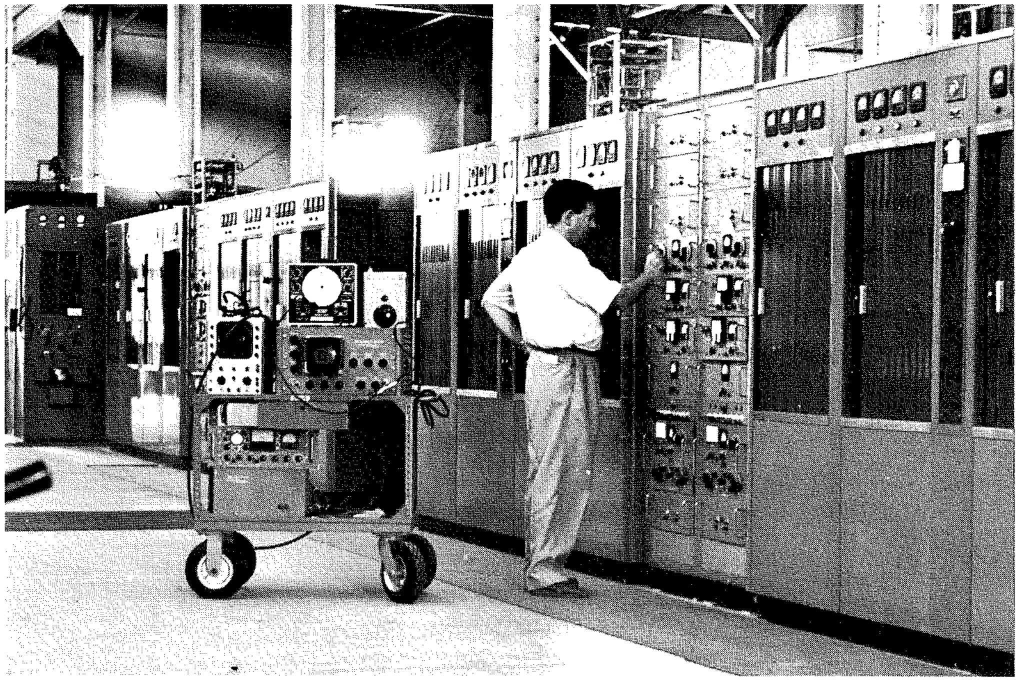
Engineers of this Company are engaged in the following activities:—

Planning, Equipment and System Design, Installation Design, Construction, and Operation and Maintenance.

COMMUNICATIONS SYSTEMS PLANNING

Planning long distance communications systems as operated by this Company requires a special kind of engineering talent to match plant facilities to the forces of nature in order to deliver the communications product rapidly, accurately, and economically. The product, in this case, is intelligence applied at one point and delivered at another point. The planning engineers must know the pecularities of the ionosphere and its effect on propagation and be able to translate these effects into useable frequencies. They must know the characteristics of plant components and their effect on transmission, and be able to reconcile them with the effects of propagation. They must weigh the effects of transmitter power, type of emission, fading, multipath, keying speed, distortion, antenna patterns, noise, diurnal and seasonal ionosphere heights, and many more conditions which can have more or less influence on the delivery of reliable communications.

Engineering a specific communication circuit in RCA Communications, Inc. first requires determination of the radio path between the points to be interconnected, for sometimes the direct path is far from being the best. North Atlantic paths, for example, cross the polar auroral zone which makes high-frequency communications unreliable at times. An indirect path, via Tangier or other suitably located relay point, will be better, and automatic relays make such indirect paths as effective, time-wise, as a direct path. Next comes determination of the range of frequencies required to cover not only daily and seasonal variations but also those of the 11-year sunspot cycle. Distance, volume of traffic to be handled, and often desires of the foreign correspondent, determine the type of emission. A low-volume circuit can be adequately handled by a fairly low-power frequency-shifted CW circuit, while a large volume, long distance circuit may require high-power single-sideband.



Installation of single-sideband transmitters at Rocky Point high-power station (RCA BHF-10-A transmitters with SSB adapters).

EQUIPMENT AND SYSTEM DESIGN

The Equipment and Systems Design engineers take over here and specify the particular internal system and type of apparatus to meet the circuit requirements. Such specifications involve the terminal office facilities as well as those for the transmitting and receiving stations and the interconnecting links between the stations. A station system includes (besides the major pieces of apparatus) the auxiliary devices, adjusting and monitoring equipment, and even patching facilities in order to produce a workable entity. At a terminal office, for example, in addition to the basic error-correcting, time-division multiplex terminal, there must be various pieces of perforated-tape handling machinery, automatic numbering devices, relay assemblies, oscillators, keyers, tone signal converters, extensors, patching panels, and more.

In general, our engineers do not have design responsibility for major apparatus other than to specify operational and engineering requirements. Manufacturing vendors, mainly RCA-IEP manufacturing groups, take on that responsibility after development, usually, by the RCA Laboratories' Radio Research group. However, our own engineers thoroughly test equipment designed and made by others, and they design improvements and modifications considered desirable for our type of operation. There are notable exceptions to the above general statement—occasionally our engineers do undertake a major development. For example, a Converter System was designed which made it possible to interconnect the USA TWX network with the overseas TELEX networks which use a different keyboard on their teleprinters. All antennas (high frequency and medium frequency) used within our system, are also designed in their entirety by our own engineers.

INSTALLATION DESIGN

Installation design is the next step. This involves the location and interconnection of major and auxiliary units of equipment with consideration in the design of such pertinent things as floor loading, ventilation, power supply, lighting, and the need for efficient supervision, adjustment, monitoring and maintenance after installation. All of the aforementioned can have some bearing on the installation design.

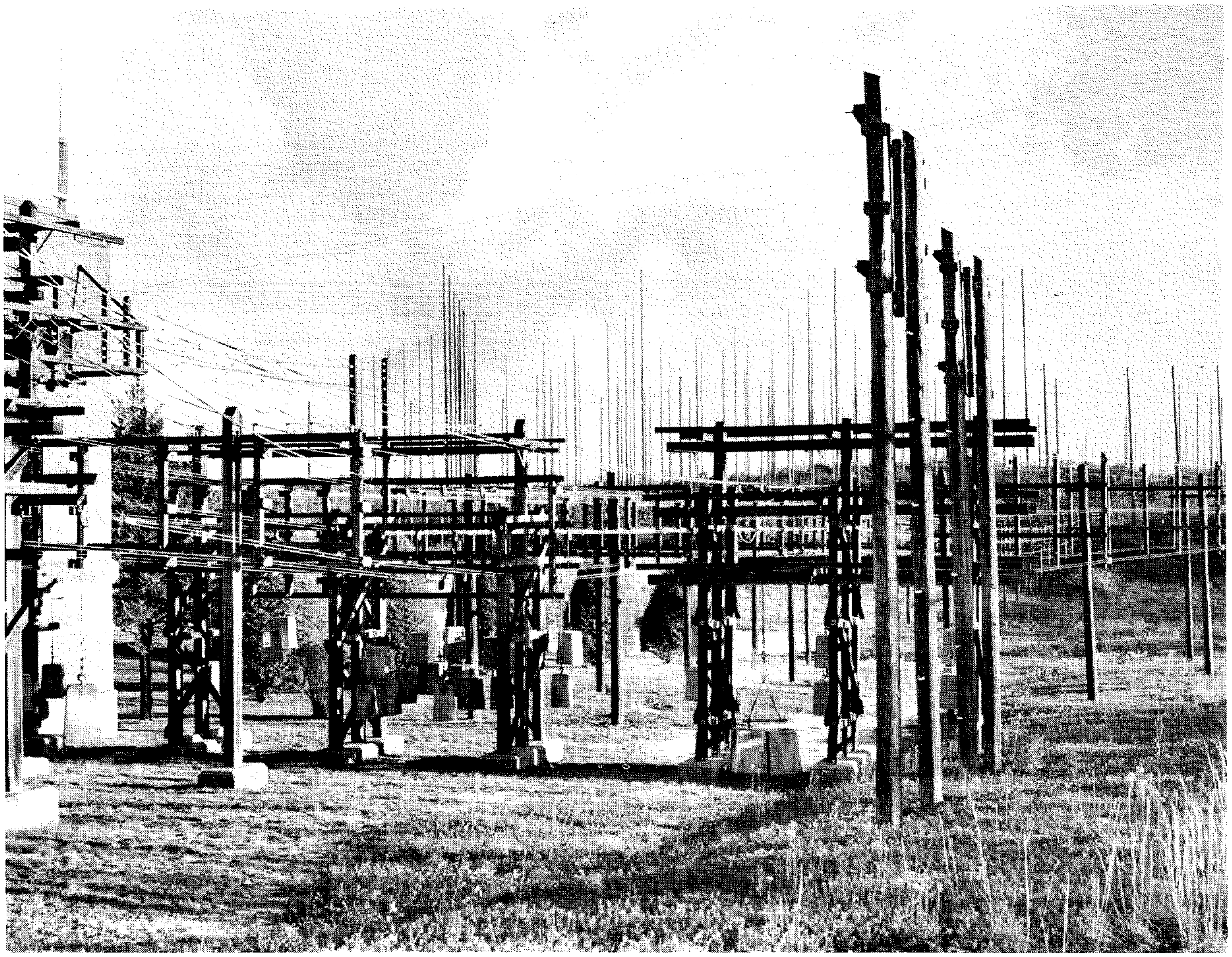
For new stations there is the important element of site location, with due consideration not only to the technical requirements for good horizon and ground characteristics, but also to the housekeeping items such as: proximity to good roads, power supply, control lines, water supply, cost of land, and taxes. Other considerations such as availability of labor, availability of supplies, and accommodations for transferred personnel are involved in the original planning.

Since communications is a continually growing industry, installation planning cannot be limited to what will care for immediate requirements only, but must for economy and continuity of service consider requirements for many years ahead. Long-range planning is the engineering goal. Although sometimes not achieved because of expediency, when the goal is accomplished, a tremendous boon is rendered to Commercial Activities that can then sell services to meet customer demands without delays, and to Operating Activities that can then provide the required facilities by merely adding the additional equipment. Such a program has been particularly effective in connection with antenna layouts. At several of our stations with from 50 to 100 antennas, like Rocky Point for example, orderly planning and construction results in a balance between effective utilization of valuable acreage and minimum coupling between antennas.

SYSTEM CONSTRUCTION

With design completed, Construction takes over. Directed and guided by a small headquarters staff, field forces

Setting up a rhombic antenna apex pole (Rocky Point).



Antenna transmission line termination structures at Riverhead Receiving Station.

under the immediate supervision of station engineers implement the instructions provided by specifications, engineering notices, and drawings. Field forces may be members of permanent station staffs, or supplemented by contractors if projects are large.

It is appropriate to mention at this point that capable communications engineers are attached to the staffs of our central offices and radio stations. These engineers are available not only for their regular operating and construction duties but can be called upon for assistance in connection with equipment, system, and installation design problems. Their assistance is particularly valuable in that it provides the important operating viewpoint so necessary for best facilities design. We feel that the supremacy of RCA Communications, Inc. in its field can be attributed in great part to the capability of its operating personnel

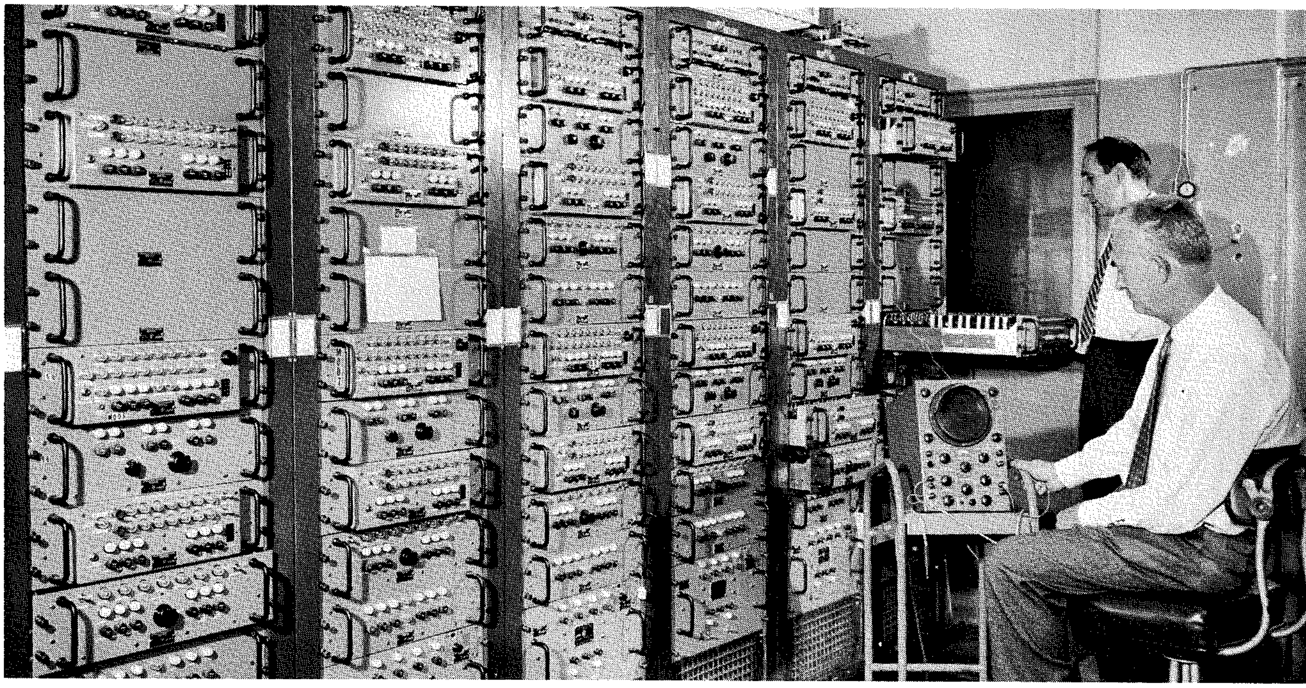
DAVID S. RAU was assigned to the Rocky Point high power transmitting station as one of RCA's first student engineers. He had graduated from the U. S. Naval Academy in 1922 with degree of Bachelor of Science. After a period as Chief Engineer of the Radio Corporation of the Philippines, a wholly owned subsidiary, and further duty at major radio stations, he was assigned to the New York Headquarters staff of RCA Communications, Inc. as a Station Design Engineer. From this duty he advanced to his present position of Vice President and Chief Engineer. He spent the World War II period on active duty in the office of the Director of Naval Communications as head of the Shore Radio Stations section. He was promoted to Captain, USNR, in this billet and Commended by Secretary of the Navy, James Forrestal, for his work. He is a Senior Member of IRE, a member of RCA Review Board of Editors and the RCA Institutes Board of Technical Advisors.

and the influence they have exerted on plant facilities.

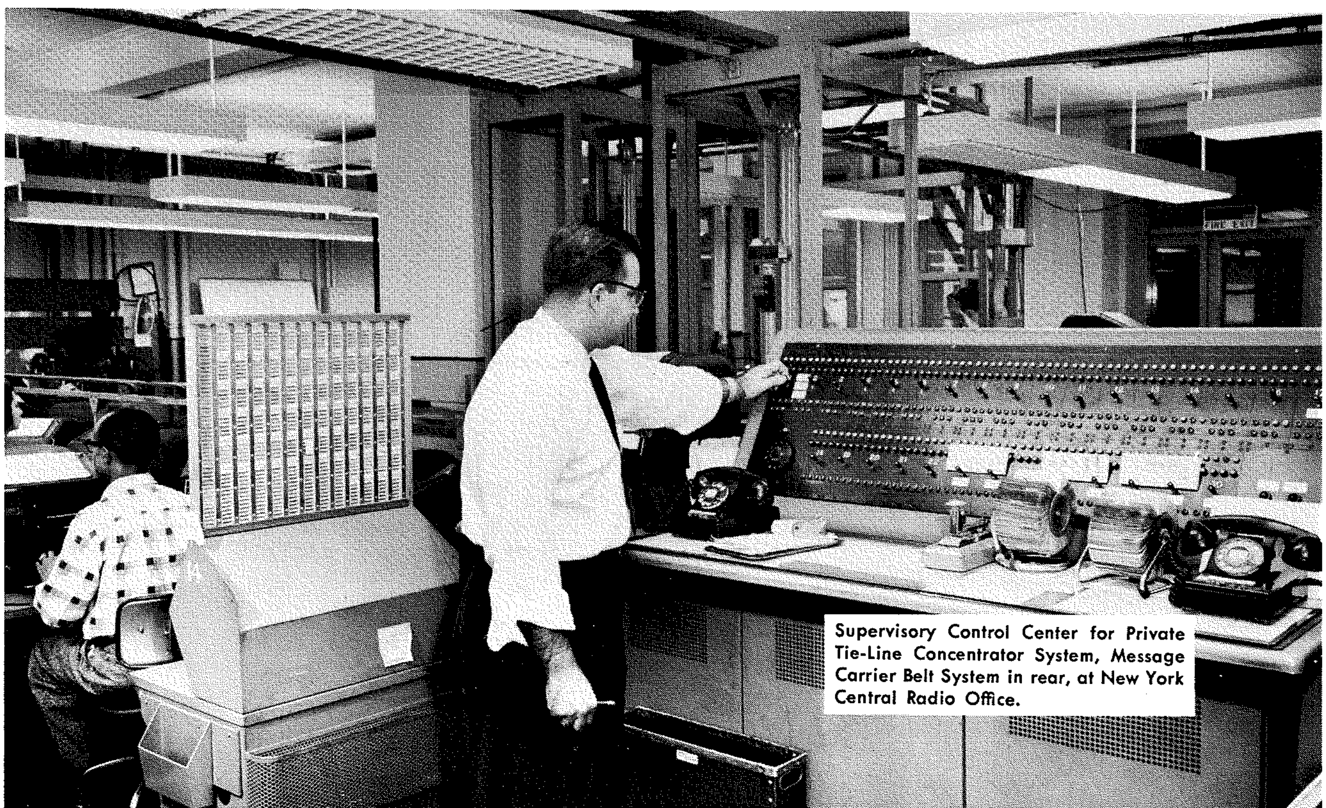
OPERATION AND MAINTENANCE

Engineers assigned to operations and maintenance duties have the responsibility, along with the operating technicians, to keep facilities in operation as required to meet the continually varying demands of the public and the equally continually varying conditions imposed by the vagaries of the radio path. All the special knowledge described for planning and system design must be similarly utilized to meet these conditions. An exceptionally thorough knowledge of the equipment in use is required in order to analyze troubles and lead to prompt correction. Furthermore, engineers in operations may have "housekeeping" responsibilities, with maintenance of buildings and grounds and management of personnel as duties as important and time consuming as their technical ones.

In summary, engineering in RCA Communications, Inc. is a major function served by engineering specialists somewhat different from those who work in electronic laboratories and factories but who are, nevertheless, professionally important in their own field. As in other industries the need for close teamwork between the several specialties is important. How well this teamwork has functioned is apparent in the rapid technical growth of the Company in recent years.



RCA MUX/ARQ-1 terminals installed at New York Central Radio Office.



Supervisory Control Center for Private Tie-Line Concentrator System, Message Carrier Belt System in rear, at New York Central Radio Office.

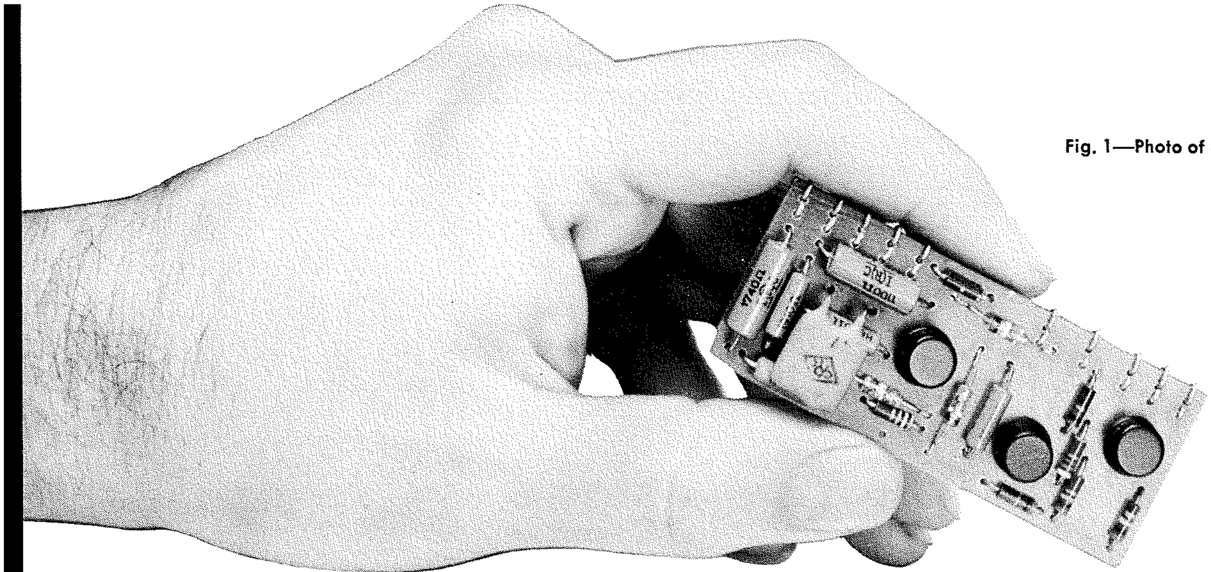


Fig. 1—Photo of a Cross-Point.

TRANSISTORIZED SWITCHING IN TV SYSTEMS

by **JOHN W. WENTWORTH**
C. R. MONRO
A. C. LUTHER, JR.
TV Terminal Equipment Engineering
Industrial Electronic Products
Camden, N. J.

A NEW LINE OF video switching equipment, designated the RCA TS-40, has been developed by an engineering team in the TV Terminal Equipment Engineering group of the Broadcast and Television Equipment Division, IEP. It is intended for television program assembly applications; that is, it provides facilities for combining the outputs of a great many cameras or other picture signal sources to form smooth-flowing programs.

The TS-40 differs significantly from earlier types of remotely-controlled switchers in that it employs transistorized circuits instead of relays for handling the video signals. It also provides much greater flexibility than ever before in the layout of complex switching systems, thanks to the extensive use of plug-in, modularized circuits. This flexibility is extremely important, because broadcast station requirements differ widely with respect to preview facilities, the number of picture signal inputs, the arrangement of equipment for producing lap dissolves and other transitional effects, and means for handling two or more programs simultaneously during rehearsal or recording periods. TS-40 equipment may be readily adapted to fit a great variety of switcher configurations within a basic framework of 24 inputs and 10 outputs, thus offering the advantages of custom-built systems assembled from stock components. Other technical advantages are extremely rapid switching (of the order of 2-3 micro-seconds, compared to 1 millisecond for a good video relay), self-latching switching elements (permitting relatively simple control circuits), and switching triggered by vertical blanking (for the cleanest possible picture transitions, equivalent to interframe splices in motion picture film).

BASIC PRINCIPLE OF OPERATION

The basic building block for TS-40 Switching Systems is the cross-point circuit shown in Fig. 1. This small, etched-wiring assembly is roughly equivalent to a high-quality, self-latching relay, having the equivalent of two sets of contacts—one for a video signal and one for a tally circuit. The circuit consists, in essence, of a semiconductor diode switch which is turned "off" and "on" by a transistorized flip-flop. The circuit is bi-stable, which means that it will remain indefinitely in either the "off" or the "on" condition until some definite action occurs on its external control leads.

Fig. 2 illustrates the operation of the cross-point circuit as far as the video signal path is concerned. The circuit is designed to have an 825-ohm input impedance in both the "off" and "on" conditions, so that up to 11 cross-points may be connected across an input bus to form a normal 75-ohm termination for a coaxial cable. If less than 11 output busses are required, padding resistors may be used to adjust the effective input impedance to 75 ohms. When a given cross-point is "on," the video signal passes through an 1100-ohm series resistor, a forward-biased germanium diode, and a common-base transistor amplifier which recovers the voltage gain lost through the 1100-ohm series resistor. When the cross-point is "off," the diode is held open by about two volts of reverse bias, and at the same time the signal on the input side of the diode is effectively shorted to a-c ground. This combined switching action results in extremely good isolation in the "off" condition (of the order of 76 db in the circuit itself).

The common-base transistor amplifier shown in Fig. 2 is called a "coupling circuit." Only one is required for each output bus, and it is designed to have a 75-ohm input impedance so that it may be located physically at the end of a short piece of coaxial cable. Because the output impedance of the coupling circuit is about 1200 ohms, it must be mounted in close proximity to a tube-type output amplifier.

MOUNTING ARRANGEMENTS FOR CROSS-POINTS

The basic cross-point circuits are mounted in groups of six on etched-wiring cards to form six-input, single output switching elements. Up to 200 *Cross-Point Groups* may be plugged into slots in a *Cross-Point Frame*, as shown in Fig. 3. Across the back of this frame there are 12 well-shielded copper buses for introducing the video input signals. Each of these buses is connected only to every other cross-point group, and means are provided for tying adjacent cross-point groups in parallel to form up to ten 12-input, single-output buses. Wires leading to tally and control circuits are brought in through a built-in cable duct, and connections are made by a simple type of solderless terminal. An interesting feature of the TS-40 is the use of small fuses in the *signal* input circuits to protect the cross-points from damage by the accidental application of excessive voltages through the video cables.

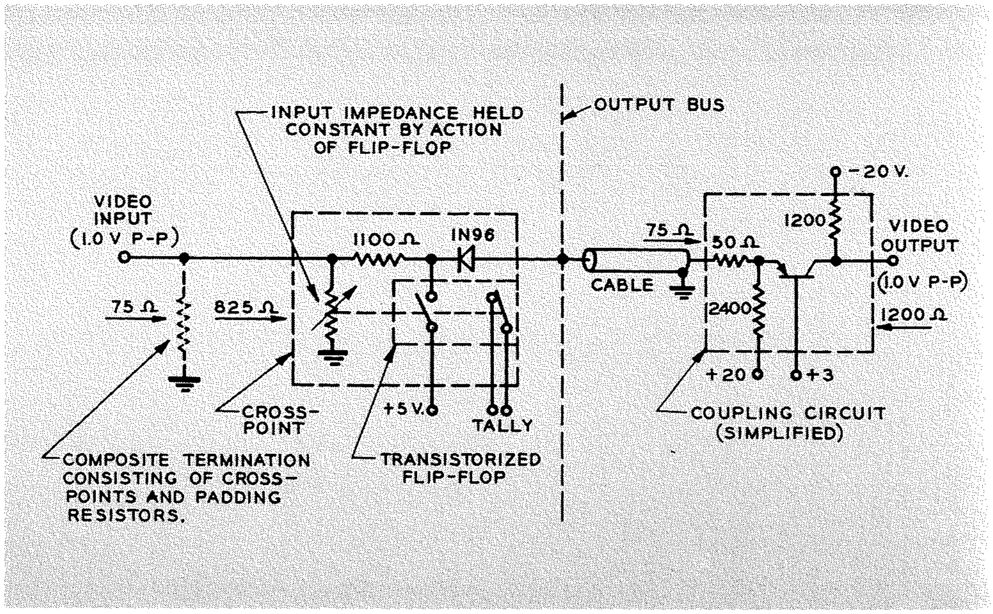


Fig. 2—Basic Circuit of the RCA TS-40 Switcher.

LATCH CIRCUIT PLATES

Another basic building block for TS-40 systems is the *Latch Circuit Plate*, which is needed to assure that each output bus carries only one signal at a time. One latch circuit plate is required for each output bus, and is connected to the cross-points through two busses, designated *Latch Trigger* and *Latch Operate*. Each time a cross-point is actuated by its individual control button, it produces a low-level signal on the *latch trigger* bus. This signal is amplified and clipped by the latch circuit plate, and fed back along the *latch operate* bus to all the cross-points connected to the same output. The amplified *latch operate* signal triggers "off" whatever cross-point was previously "on." The entire sequence of operation is extremely fast, requiring only a few microseconds. The latch circuit plate also includes a special circuit to assure that the switcher comes up in a "black" (no signal) condition when power is first applied.

The Latch Circuit Plates are mounted as plug-in units in a so-called Latch Frame located immediately below the Cross-Point Frame, as shown in Fig. 3. For 12-input systems, only one Latch Circuit Plate is required for each pair of Cross-Point Groups, and all interconnections are made by wire jumpers extending through clearance holes in the frames. For 24-input systems, a second Cross-Point Frame may be mounted upside-down below the Latch Frame, and four Cross-Point Groups may be connected to a single Latch Circuit Plate. Means for bringing out the video-output signals through short coaxial cables are provided at the rear of the Latch Frame.

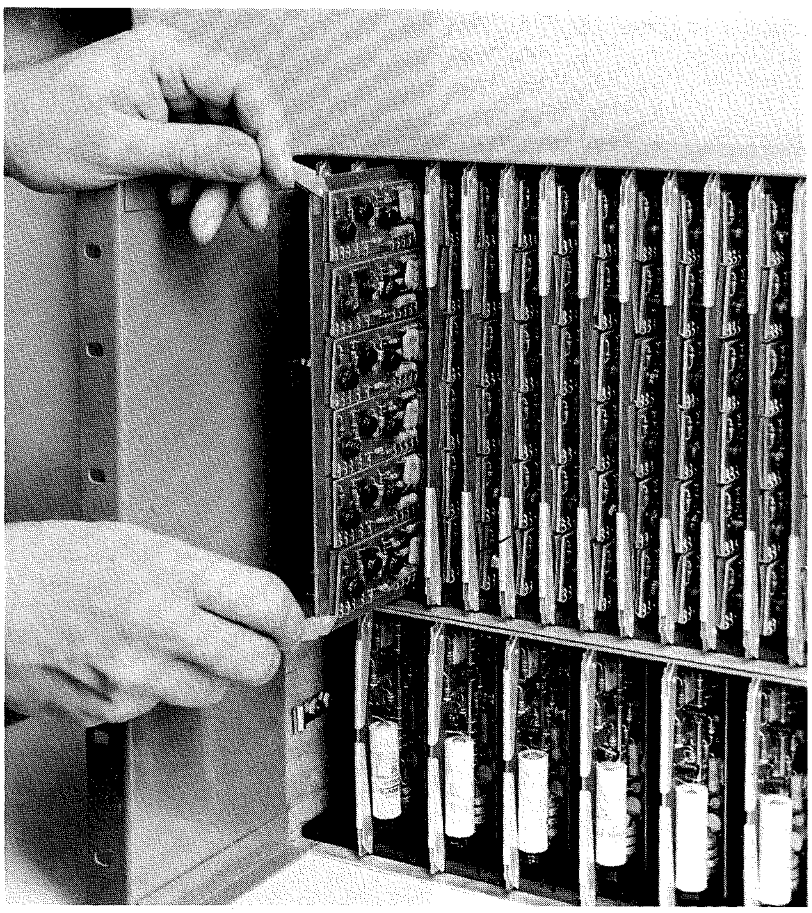


Fig. 3—Front view of a Cross-Point Frame and Latch Frame, showing a Cross-Point Group being inserted.

OUTPUT AMPLIFIERS AND ACCESSORIES

The output amplifier required for each output bus of a TS-40 switching system consists of a transistorized coupling circuit (which recovers the gain lost in the cross-point circuits) followed by a two-tube, feedback-stabilized amplifier designed to drive a 75-ohm output line from a 75-ohm source. The amplifiers are constructed as plug-in units, and are mounted in the manner shown in Fig. 4. The amplifier frames must be located within a few feet of the switcher proper, but the output lines may have any reasonable length up to several hundred feet.

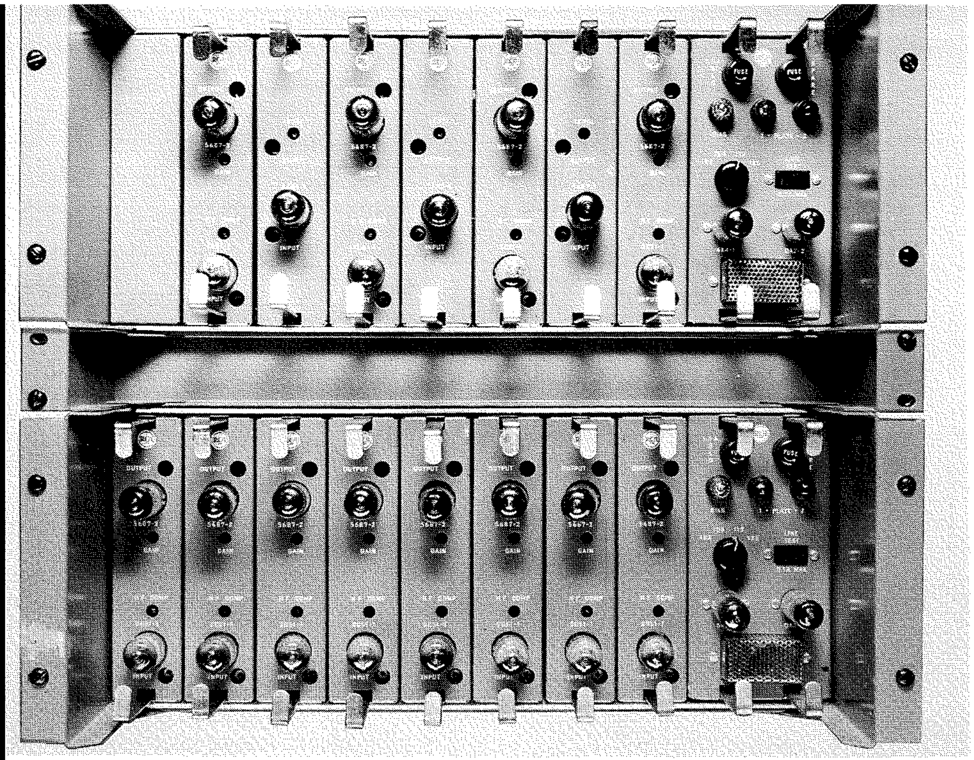


Fig. 4—TA-12 Amplifier Frames, showing TS-40 output Amplifiers and accessories.

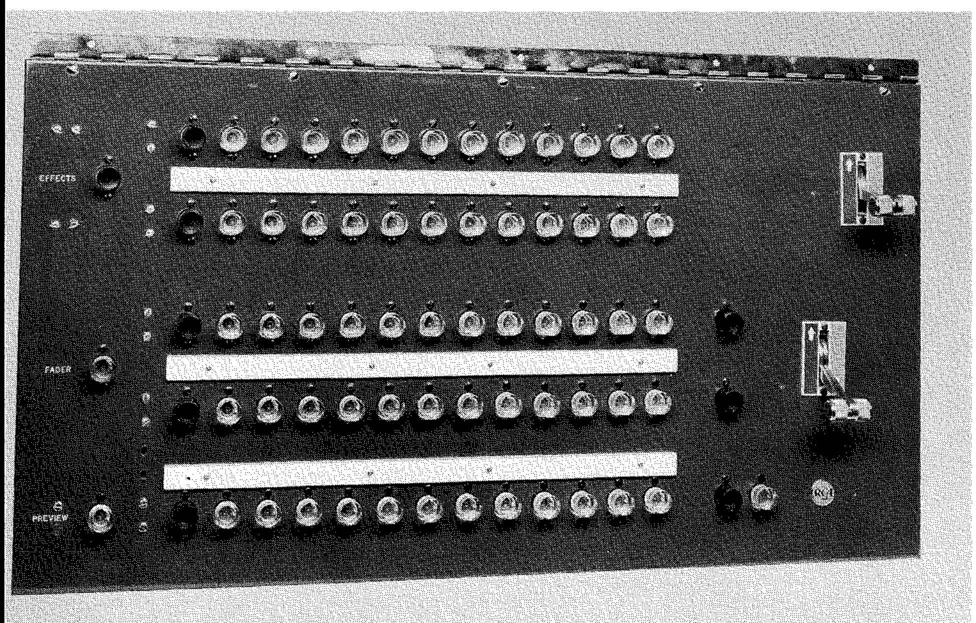


Fig. 5—Typical Control Panel for a TS-40 Switching System.

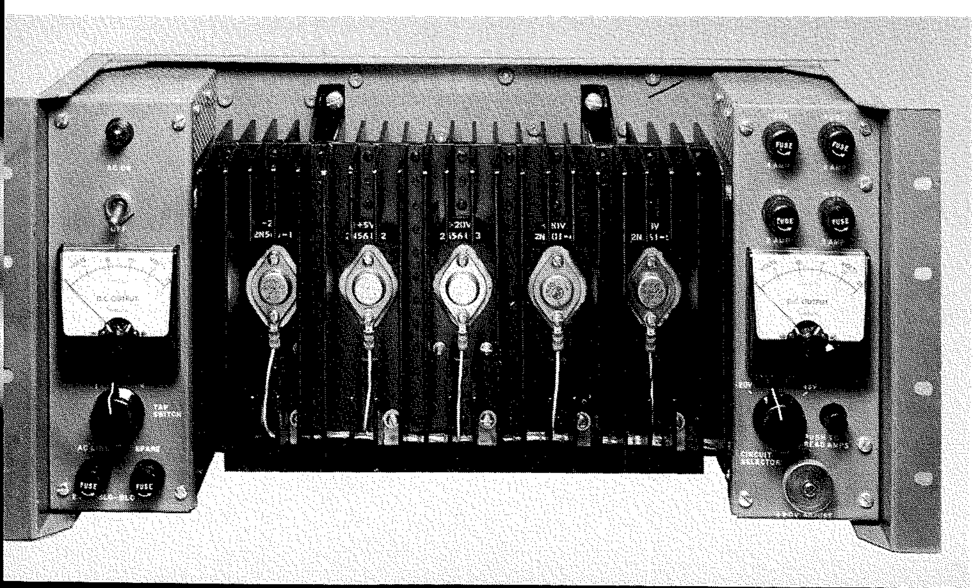


Fig. 6—WP-40 Power Supply.

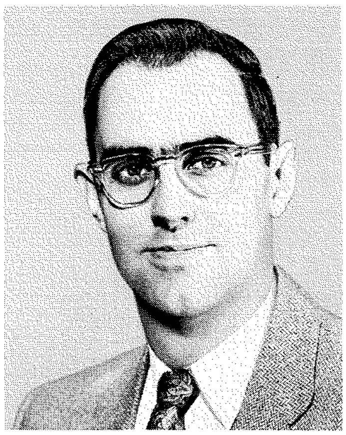
Except for the transistorized *Coupling Circuit Plates* mounted within the plug-in boxes, the TS-40 Output Amplifiers are identical to the general-purpose, unity-gain isolation amplifiers known as *TA-12 Distribution Amplifiers.* (The TA-12 amplifiers have ordinary coupling capacitors in place of the Coupling Circuit Plates). Other items in the TA-12 family of equipment are useful accessories in TS-40 systems, and are shown in Fig. 4. The single-tube units shown in the upper frame are *Sync or Blanking Adders,* used to add synchronizing or blanking pulses in certain of the output lines. At the right side of each frame is a double-width plug-in unit known as the *Heater and Bias Supply.* It contains a heater transformer and a —150 volt bias supply with capacity for up to ten plug-in amplifiers. In keeping with the standard practice for television studio equipment, an external +280-volt supply is required for +B power.

TALLY RELAY EQUIPMENT

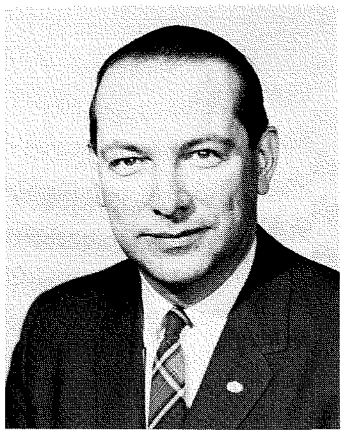
It was noted earlier that each video cross-point has the equivalent of a pair of tally contacts to operate an auxiliary circuit. This tally output may be used to actuate a multi-contact relay to control the tally lamps on cameras, monitors, and control panels, and to operate such auxiliary circuits as sync interlocks and audio ties. The relays are mounted in groups of six to form direct analogues of the video cross-point groups. A dust-tight enclosure provides means for mounting up to ten Tally Relay Groups. All external connections are made through taper-pin and taper-tab terminals, so that no soldering operations are required for installation.

CONTROL PANEL COMPONENTS

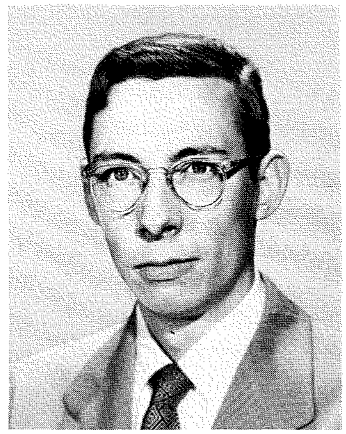
All control panels for TS-40 systems are custom-built to customer specifications, in recognition of the fact that most broadcast stations like to express individuality in their control panel arrangements. Fig. 5 illustrates a typical arrangement of pushbutton switches and fader levers for a TS-40 system of moderate size. Each time a pushbutton is pressed, it connects the corresponding cross-point to a source of pulses derived from vertical blanking. The very first pulse which passes



JOHN W. WENTWORTH graduated from the University of Maine in 1949 with a BS degree in EE, and came to RCA the same year. Since 1950 he has specialized in color television, and has done development and design work on color cameras, colorplexers, and other studio equipment. His present position is Manager, TV Terminal Equipment Engineering. For four years of his career he taught courses in color television for RCA engineers in Camden and NBC New York, and has written an authoritative text, *Color Television Engineering,* published by McGraw-Hill, N. Y. Mr. Wentworth is a member of Tau Beta Pi and Phi Kappa Phi, an Associate in the Society of the Sigma Xi, and an associate member of the IRE.



C. R. MONRO received the BE degree from the University of Toledo in 1942. He worked for RCA at Indianapolis from 1942 to 1946 as an engineer on Navy Underwater Sound Equipment before coming to Camden, where he worked on wire recorders and Sound amplifiers. After a brief stay in the Army in 1947-48, Mr. Monro returned to RCA in Product Design in the Broadcast and Television Department working on video switching, flying spotscanners, and consulting in custom systems. In 1958 he was promoted to Leader in TV Terminal Engineering, responsible for switching and distribution equipment.



ARCH C. LUTHER, JR. graduated from the Massachusetts Institute of Technology in 1950 with a BSEE degree. He joined RCA in July, 1950 in Broadcast and Television Engineering. He has worked on the design and development of sync generators, camera control equipment, monitors, switching equipment, and other items of television studio equipment.

Mr. Luther is now Leader of Television Terminal Equipment Advanced Development Engineering, responsible for development of new and improved products in the Television Terminal equipment line. Mr. Luther holds ten U. S. Patents in the field of television. He is affiliated with Eta Kappa Nu, the Society of the Sigma Xi, and the IRE.

through activates the cross-point, resulting in a clean switch at the very top of the picture. The pulses are generated in the WP-40 Power Supply (to be described presently) and are distributed to the several rows of pushbuttons by a small transistorized circuit known as the *Trigger Circuit Plate* mounted beneath the control panel.

THE WP-40 POWER SUPPLY

Most of the power requirements for TS-40 Switching Systems are met by a specially-designed power supply known as the WP-40, shown in Fig. 6. There are four main branches in this fully transistorized supply, providing current at +20, −20, +5, and 18 volts. Each branch is independently regulated by series transistors (mounted on the convection-cooled heat sink shown in Fig. 6), but a common voltage-reference system is used, so that only one voltage calibration adjustment is required for all four branches.

Also included in the WP-40 Power Supply is a *Trigger Pulse Generator,* consisting of transistorized circuits for generating and shaping pulse signals derived from the trailing edge of vertical blanking. These pulses are conducted by a coaxial cable to the Trigger Circuit Plates mounted under the control panels. The pulse rise time is deliberately made quite long to limit the high frequency energy in the pulses, thus permitting them to be conducted along ordinary wires from the control panel to the cross-points without significant cross-talk between leads.

EFFECTS EQUIPMENT

Fades, lap-dissolves, superimpositions, wipes, inserts, and other special effects may be accomplished in TS-40 switching systems by the use of remotely-controlled mixing amplifiers or special effects amplifiers. A mixing amplifier has two picture inputs controlled by separate rows of buttons on the control panel and supplied by separate switching buses. Potentiometers to control the gains of the two channels are coupled to lever mechanisms like those shown in Fig. 5. As the levers are moved from one row of buttons to the other, a lap-dissolve transition is made between the two picture signals selected by the buttons. A special effects amplifier is actually an extremely fast switch (operating in the order of 0.1 microsecond), and normally has provision for three inputs—two picture signals and a keying signal—each of which is normally controlled by a separate row of pushbuttons. The keying signal may be derived from a special effects generator to give wipes, splits, and iris effects, or it may be derived from a picture signal for insert letters or self-keyed inserts for artificial background effects.

SUMMARY

The significance of the TS-40 switching equipment in RCA's broadcast equipment product line extends well beyond its obvious function in solving complex video switching problems. With respect to the broadcast industry, it represents the first major use of transistors and etched wiring in video equipment, the first use of plug-in designs for complete switching facilities, and the first extensive use of solderless terminals for control wiring. Needless to say, the TS-40 is the culmination of a major engineering program involving the contributions of a number of engineers in the TV Terminal Equipment engineering group.

RCA ENGINEERING MANAGERS MEET AT CHERRY HILL

Over 300 RCA Engineering Managers compared their personal experiences and ideas on the subject of Management in a concentrated two-session Seminar (Nov. 24, 25—Dec. 1, 2) at Cherry Hill Inn, near Camden. Primary objectives of the Seminar were to communicate information of an economic nature to engineering managers and to assess or identify major problems of engineering operations. Those assembled were asked to discuss and assess their engineering operations and then develop a practical written plan of action.

This assignment was tackled on the basis of dividing the two-day sessions into a business review meeting and a workshop session. The first day was spent in acquiring a deeper understanding of business operations generally and of RCA's plans and objectives specifically. The second day was devoted to the comprehensive analysis of engineering operations.

All participants including President John L. Burns, Dr. E. W. Engstrom, Dr. D. H. Ewing, W. A. Hendrickson, C. R. Denny, D. F. Schmit, and Divisional Staffs (Operating Vice Presidents, Chief Engineers, Marketing and Finance specialists) combined their talents with those of the 300 engineering managers in relating engineering problems to RCA Corporate objectives.

This brief introduction to the Seminar is intended to summarize the many valuable talks and presentations given in the various sessions. Photos taken during the conference are reproduced on the following pages. Also included are the Speakers Programs for the first and second day, and a general capsule describing the topics of the first and second day.

FIRST DAY

The engineering managers were welcomed by Dr. Engstrom who appropriately reviewed the history and growth of RCA, its engineering operations and the need for developing the managing aspects of the engineering manager's job. Two future Seminars were mentioned as being planned to accomplish these objectives of effective leadership which will result in high professional productivity.

Dr. Ewing described what was planned for the present two-day sessions, mentioned what had been accomplished by other organizations such as the Industrial Research Institute, Bell Labs, and G. E. Co.—and emphasized that major focus will be on economic issues so necessary to effective management of engineering operations.

Some of the areas covered by Warren Hendrickson, Assistant Treasurer, and C. R. Denny, Vice President Product Planning, were financial status of RCA, economic outlook for electronics industry and RCA, Corporate objectives, consumer expectations, and product division objectives. Other vital areas discussed were the concepts of return on assets, cash position, and anticipated share of the market as related to engineering management.

CORPORATE OBJECTIVES

To lead off the afternoon portion of the business session, Dr. Ewing introduced John L. Burns, President of RCA, who spoke on *Corporate Objectives*. The talk included plans and projects to meet corporate objectives. The following excerpts from Mr. Burns' informative presentation help clarify the role of engineering in accomplishing these goals.

"Where do engineers and engineering management fit into the corporate picture?

"Let me begin my answer this way: Engineering represents the single most important investment in RCA. This year, for example, we are going to spend an estimated $175,000,000, including $43 million of our corporate funds, on engineering.

"I mention these figures to emphasize to you the tremendous stake that RCA has in its engineering function,

Speakers Table (from l. to r.): Dr. E. W. Engstrom, Senior Executive Vice President, Dr. D. H. Ewing, Vice President, Research and Engineering, D F. Schmit, Vice President, Product Engineering, J. J. Brant, Director, Personnel, C. R. Denny, Vice President, Product Planning, and W. A. Hendrickson, Assistant Treasurer, Banking and Investments.

and the great responsibility you, as engineering managers, have in helping to safeguard our investment.

"Now let me tell you, briefly, my philosophy on research and engineering. I believe:

1. That engineering is a major source of new products and other ideas.
2. That while there must be complete freedom for research and engineering in non-competitive activities, we must have generally directed research for a competitive business such as ours. We must stay competitive and return a fair balance of profit, or we won't continue in business.
3. That the selection of engineering programs must be directly related to the overall objectives of the company, and to the areas in which we intend to maintain business leadership. (Research will naturally have a wider range because fundamentals cannot be limited by product.)
4. That it is top management's job to state clearly the objectives of the business, thus providing the guidance needed in the formation of the engineering program. The people who conduct and administer engineering must know management's aims and be assured of full management support.
5. That the job of engineering management is to formulate a program within this framework. Such a program, of course, must gear engineering efforts to corporate objectives.
6. That it is impossible to have industry leadership in our chosen areas without having research and engineering leadership in these areas.
7. That the relative research and engineering emphasis on products must be varied over the life of the product.

RCA President, John L. Burns during address to the Engineering Managers on RCA plans and objectives.

"In conclusion, let me say this. In the fastest growing U. S. industry—electronics—with its deep roots in basic science, I believe that maximum success will go to the company which has the best combination of these factors: (1) Outstanding engineering people working on a well developed plan for production; (2) Under the top engineering leaders occupying important posts within the total enterprise; (3) Working within a framework of top corporate objectives . . . and (4) Working with the sympathetic understanding of top management."

Following Mr. Burns' presentation, the meeting was opened for questions from the floor.

Next, Dr. Ewing announced that the meeting would break up into divisional groups and go to their assigned meeting areas to discuss "Major Operating Unit Objectives and Consumer Expectations." This part of the program was conducted by the Vice Presidents and their staffs including Marketing, Accounting, Sales and other departments decided by the Vice President. Since the Panels included talks by numerous panel members, no attempt will be made to publish the talks in this brief review.

In the evening, Dr. Lee E. Danielson, Psychologist from University of Michigan, gave a challenging, informative talk on the Characteristics of Engineers and Scientists and the Supervision of Technical Employees. The speaker of the evening discussed the various management techniques which may be employed. A good

committee responsible for planning and arranging Engineering Management Seminar (from l. to r.): G. Young, Personnel Services, RCA Staff; R. F. Madks, Administrator, Training, RCA Staff, P. C. Farbro, ager, Professional Personnel Programs, RCA Staff; Lowell H. Good, Director, Engineering Utilization.

SEMINAR 1

FIRST DAY

Introduction to "Development Seminars for Engineering Managers"	E. W. Engstrom, Sr. Exec. Vice President
Introduction to Seminar 1	D. H. Ewing, Vice President Research & Engineering
Financial Status of RCA—Past and Present	W. A. Hendrickson, Asst. Treasurer
The Future of the Electronics Industry and RCA's Anticipated Share of the Market	C. R. Denny, Vice President Product Planning
Corporate Objectives	J. L. Burns, President
Major Operating Unit Objectives—Consumer Expectations	Divisional Panel Presentations
Changing Patterns of Leadership of Engineering and Scientific Personnel	Lee E. Danielson, Psychologist, University of Michigan

SECOND DAY

Introduction to Second Day	D. F. Schmit, Vice President Product Engineering
How Engineering Utilization Can Be Influenced—Assessment of Problems	Small Groups Under Direction of D. F. Schmit
Reports from Work Groups, D. F. Schmit, Chairman	Panel of Small Groups
Assignment for the Afternoon	D. F. Schmit
The Manager's Role in Motivating Scientific and Engineering Utilization—Discussion of Usefulness of Economic Data, Corporate Objectives, Major Operating Unit Objectives	Small Groups Under Direction of D. F. Schmit
Reports from Work Groups	Panel Groups Chairmen Moderated by D. F. Schmit
Summary, Follow-up Assignments, Closing Remarks	E. W. Engstrom D. H. Ewing

manager needs to be able to judge what pattern to use or what type of manager he should be for every situation and for every person he supervises in order to be most effective. Studies of technical managers seem to indicate that it is a greater challenge for technical people to become successful managers in their fields than it is for non-technical people working in non-technical fields.

THE SECOND DAY

On the second day, D. F. Schmit invited the engineering managers to turn their attention to an analysis of engineering operations and to consider the meaning and application of the information presented the day before.

To accomplish this, the managers assembled into eleven separate groups having men from each division, so that each group represented a cross section of engineering management at RCA, and each with its own chairman. Each group was asked to assess the problems of the company environment, the engineer, and of engineering management.

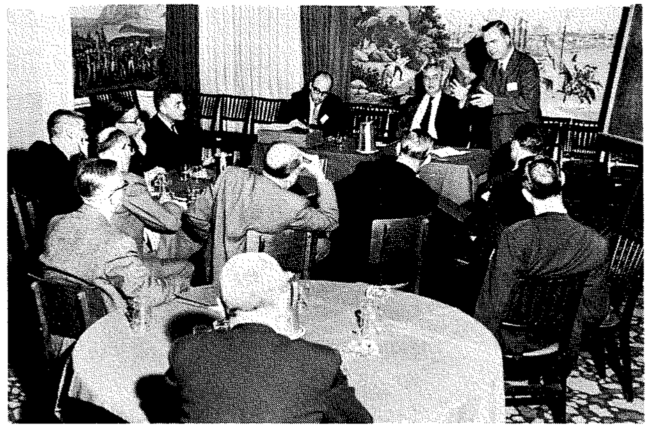
Later in the day, the managers reconvened with the eleven chairmen comprising a panel to present the essence of their work group accomplishments.

In the afternoon, the same groups were asked by Mr. Schmit to discuss, decide and prepare a report on (1) the significance to the manager of the information previously given, (2) effect of communicating this to all RCA engineers, and (3) what should the manager do with this information.

The engineering managers suggested further seminars on leadership and management as a start toward improving engineering capabilities. They were unanimous in declaring that the time was well spent, that the managers themselves were the first who should help implement the divisional 5-year plans, and that they will more fully utilize the responsibility vested in them as managers.

At the close of the sessions, Dr. D. H. Ewing adjourned the meetings with the following closing remarks, "We are determined that this kind of seminar will be continued in the future. We have plans already for a successive seminar to be held sometime during the first quarter of 1959."

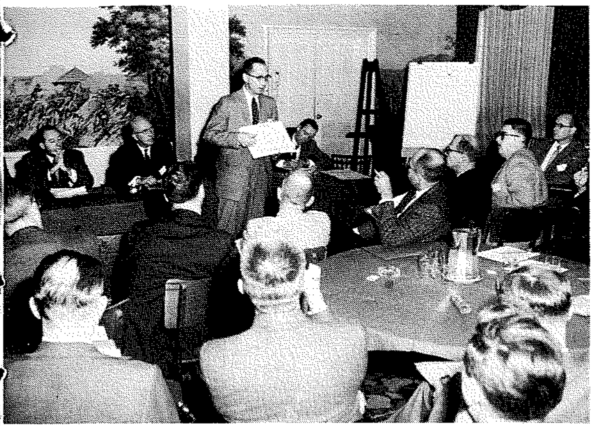
TYPICAL SCENES AT BUSINESS SESSIONS



L. J. Collins, Sales Mgr., RCA Radio and "Victrola" Division is shown during his presentation to Managers. Also at speakers table (l. to r.) A. R. Baggs, Marketing Manager and R. W. Saxon, Vice President and General Mgr. of the division.

One of the groups of Engineering Managers comprising the head-table panel #1 (from l. to r.) A. D. Beard (DEP), M. M. Bell (Electron Tubes), G. G. Carne (Electron Tubes), J B. Cecil (DEP), D. H. Cunningham (R & V), F. S. Veith (Electron Tubes), D. F. Schmit, (Chairman), G. L. Dimmick (DEP), C. M. Sinnett (TV Div.), C. P. Smith (Electron Tubes), J. W. Wentworth (IEP) and J. D. Woodward (DEP).

A second group of Engineering Managers that made up a head-table panel—(from l. to r.) H. J. Woll (DEP), R. M. Cohen, hidden from camera, (Semiconductor & Materials Div.), M. S. Corrington (TV Div.), B. B. Brown (Electron Tubes), L. Jacobs (DEP), R. Trachtenberg (DEP), H. W. Collar (DEP), J. R. Gates (Electron Tubes), F. W. Widman (DEP), D. F. Schmit, Chairman, D. L. Nettleton (IEP) and J. N. Marshall (IEP).



M. Kalen, Controller, RCA Electron Tube Division, is showing graphs of Engineering "costs-to-sales" ratios. Also visible at the Speakers table are W. H. Painter, Manager, Administration; D. Y. Smith, Vice President and General Manager; and L. R. Day, Manager, Planning.

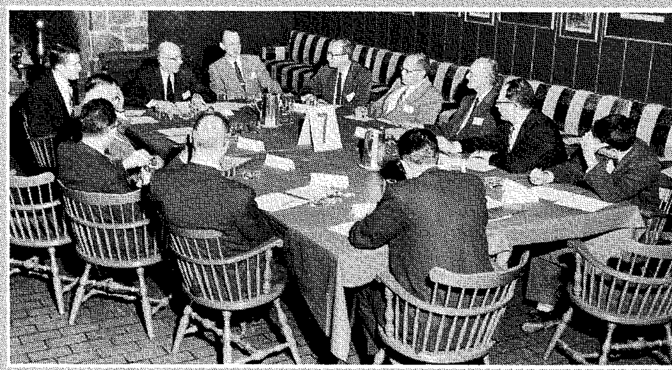
A. L. Malcarney, Executive Vice President, Defense Electronic Products, is shown before the rostrum during the DEP meetings. Also at Speakers table (l. to r.) T. W. Massoth, Manager, Operations Control; C. A. Gunther, Chief Engineer; and Dr. C. B. Joliffe, Vice President and Technical Director.

GROUP PHOTOS TAKEN DURING ENGINEERING WORKSHOP SESSIONS

GROUP 5—J. B. Cecil (DEP) was Chairman for this group consisting of R. M. Fisher (DEP), E. F. Bailey (DEP), Rodger Davis (DEP), S. M. Hartman (Electron Tubes), A. D. Zappacosta (DEP), D. P. Heacock (Prod. Eng. Staff), R. F. Dunn (Electron Tubes), E. E. Moore (R&V), A. J. Torre (TV Div.), H. W. Pickford (DEP), W. Pleasants (DEP), D. S. Rau (IEP) and A. F. Inglis (IEP).

GROUP 1—G. G. Carne (Electron Tubes) at left served as Chairman with R. H. Burger (DEP), D. C. Beaumariage (DEP), H. W. Phillips (DEP), H. C. Lawrence (DEP), W. Ussler (DEP), L. R. Cederbaum (DEP), J. E. Young (IEP), R. W. Hawery (DEP), W. Y. Pan (TV Div.), J. A. Cornell (DEP), and P. R. Bennett (R&V).

GROUP 7—was led by D. H. Cunningham of the Radio & "Victrola" Division. Others participating are J. F. Biewener (DEP), D. M. Cottler (DEP), W. R. Isom (DEP), G. F. Breitwieser (DEP), E. B. Cain (TV), R. N. Knox (IEP), R. L. Rocamore (DEP), D. H. Westwood (DEP), J. P. Eugley (DEP), J. G. Woehling (Electron Tubes), and H. K. Jenny (Electron Tubes).



GROUP 11—Frank Widman (DEP) is Chairman for this group of engineering managers: E. Goldberg (Astro), L. M. Grant (DEP), J. J. Guidi (DEP), R. N. Knox (IEP), S. I. Tourshou (TV Div.), R. D. Pewitt (DEP), A. C. Gay (DEP), A. F. Coleman (DEP), I. Brown (DEP), N. M. Brooks (IEP), J. D. Aronson (DEP), M. C. Myers (DEP), D. Mackey (Semiconductors & Mat'ls.), and W. M. James (Electron Tubes).

CONTROLLED THERMONUCLEAR FUSION

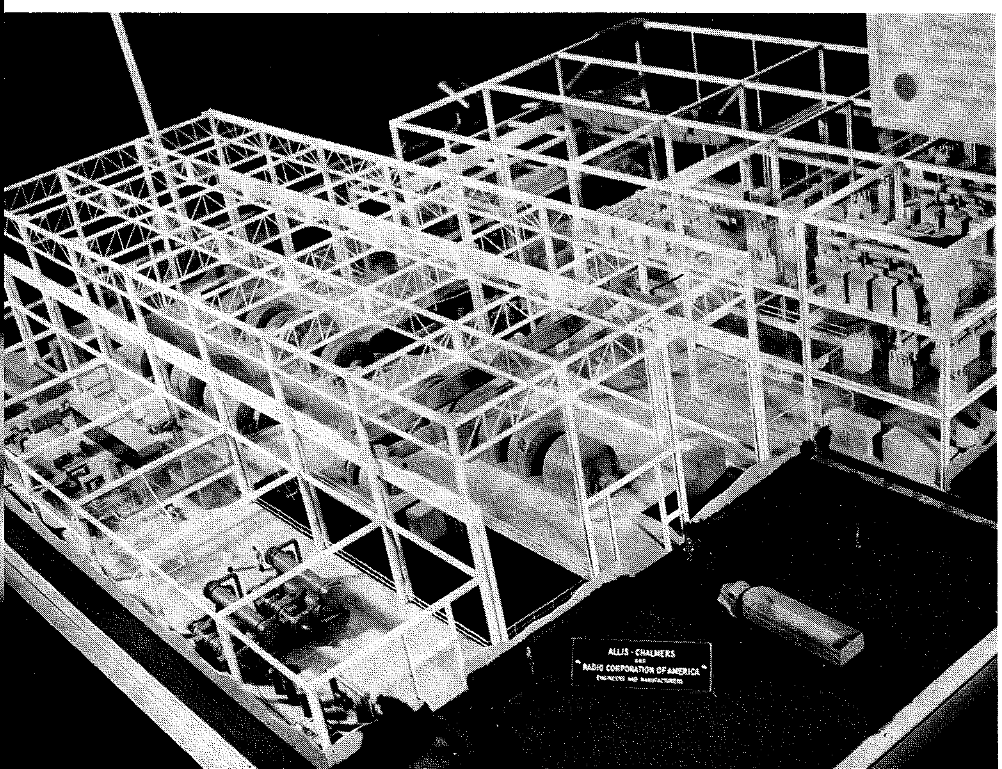
by **DR. P. T. SMITH**
RCA Laboratories
Princeton, N. J.
RCA Technical Director
C Stellerator Associates

THE SUCCESSFUL CONTROL of thermonuclear fusion can supply unlimited power for all human needs, relieving mankind forever from complete reliance upon a dwindling supply of fossil fuels and a limited store of fission materials. This prospect has led to extensive research by a number of scientist and engineer groups in this country and abroad. The United States effort, sponsored by the Atomic Energy Commission, comprises at least four major programs, of which one of the largest is the so-called "Project Matterhorn" at the James Forrestal Research Center of Princeton University.

The Princeton program, directed by Dr. Lyman E. Spitzer, Jr., Chairman of the Princeton University Department of Astronomy, is based upon an approach conceived by Dr. Spitzer and embodied in a device known as the "Stellerator"—a combination of the words "stellar" and "generator." A series of relatively small Stellerators have been built and operated experimentally during the past several years by the Matterhorn group, carrying the research forward to a point where a major research facility, the Model C Stellerator, must now be designed and built for advanced studies.

The development of these facilities is basically an engineering problem involving heavy power equipment, high power electronic gear, and unusual vacuum systems and techniques. For this reason, RCA and the Allis-Chalmers Manufacturing Company have been selected to design, build, and install the C Stellerator and its related electronic and electrical equipment. The program is now occupying a large number of RCA engineers at Camden and Lancaster as well as in C Stellerator Associates, the special engineering group established by RCA and Allis-Chalmers to work directly with the Matterhorn organization at Princeton.

On the basis of present knowledge, it is apparent that controlled thermonuclear fusion will rely heavily upon electronic technology. For this reason, the fusion process itself has become a matter of interest to all RCA engineers. Contrary to the general impression, a basic understanding of the process does not require a broad background in modern physics. A few fundamental facts suffice. The purpose of this article is to present these facts, drawing upon current knowledge relating to matter and incorporating certain material contained in recent writings on the subject.*



SOME BASIC PHYSICS

The three most important building blocks of matter are the electron, the proton and the neutron. The electron has a negative charge of 1.60×10^{-19} coulomb and mass of 9.11×10^{-28} gram. The proton has an equal positive charge but the neutron has no charge. The proton mass is 1836 times larger than the electron mass whereas the neutron is 1845 times larger. Each atom has a heavy core or nucleus with a diameter of about 10^{-12} centimeter which is believed to consist of only protons and neutrons. Electrons revolve about the nucleus in orbits of the order of 10^{-8} centimeter diameter. The net charge on an atom is zero. Thus, there are as many external electrons as there are charges on a nucleus. The number of charges on a nucleus is determined by the number of protons and is denoted by Z, the atomic number. Atoms with the same atomic number may have different masses—these are called isotopes. For example, hydrogen with atomic number one, has three isotopes. The nucleus of the most abundant form is the proton, a nucleus with one proton and one neutron is called deuterium, and a nucleus with one proton and two neutrons is called tritium.

CONTROLLED THERMONUCLEAR FUSION

The stability of a nucleus is measured by the amount of energy required to break it apart into its component particles or nucleons. This energy is called the binding energy. We do not understand the why, but we do know the source of this binding energy. The observed mass M of each nucleus is a little less than the sum of the masses of the protons and neutrons of which it is composed. This sum is given by $(Z\,M_p + N\,M_m)$, where M_p and M_m are the proton and neutron masses, respectively, and N the number of neutrons. The mass difference, $(Z\,M_p + N\,M_m) - M$, accounts for the binding energy from the relationship between mass m and energy E by the Einstein equation $E = mc^2$ where c is the veloc-

*G. Warfield: "Controlled Thermonuclear Fusion—Promise of the Future," *RCA REVIEW*, June, 1958.
E. W. Herold: "Controlled Thermonuclear Fusion—Its Meaning to the Radio and Electronic Engineer," *RCA REVIEW*, June, 1958.

ity of light. As an example, the helium atom consists of two protons and two neutrons. The total mass of these particles is

$$2 \times 1.00759 + 2 \times 1.00898 = 4.03314$$

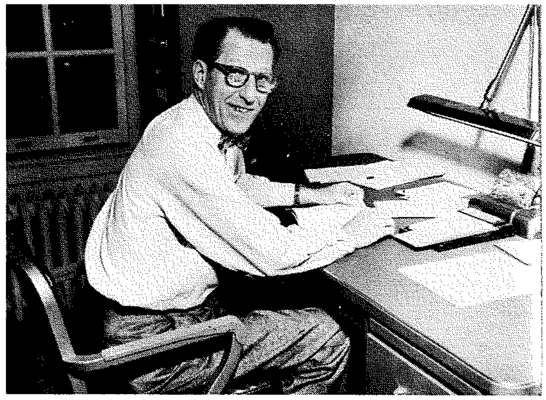
a.m.u. (atomic mass unit). The observed mass of helium is 4.00277 a.m.u. This means that if two protons and two neutrons were brought together to form a helium nucleus, the loss in mass of 0.03037 a.m.u. would be converted into energy released from the system. Conversely, it would take the same amount of energy to tear a helium nucleus apart into two protons and two neutrons. 0.03037 a.m.u. corresponds to 28.3 mev. This is an example of fusion. Fusion is in general possible with nuclei having less than about 40 nucleons.

A study of nuclei having more than 100 nucleons shows that the average binding energy per nucleon decreases with increased nuclear mass. As a consequence, energy is released when a heavy nucleus is broken down into lighter particles. This is fission.

PARAMETERS OF FUSION

Two appropriate nuclei can be made to undergo fusion if they are brought to within the order of 10^{-12} centimeter of each other. This requires energetic particles to overcome the repulsive (coulomb) force resulting from the positive electrical charges on the nuclei. This is a pretty small target in the first place and because of the repulsive force, two approaching nuclei will in general be deflected away from each other or scattered even if they have sufficient relative energy to fuse. This force is not small at nuclear distances. For example, to bring two protons together to a distance of 10^{-12} centimeter requires 1.4×10^5 electron volts of energy.

It is customary to describe collision phenomena in terms of target cross-sectional areas. Fusion cross-sections are so small that a new unit has been defined, the barn. A barn is 10^{-24} square centimeter and derives from the old expression "you can't hit the broad side of a barn". The fusion cross-sections are so small that many ingenious schemes for fusion must be excluded. For example, fusion particles shot at an appropriate target will dissipate their energy as heat since only one particle in many thousands



PHILIP T. SMITH received the B.A. Degree from the University of Minnesota in 1927 and the Ph.D. Degree in Physics from the same University in 1931. His doctoral work was on the ionization probability of various gases under electron impact. Following 1931 he served for two years as research assistant to Professor John T. Tate at the University of Minnesota, continuing his work on ionization of gases. These studies were later continued at Princeton University where Dr. Smith was associated with Professor H. D. Smyth as a National Research Fellow.

From 1934 to 1937, Dr. Smith was an instructor in physics at M.I.T. In 1937 he joined the RCA Electron Tube Division at Harrison, New Jersey and was transferred to the RCA Laboratories at Princeton in 1942. He has specialized in research pertaining to gas discharge, high vacuum systems, and ultra-high frequency power tubes.

Dr. Smith has been on leave from the RCA Laboratories since 1957 when he was made a Technical Director of C Stellerator Associates at the James Forrestal Research Center of Princeton University. He is a Senior Member of the Institute of Radio Engineers and a member of the American Physical Society and of the Society of Sigma Xi.

will result in a fusion reaction. This suggests that to realize any power gain a condition must be established in which most of the particles will have a chance to make thousands of collisions with sufficient relative energy to allow a fusion collision. The only known method which satisfies these conditions is a hot gas. Calculations indicate that the temperature of this gas must be of the order of 100 million degrees. It is obvious that the fusion fuel, at these temperatures, could not be contained by material walls. At these temperatures, all matter is completely ionized and the hot gas would constitute a plasma (a gas made up of an equal number of positively and negatively charged particles per unit volume).

A MEANS FOR CONTROLLING FUSION

The fundamental problem is one of heating a suitable fuel to temperatures of 100 million degrees or more, and to confine it long enough at these temperatures for the fuel nuclei to undergo fusion. To find a solution is to search for a means of confining a high temperature plasma. The success or failure of any method will rest largely upon whether it can confine the plasma long enough.

Physically, this means that the average energy of the particles is raised to about 10,000 ev, while increasing the pressure of the gas about a million fold. The heating may be done by electric currents and r-f induction. The main loss of energy from such a plasma is in the form of electromagnetic radiation emitted as a result of the acceleration of electrons during electron-ion collisions. This radiation extends from the infrared into the x-ray region and is called Bremsstrahlung.

Considering the coulomb forces between nuclei and the relatively high stability of helium, the most promising fuels involve the isotopes of hydrogen and helium. The hydrogen isotopes are denoted by H, D, and T, having approximate relative masses one, two, and three, respectively.

The most important basic fusion reactions of these isotopes are:

Controlled Thermo-Nuclear Fusion

1) $D + D \rightarrow He^3 + 0.8$ mev tn $+ 2.45$ mev
2) $D + D \rightarrow T + 1.0$ mev $+ p + 3$ mev
3) $T + D \rightarrow He^4 \times 4$ mev $+ p + 14.6$ mev
4) $He^3 + D \rightarrow He^4 \times 4$ mev $+ p + 14.6$ mev

The average energy of the fusion products are given in mev, the division of energy results from momentum considerations.

1) and 2) are equally probable and 3) is about 100 times more probable but there is no natural source of T. However, it can be manufactured by the reaction $n + Li^6 \rightarrow T + He^4 + 4.6$ mev.

The use of magnetic forces to contain a thermonuclear reaction has received the greatest attention. One effort, the so-called "pinch effect," generates the confining field by passing a large electrical current through the hot gas. The resulting field also compresses the gas and further heats it. The stellarator uses a confining field produced by external coils. A limited current is passed through the hot gas to raise the temperature to about one million degrees. It is hoped that higher temperatures will be reached by r-f induction methods.

THE "MODEL C" STELLARATOR

By

J. Q. LAWSON

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THEORETICAL AND EXPERIMENTAL research on the production of controlled thermonuclear reactions has been actively pursued for the past several years in the United States and many other countries. Although the test devices used in the different research programs differ radically in configuration, basically each must confine, ionize, and heat one of the lighter gasses to a temperature where thermonuclear reaction will occur. During this period of advanced study the Radio Corporation of America has supplied engineering assistance and electronic components to a number of the research programs including Project Matterhorn at Princeton University.* Since early in 1957, RCA participation in this field has increased many fold as a result of a contract to design and manufacture the electronic and vacuum equipment for the latest Project Matterhorn research device called the "Model C" stellerator.

NUCLEAR REACTIONS

To more fully understand the engineers' role in thermonuclear research and the basic operation of the stellarator, it will be well to review briefly atomic nuclei and nuclear reactions. The nucleus of any atom is composed primarily of protons, which are positively charged particles, neutron particles which have no charge, and a force known as the binding energy which holds the protons and neutrons together. When a curve of the binding energy of each element is plotted as a function of their atomic numbers, it will be noted that the elements at each end of the periodic chart have the least amount of binding energy and that the differential binding energy between elements is greatest in the lighter elements such as hydrogen, helium and lithium. The fact that there is a differential binding energy between various elements makes it possible to release a net gain in energy when certain nuclei are bombarded by particles which have sufficient kinetic energy to overcome the positive static charge of the nucleus. The bombardment of a nucleus by a particle and the resultant change of state and release of energy is called a nuclear reaction.

The nuclear reactions of prime interest in the stellarator program are those which involve the light elements, and are called thermonuclear reactions or nuclear fusion. In these reactions the bombarding particle attaches itself to the nucleus and forms a heavier element and releases other particles and energy. The elements which are used in fusion experimentation are deuterium and tritium, the isotopes of hydrogen. When two deuterium nuclei, each containing a proton and a neutron, collide, there can be two fusion reactions. The first produces a helium nucleus, an unattached neutron and a small release of energy. The second produces a tritium nucleus, a proton, and a small release of energy. Further bombardment of these new nuclei by other deuterium nuclei produce reactions whose products are helium, protons, neutrons, and large amounts of energy. If sufficient reactions of the above type occur in a fusion generator, the energy output will be greater than the energy input such as occurs in the hydrogen bomb. If such reactions can be controlled, a tremendous and almost limitless power source will be available to mankind.

EARLY HISTORY OF THE STELLARATOR

In 1951, Dr. Lyman Spitzer, Jr., Chairman of the Astronomy Department at Princeton University, conceived a device which could, in theory, produce controlled thermonuclear reactions. In principle it consists of an evacuated continuous cylinder into which one or more of the lighter gasses is injected and heated by electronic means to an ultimate temperature of 100,000,000 degrees. At this temperature the fusion reactions should be self-sustaining provided a constant supply of gas is fed into the machine and the heavier non-active nuclei removed. The machine also utilizes magnetic fields to hold the gas in the center of the vacuum vessel so that it will not be cooled by striking the vessel walls.

Since the inception of the device many operating models have been built, each to study a particular phase of achieving the desired result. The first models were made to determine the best way to contain the plasma for sufficiently long periods to make studies and also make some attempts to produce heating of the ionized gasses by radio-frequency excitation. By 1954 the first of a series of second heating stellarators, called B-1, was made and a pulse type of heating produced temperatures as high as several hundred thousand degrees. This stellarator, however, pointed out the need for ultra-high vacuum techniques and longer confinement times. Subsequent B stellarators have been built to study methods to produce the longer confinement times and study other methods of heating.

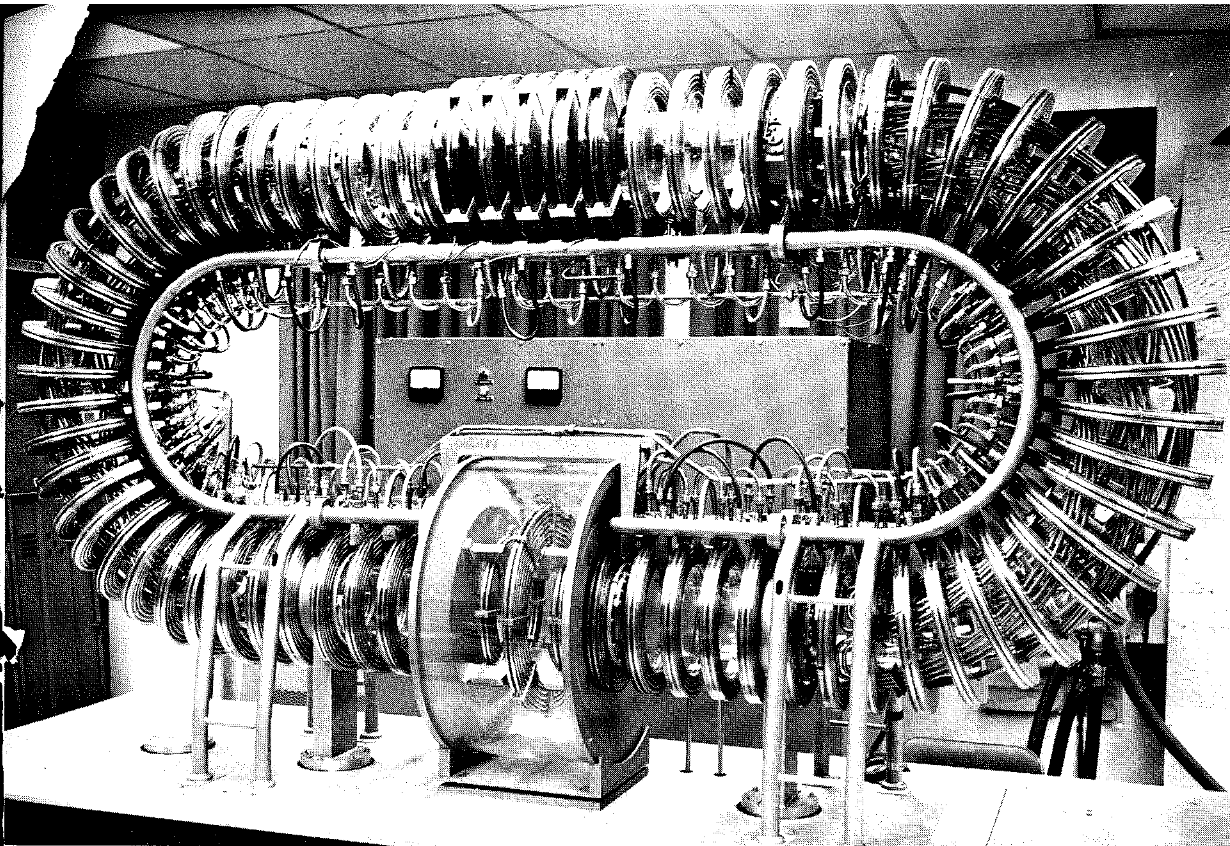
C-STELLARATOR ASSOCIATES

In 1957, The Atomic Energy Commission awarded a contract to build the largest stellarator facility at Princeton University. The award was made to the Allis Chalmers Manufacturing Company and the Radio Corporation of America, with each company supplying design engineering and manufacturing facilities in its specialized fields. In order to best serve the needs of the physicists and provide liaison between Princeton and the respective manufacturing plants, a group consisting of engineers and management from both companies was formed. This group is called C-Stellarator Associates (CSA) and is responsible for the preliminary design and system engineering of the "Model C" stellarator facility.

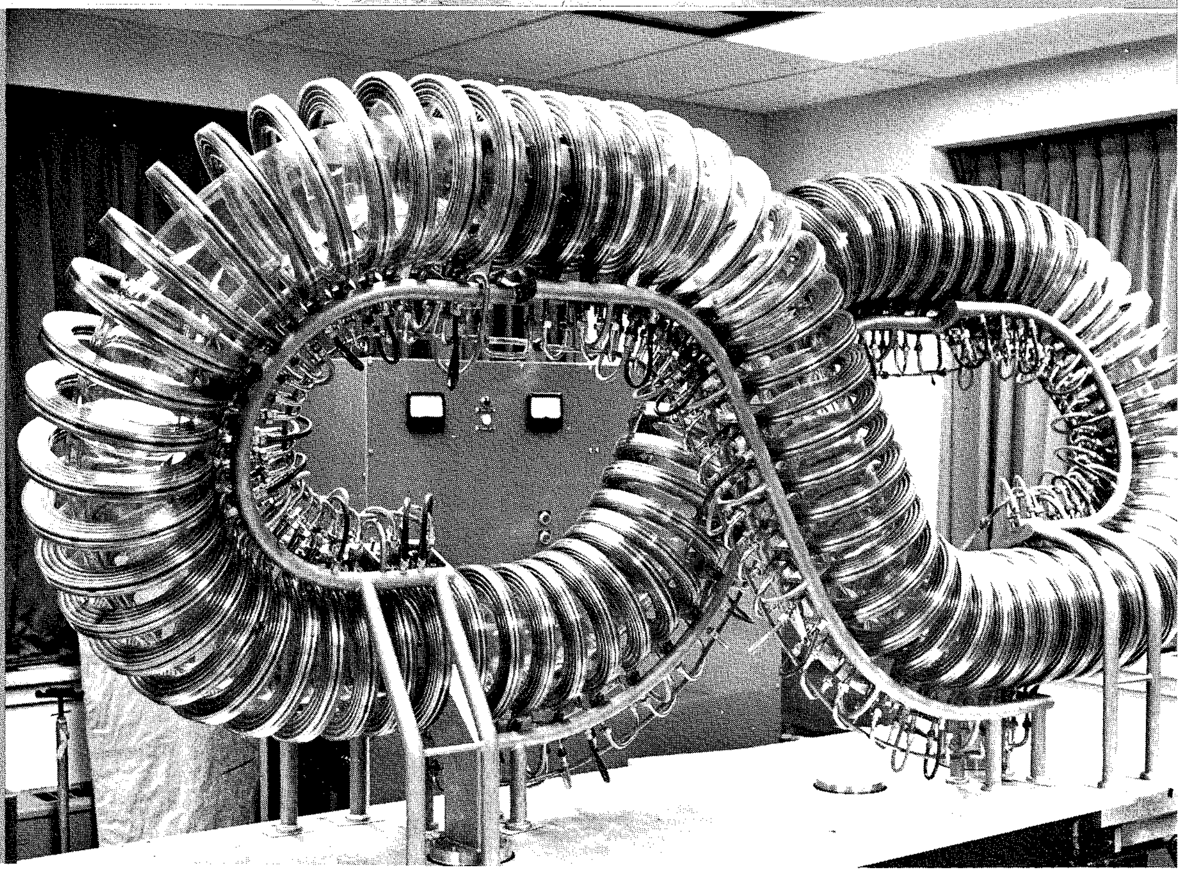
THE "MODEL C" STELLARATOR FACILITY

There are three equipment buildings under construction at the present time to house the C stellarator facility (see Fig. 1). The stellarator building, approximately 100 feet long, 100 feet

*For example, Mr. George Klingaman of B.T.E. and Dr. P. T. Smith of RCA Laboratories were assigned to work at Project Matterhorn until Sept. 1957, when they joined the RCA Group at C Stellarator Associates to continue their participation.



Stellarator tubes, photographed at Project Matterhorn at Princeton University, have twisted magnetic fields designed to prevent the contained gas from striking the vessel walls.



In the arrangement at top the twisting is produced by means of the set of helical coils which can be seen between the sections of the main field coil. Figure-eight shape at bottom also produces twist.

wide, and 50 feet high, houses the stellarator machine and the master control room. The r-f building, approximately the same size as the stellarator building, houses the three heating generators and a test facility. The third building, approximately 115 feet wide, 225 feet long, and 50 feet high, houses the motor generator sets and the vacuum pumping equipment.

The stellarator machine, a scale model of which is shown in Fig. 2, consists of a 250,000 pound non-magnetic stainless steel structure on which are mounted the vacuum vessel, the confining field coils, and the heating applicators. The vacuum vessel, which holds the deuterium gas, is an eight-inch diameter stainless steel tube fabricated to form a closed loop "race track" having an axial length of approximately forty feet. The tube will have one ceramic insulating section where the B and IH generators will be coupled and some thirty odd ports or windows to be used for viewing the ionized gas, gas injection, and microwave measurements. There are thirty-six water cooled coils which encircle the vacuum vessel, each weighing approximately 1800 pounds, with an outside diameter of forty inches. The 55,000 (maximum) gauss field produced by these coils during the stellarator operation squeezes the plasma into the center four inches of the vacuum vessel. At each end of the major axis of the vacuum vessel there is a 30,000 pound transformer core which links the one turn plasma secondary. The primary windings of each of these transformers are connected by an eight-to-one isolation transformer to the ohmic heating generator. Along one leg of the vacuum vessel is a multiturn radio frequency coil which is the output tank coil of the ionic heating generator.

Dual vacuum pumping systems consisting of liquid nitrogen traps, diffusion pumps and rotary pumps will be located next to the stellarator machine. These pumps will be capable of evacuating the vacuum vessel to a base pressure of 2 to 3 $\times 10^{-10}$ millimeters of mercury at an effective pumping speed of 3000 liters per second.

The three heating generators in the r-f building are the Breakdown (B) system, the Ohmic Heating (OH) system, and the Ionic Heating (IH) system, listed in order of operation during a test cycle.

The B system consists of a master oscillator power amplifier (MOPA) operating at either of two frequencies (100 kc or 200 kc) with a pulsed power output of 400 kw for 10 milliseconds. The system is used to ionize and heat the deuterium gas until the plasma resistance is in the order of 0.1 ohms. The B system also has the required auxiliaries to permit continuous operation at 70 kva to assist in the bake out of the vacuum vessel.

The OH system is a super power pulse amplifier using six or ten RCA type 15030 tubes in the output stage. The generator will produce a controlled pulse of current in the plasma ranging from 50,000 amperes for one millisecond to 34,000 amperes for five milliseconds. These currents are expected to heat the plasma to a temperature of 1,000,000°K at which time its resistance will be roughly .005 ohms. The OH equipment can also be operated as a 10,000 cycle generator to study heating methods at very low frequencies.

There will be two IH generators utilizing the RCA type 15030 tube in the final stages. The Low Frequency (LF) generator will operate in the frequency band from 100 kcs to 2.0 mc with a power output of 56 megawatts for 5 milliseconds. The Resonant Frequency (R) generator will have a power output of 14 megawatts. The final tank circuit coils or applicators of the generators will couple directly to the plasma and produce alternately, at the operating frequency, a field aiding and bucking the d-c confining field to produce a modulated plasma.

The other major building at the facility houses the motor generator sets used to excite the plasma confining field coils. There are three main MG sets each arranged so that one 7000-horsepower induction motor drives four parallel connected direct current generators. The four parallel generators have a continuous output of 16 megawatts at 800 volts and a pulsed output of 64 megawatts at 750 volts. Each of the forced air cooled MG sets, including the 20-foot diameter flywheel, weigh 185 tons and are 76 feet long.

DETAILED ENGINEERING AND MANUFACTURING

When the basic designs of each engineering group at CSA have been approved by the University staff in charge of stellarator experimentation, the specifications are forwarded to the respective parent companies for detail design and manufacture. At the present time in the Broadcast Transmitter section of IEP there are twenty engineers contributing to the detailed design of the B system and the OH system. These two systems will be assembled in building 53 in the first quarter of 1959 for delivery in the second quarter of 1959. The majority of the engineers presently designing the B and OH systems will be diverted to the detail design of the IH system scheduled for delivery in the second quarter of 1960. The vacuum vessel and the vacuum pumping equipment are being designed by the Large Power Tube group assisted by the Equipment Development group at the RCA Lancaster plant. A force of twenty-five engineers and technicians are actively engaged in the design of these stellarator components.

SUMMARY

Controlled thermonuclear reactions are the objective of many research groups with an ultimate goal of obtaining an unlimited source of inexpensive power. The Electronics engineer is making major contributions to the research programs by supplying equipment to heat the plasma and confine the reactions. In subsequent articles the detail design of the RCA supplied equipment for one of these programs, the C stellarator, will be discussed.

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JOHN Q. LAWSON graduated from Northwestern University with a BSEE degree in 1948. He joined RCA in February 1948 as a student engineer in the Broadcast Transmitter group. He has conducted design and development work on the AN/FRT-3 "Jim Creek" 1.2-megawatt communications transmitter, the TT-50AH, 50-kw TV transmitter, the BTA-50G, 50-kw broadcast transmitter and the BTH-250A, 250-kw broadcast transmitter.

Since 1957 Mr. Lawson has been a member of the R-F Design group at C Stellarator Associates.

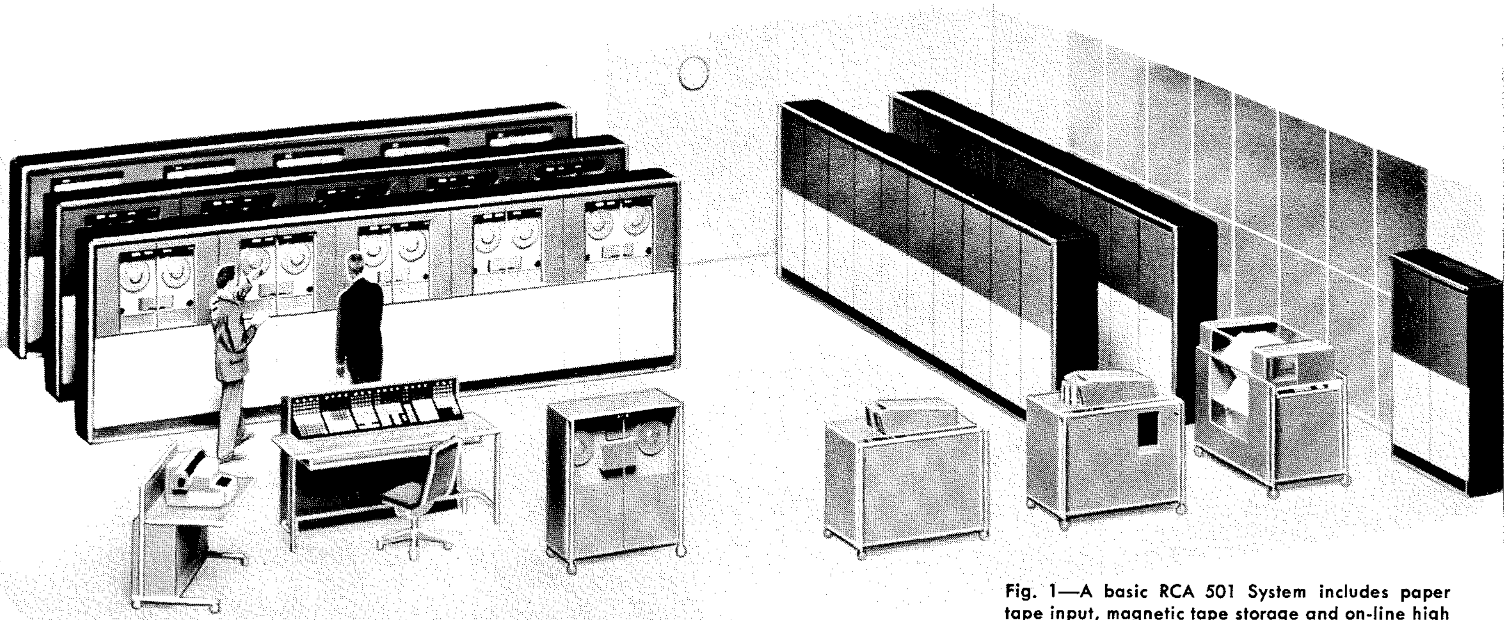

Fig. 1—A basic RCA 501 System includes paper tape input, magnetic tape storage and on-line high speed page printing output.

THE RCA 501 SYSTEM

by

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BASICALLY, A COMPUTER IS a mechanism that can perform an adding function. Counting in your head or on your fingers is a form of computation and you can classify yourself as a form of computer. Although there are four basic arithmetic processes: addition, subtraction, multiplication and division, there is really only one—addition. Subtraction is addition of negative quantities, multiplication is successive addition, and division is successive subtraction. A desk calculator is a computer, so is an adding machine, a slide rule, an abacus, an odometer, a payroll clerk, a croupier, an internal revenue agent —and electronic data processing machines by RCA.

BASIC COMPUTERS

Computing machines fall into two general classes—analog and digital. Consider the analog principle first: an analog machine is based on the principle that numbers are represented by certain physical quantities. For instance, we might use a current, a voltage, the angle of rotation of a shaft, or a length. Operations like addition and multiplication may then be performed by finding various natural processes which act on these quantities in the desired way. Currents may be multiplied by feeding them into the two magnets of a dynamometer, producing a rotation. This rotation may then be transformed into an electrical resistance by the attachment of a rheostat; and, finally, the resistance can be transformed back into a current by connecting it to two sources of fixed (and different) voltages. The class of analog machines ranges from the slide rule where length represents the logarithm of a number, to Bush's Differential Analyzer which used rotating discs and to the gun directors of WW II which used linear amplifiers.

The second class of machines is the digital. A digital machine operates on the principle of counting, and numbers or quantities are represented as aggregates of digits in the decimal system. In a digital system the size of the number—the number of digits used—is a function only of the precision we wish to obtain; in our analog system the size of the quantity used is a function of the magnitude of the number to be represented. In our everyday decimal system, only the units place is needed to express the numbers 0 through 9; whereas in our analog system using d-c amplifiers this could very well be 0 through 9 volts. The class of digital machines ranges all the way from the abacus to the early Mark III Computer to the present RCA 501 System.

THE 501 SYSTEM

The 501 Electronic Data Processing System is RCA's bid for leadership in the field of commercial computer systems. The various equipments in the system employ transistor logic of advanced design making possible the use of low-cost, high production transistors manufactured by the RCA Semiconductor and Materials Division. Each equipment in the system has been designed and styled with the idea of easy and economical installation in mind. This, together with the overall building-block philosophy inherent in the system concept, makes the RCA 501 System ideal for a wide range of business applications.

The heart of any data processing system is the computer itself—the machine that, under control of a stored program of instructions, processes all the data fed into the system; and by referring to its instructions, makes literally hundreds of thousands of decisions daily. The 501 Computer together with its High-Speed Memory is an extremely flexible machine. It can perform more than one operation at a time, and the decision to perform two things sequentially or do them simultaneously is made by the machine itself. It can handle up to 63 magnetic tape units—each capable of storing up to 9 million characters. It can operate a high-speed printer which spills out page printed copy at the rate of up to 600 lines a minute. And its internal memory can be expanded to sixteen times its original size merely by adding banks of magnetic core planes. The machine has the facility to read punched paper tape at the rate of 1000 characters per second, and reads and writes on magnetic tape at the rate of 33,333 characters per second. A monitor printer and punch on the console provide output in the form of hard copy or punched paper tape at up to 10 characters per second; these facilities are used primarily for program checking and routine interrogation.

What we have just briefly described is known as the basic RCA 501 System: Computer, with High-Speed Memory, Tape Stations, and On-Line Printer ("on-line" meaning under direct control of the Computer.) The system can be expanded by adding punched card equipments, additional tape units, off-line printer, and random access memory. This is what we mean by a building-block philosophy.

BINARY CODED DECIMAL SYSTEM

Let us go back and describe the basic system organization. In the world of computers, there are a number of methods of machine logic organization. The RCA 501 is a binary-coded decimal system. By binary we mean that the machine number system uses only two symbols, 0 and 1; this contrasts to our everyday world which uses the decimal system having ten symbols, 0 through 9. Mechanizing the binary system works out very nicely since with pulse circuits we can represent the 0 by "no pulse" and the 1 by "pulse" or with a switch, 0 = Off and 1 = On; or a relay 0 = Open and 1 = Closed, and so on. Now, by "coded decimal" we mean that in order to represent all the decimal symbols (0 through 9), the letters of the alphabet, dollar signs, etc. and a few other things necessary for control, we must use a combination

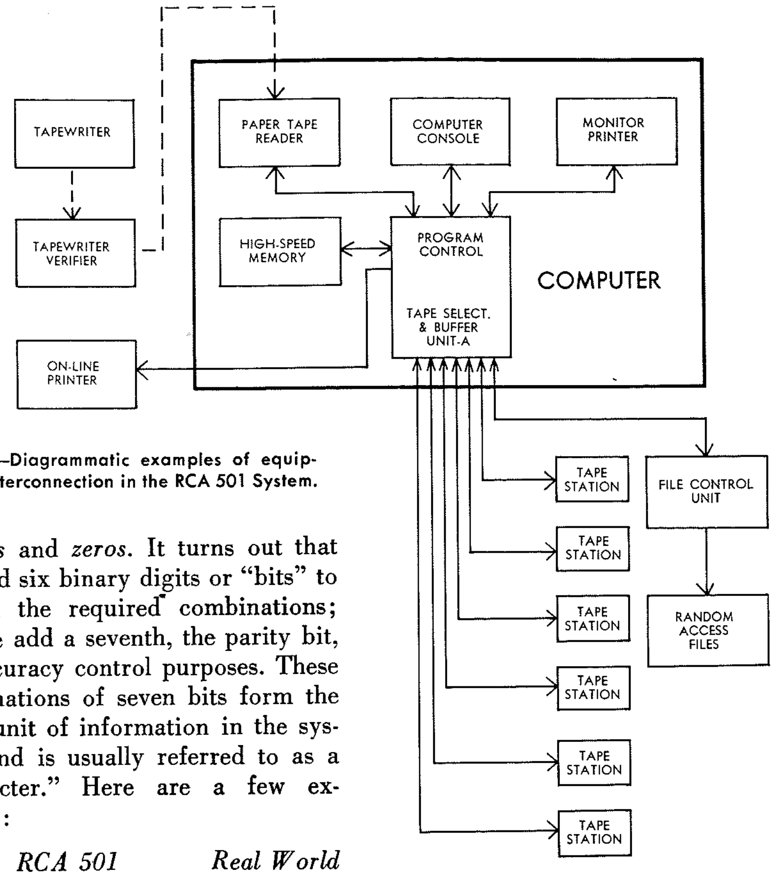


Fig. 2—Diagrammatic examples of equipment interconnection in the RCA 501 System.

of *ones* and *zeros*. It turns out that we need six binary digits or "bits" to get all the required combinations; and we add a seventh, the parity bit, for accuracy control purposes. These combinations of seven bits form the basic unit of information in the system, and is usually referred to as a "character." Here are a few examples:

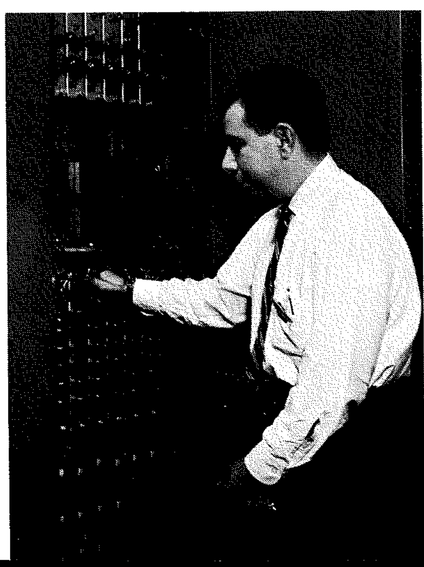
RCA 501		*Real World*
P		
0	010011	0 (zero)
1	010111	4
0	100000	A
1	100111	H

It can be seen that the parity bit (P) is sometimes one and sometimes zero. As one means of accuracy control, each character must always have an odd number of ones; this is checked continuously throughout the system. Consequently, if the first six bits have an even number of ones, we make the parity bit one; and conversely, if the first six bits have an odd number of ones, we make the parity bit zero. Since it is obvious that the system deals with both numbers and written information, it can also be described as an "alpha-numeric" system. Transmission of a character within the system is serial with the seven bits of each character in parallel.

VARIABLE WORD ORGANIZATION

Another basic characteristic of the RCA 501 System is that it uses true variable word organization. This means that all data coming into the system from the outside world is handled in the form that it came in. It does not have to be formed into blocks or units, or restricted in some manner in order to be processed in the system; the RCA system is the only system that has that capability.

Let us explain this important feature in more detail. Previously we have discussed the basic unit of information as the character, which represents a number or a letter. A widely used method of data organization is to establish a "word" which is a fixed number of characters—let us say ten, for purposes of discussion. Consequently, in our hypothetical machine, all data is handled in blocks of ten characters, and this is rigidly enforced. Wherever a unit of information is not 10 characters in length, the unused spaces must be filled by



HERBERT M. ELLIOTT received the BA degree from City College of New York in 1946, and the BS in EE and MS in Physics from the University of New Hampshire in 1950.

At the Air Force Cambridge Research Center of the Lincoln Laboratory, MIT, he participated in research and development on magnetostriction filter banks and storage tubes. He joined RCA in 1953 and was promoted to Leader of the High-Speed Memory Group of IEP in 1954. He is presently Manager of Computer Devices Engineering and Advanced Product Development, Electronic Data Processing.

zeros. So in a fixed word system, the name, "Ben Champion" would be carried in this manner:

1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
B E N 0 0 0 0 0 0 0	C H A M P I O N 0 0

In this manner, out of 20 possible units of information nine of them, or almost 50%, are meaningless. Yet, because of the system organization, we are forced to carry these around the system, taking up both time and space—time in processing, space in memory or on magnetic tape.

One way to reduce this inefficiency is to organize these words into groups, where the word-length, or "field" may vary according to some pattern. A field is always the same length, but the length may vary from field to field. As an illustration:

field "1"	field "2"	field "3"
Name	Age	S.S. No.
18 spaces	2 spaces	11 spaces

Taking a typical case:

ANDREW J CHAMPION000/37/043/043-77-3950

In this example, the utilization is very high, but in the next case:

JOHN DOE00000000000/25/752-14-4975

The utilization is not too good.

In the RCA System, the data is recorded as it comes in; the only change is to add a control symbol which denotes an item, or the beginning or end of a message (which is a group of items).

Let's now go back over our three examples, and compare the number of character spaces used:

	Fixed Word	Var. Field	RCA
BEN CHAMPION	20		12
• ANDREW J CHAMPION • 37•043-77-3956		31	31
• JOHN DOE•25•752-14-4975		31	23

Thus it can be seen that the RCA system of data organization is one which keeps the amount of information to be passed through the system to a minimum. Minimum time in processing and minimum space in storage mean minimum cost.

At the present time, thirty RCA 501 Systems are in production, over and above a system being built for RCA's own use. Six systems are scheduled for delivery to customers by the end of 1959. More than half of the systems to be built are already committed. We in the EDP Division feel that the RCA 501 will further establish RCA in the electronic data processing industry.

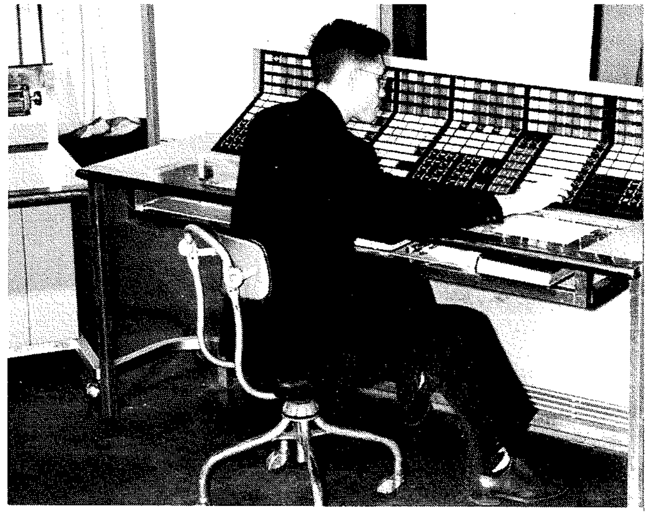


Fig. 3—This view of the prototype system shows the Computer console.

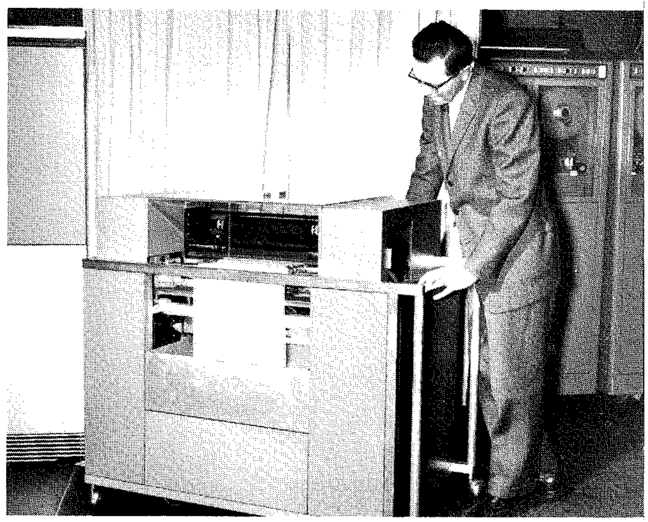


Fig. 4—The high-speed printer produces controlled-format printing at 1200 characters per second from information received in one-line bursts at 33,333 characters per second.

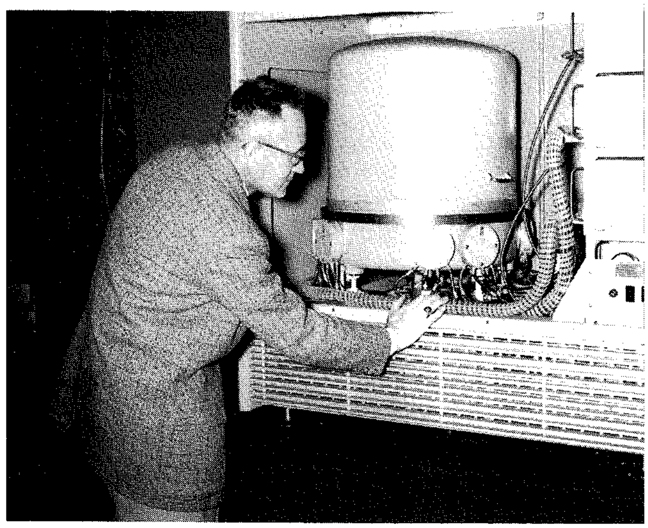


Fig. 5—The magnetic drum Random Access File stores 1.5 million characters on 300 parallel tracks. The File Control Unit makes the drum appear as a Tape Station for addressing by the Computer.

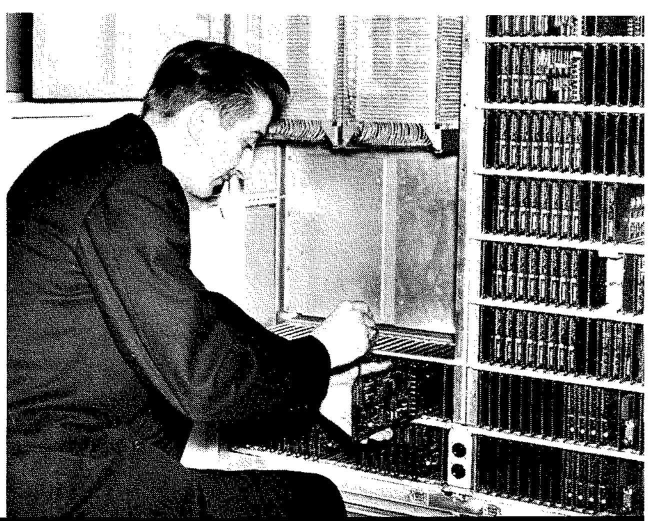


Fig. 6—The High Speed Memory uses ferrite cores to store characters for access in 15 microseconds by the Computer. Each bank (2 are shown) stores 16,384 characters, with 65,536 maximum in this one rack.

THE SYSTEMS CONCEPT – A Novel Method of Sampling Variables

by
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Many control and monitoring applications in military and industrial systems require rapid and flexible schemes for sampling large numbers of system variables. Examples are numerous. For instance, optimum production in oil refineries depends on many variables in a continuous process. A guided missile system, too, must rely on rapid assimilation of many variables for optimum performance analysis. We are concerned here with a flexible method of sampling data applicable to systems such as these.

The author has developed a unit that performs the basic functions of the sub-system described in this article. For more than one year this unit has been operating successfully as an important part of a large scale system.

AN APPLICATION

A typical application for this sampling control is in the "system checkout" logic of a large scale system. A major function of the "system checkout" is to record periodically digital data relating to the performance of all important system variables during a test problem. The objective is to compile sufficient data pertaining to the test problem that would permit a detailed analysis by a data processing machine.

In this large scale system there are a basic number of system variables being considered for recording. The sampling control unit samples only those system variables that produce useful information at the time of recording and rejects all other inactive system variables. The criterion for making this sampling decision is recognition of an activated assignment signal.

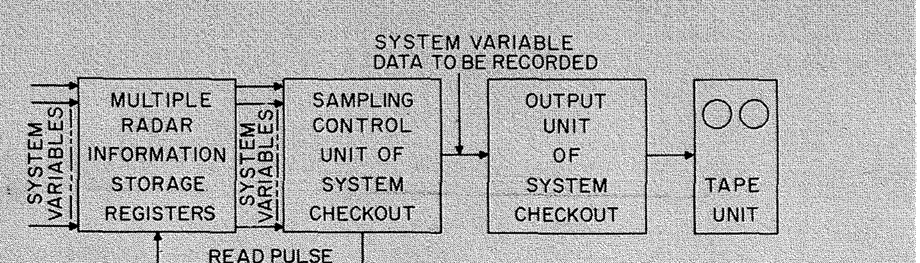
The sampling rate of the system variable data must be sufficiently fast to satisfy the requirements of the data processing machine. A minimum quantity of recorded data must be compiled in order for the data to be properly analyzed.

A further requirement of the sampling control unit is that at the beginning of each recording cycle the data pertaining to all of the system variables is read into storage registers. As a result, all the recordings in a cycle are referenced to the same time base and there is good correlation between variables. The significance of this requirement is that the data processing machine is not burdened with the task of interpolating the information it receives. This additional load may represent as much as 15% of the overall computation time.

A specific example of the large scale system is a multiple radar installation. The system variables of interest are the azimuth, elevation, and range of each radar. Assume that there are four radars at the installation, making a total of 12 system variables to be considered for recording. In the situation where radar #1 is inoperative because it is on standby or malfunctioning, it is not necessary to record its performance during a test problem. As such, the radar #1 assignment signal is not activated and its three system variables are rejected for recording by the sampling control unit.

Since the pattern of radar assignments is changeable, the sampling control unit must be sufficiently flexible to sample from any combination of assigned system variables. The "system checkout" concept for the multiple radar installation is illustrated in the block diagram of Fig. 1. The output device is shown as being a magnetic tape unit, although a high speed printer or a tote board display would be equally acceptable to the proposed sampling control logic. The read pulse shown in the diagram is generated at the beginning of each recording cycle and it calls for the transmission of data from all the system variables to the storage registers.

Fig. 1—Block diagram of the "System checkout" concept for a multiple radar installation.



THE PROPOSED SAMPLING CONTROL LOGIC

In general the sampling control logic is based on the ability to control automatically the stepping operation of a program counter, such that at specified times, the stepping rate can be greatly increased to permit skipping pre-determined outputs in its cycle. Each output of the program counter represents a specific system variable that is being considered for sampling. The sampling of the system variable is accomplished by stopping the program counter at a particular output line for a period of sufficient duration to perform the intended function. The skipping of any undesirable output lines is performed extremely fast relative to this sampling period and consequently there is no interference with the sampling function.

The method to achieve the desired performance of the sampling control unit is shown in the block diagram of Fig. 2. The program counter is designed to cycle through n outputs with each output representing one of the total of n system variables being considered for sampling. The program counter is stepped either by an external source of periodic pulses or by the skip pulses generated within the sampling control unit. In each period p of the external stepping pulses, there is one execution of the intended output function. This period p should be made long enough to permit execution of the intended output function, and yet small enough to satisfy the minimum cycle sampling rate for the output function. For example, if the minimum time to execute a recording is 1 millisecond and the minimum sampling rate of 13 system variables is 10 samples per second, then the duration of the period p should be chosen between 1 and 7.69 milliseconds.

Hereafter the term "system variable" is referred to as an "item" and the outputs of the program counter are designated as "item lines." Each item line serves to alert its information storage register in the event that its selection is made to perform the output function. In addition, each item line feeds the item identity coder as well as addressing its associated skip gate in the skip circuits.

In this discussion there is no mention of how the output function is performed or how the item assignment signal is generated. These features are peculiar to each system application and are considered external to the logic presented here.

The skip circuit functions to produce rapid stepping of the program counter whenever an item line is not selectable. The criterion for performing this skip operation is just the opposite to that of making a selection and is the recognition of an inactivated item assignment signal. This recognition is accomplished by the skip gate, which is nothing more than a 3-input AND gate requiring all 3 inputs to be in a definite state before the output is energized. The 3 inputs to each skip gate include the item line addressing signal, the item assignment control signal, and the skip pulse. For the skip pulse to be gated through a skip gate, the associated item line addressing signal must be activated and the associated item assignment signal must be inactivated. Regarding the example of the multiple radar system, it is not necessary to have an individual skip gate associated with each item line. In this case, a group of three item lines representing azimuth, elevation, and range are controlled by the same radar assignment signal. The three

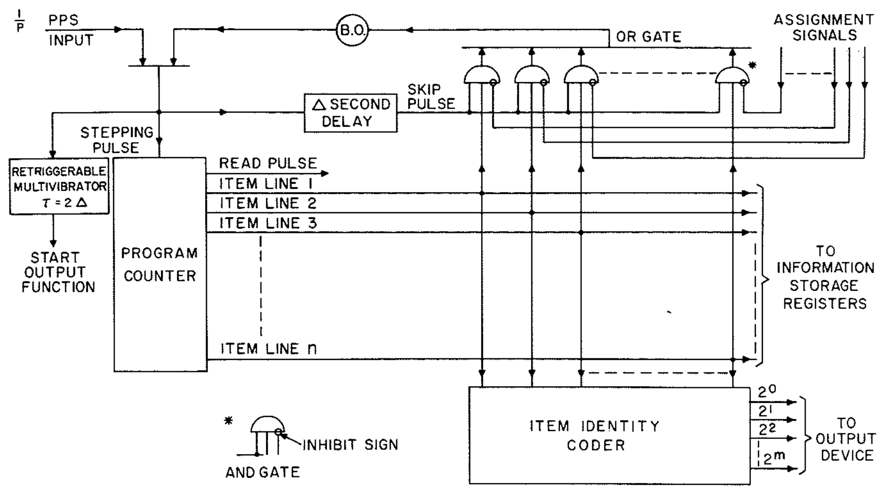


Fig. 2—Method of achieving desired performance of sampling control unit.

item lines associated with each radar can therefore be combined to feed their corresponding skip gate.

The steps involved in the complete skipping process are as follows. The skip pulse is first generated by transmitting the program counter stepping pulse through the Δ second delay line. This skip pulse is then fed to all the skip gates in parallel. Though many skip gates may have permissive control signals due to their unassigned items, the skip pulse is only able to gate through the one that is addressed by its item line. If that skip gate receives an inactivated item assignment signal, the skipping process is continued; otherwise it is interrupted. Should the skip pulse be gated through, it is reshaped by the blocking oscillator and sent to step the program counter to the next item line in the sequence. This stepping pulse in turn generates another skip pulse. In this way it is possible to skip any number of item lines in succession until one is reached that is selectable.

The start of the output function must be delayed until after an item has been properly selected, and the correct information storage register alerted. This is, of course, after the skipping process which utilizes $\Delta\ k$ seconds, where k represents the number of item lines skipped. It is desirable to keep the Δ delay extremely short compared to the period p in order to make available as much of the period p as possible for the execution of the output function. In this respect the delay line should be very short. But on the other hand, the delay line must be long enough to give sufficient time for the item line to properly address its skip gate. This is a circuitry problem and does not necessarily involve the use of a quartz delay line as such.

With regard to the starting of the output function, one practical scheme might be to always delay it for the maximum required time. When n items are involved, the extreme condition would be to make n skips in succession. Since it takes approximately Δ seconds to skip one item line, it would take $n\ \Delta$ seconds to make the maximum number of skips in succession. Thus, the start of the output function could always be delayed $n\ \Delta$ seconds to allow the program counter to reach a steady state regardless of the transient skipping pattern.

A second scheme involves having the skip pulses set a retriggerable one-shot multivibrator whose period is slightly greater than one skip period. In this way the multivibrator is only allowed to recover at the end of a series of skip pulses, which is after an item line is properly selected. The differentiation of the multivibrator output produces a pulse of the correct polarity every time the multivibrator recovers, and this represents a satisfactory start output function pulse.

The read pulse for this sampling control unit is generated at the beginning of the program counter cycle when the program counter is stepped to item line #0. This results in read-

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In May 1953 he joined the Univac Division of the Remington Rand Company where he organized the Univac Maintenance Training School, and later worked on the logical design of the Univac II computer.

Since June 1956 he has been associated with DEP's Missile and Surface Radar Department as a digital computer design engineer. He designed and developed the sampling control unit for the Talos Project. He is presently working on the BMEWS System Checkout Data Processor.

Mr. Hammel is a member of the IRE.

ing data from all the items to the storage registers. The time of this event is noted by the output function and all succeeding output functions in the cycle are referenced to it. This procedure establishes that all the output functions in one cycle are referenced to the same time regardless of the length of time involved to perform the output functions.

Each item that is selected to perform the output function must be properly indentified due to the questionable pattern of the selections. Consequently, an item identity coder is required to interpret into a binary code each item as it is selected. For the case of n item lines the item identity coder will generate m number of binary coded outputs as defined by the expression, $2^m \geq n$. These m binary coded outputs are transmitted to the output unit to identify each item as it is performing the output function.

EXAMPLE

In the example of the "system checkout" logic, consider that only radar #2 is operating in the group of four radars. When the program counter is stepped to item line #0, it produces a read pulse that simultaneously gathers azimuth, elevation, and range data from radar #2 only. The time of this sampling is recorded on tape, utilizing the total period of p seconds The next external stepping pulse advances the program counter to item line #1. The skip gate #1 is addressed, and because it has a permissive control signal, the skip pulse is gated through to step the program counter to item line #2. This in turn generates another skip pulse that gates through the permissive skip gate #2. Similarly, the program counter continues rapidly stepping to item line #4; but there the skipping process is interrupted because of the inhibitory control signal at skip gate #4. As a result, the output of the program counter reaches a steady state condition where item line #4 is selected for the remainder of the period p. With the interruption of the skip pulses, the one-shot multivibrator is allowed to recover and the start output function pulse is generated. The result of this effort is the recording of the radar #2 azimuth data on magnetic tape.

The next external stepping pulse steps the program counter to item line #5, and since this item is assigned, its data is also recorded. Following this, there is the recording of the radar #2 range. Then the program counter steps to item line #7 whereupon successive skip pulses are generated to bring the program counter to a steady state at the item line #0, and another read pulse is produced. The sampling control unit has now completed one cycle of operation. The timing diagram of Fig. 3 illustrates the pattern of skip pulses for this example. The pattern repeats itself for as long as the item assignment signals do not change.

CONCLUSION

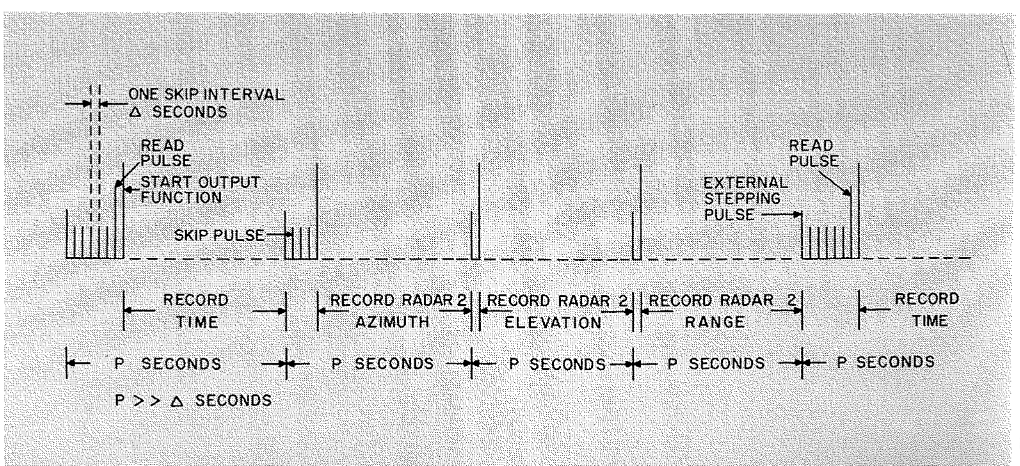
A salient feature of this logic is that an output function is executed every p seconds. Notice that when ten items are assigned, each item is sampled $1/(10\ p)$ times per second; however, when five items are assigned each item is sampled $1/(5\ p)$ times per second. This characteristic of the systems performance is desirous in certain applications and it is an important consideration in determining the rate of the external stepping pulses. In fact, the flexibility of the sampling control unit could be improved by permitting the selection of anyone of a number of external stepping pulse rates to satisfy the demands of the output unit.

This brings to light another major advantage of this logic which is the ability to vary the sampling rate over a wide range. There is no lower limit to the sampling rate, and the upper limit is strictly a function of the state of the art in circuit design. This logic is appropriate to high-speed computer methods and is compatible with transistor techniques.

Another feature to this logical design is the ease in which items can be added to or deleted from the operation. The limit to the quantity of items that can be added is governed by the minimum item sampling rate. As a result the period p must satisfy the minimum sampling rate while being of sufficient duration to permit the performance of one output function and the maximum number of item skips.

Finally, it can be pointed out that this logic permits the referencing of all samples to the same time base. This provides good correlation between the data and adds no complexity to the task of analyzing the data.

Fig. 3—Timing diagram showing the pattern of skip pulses in the example described in the text.



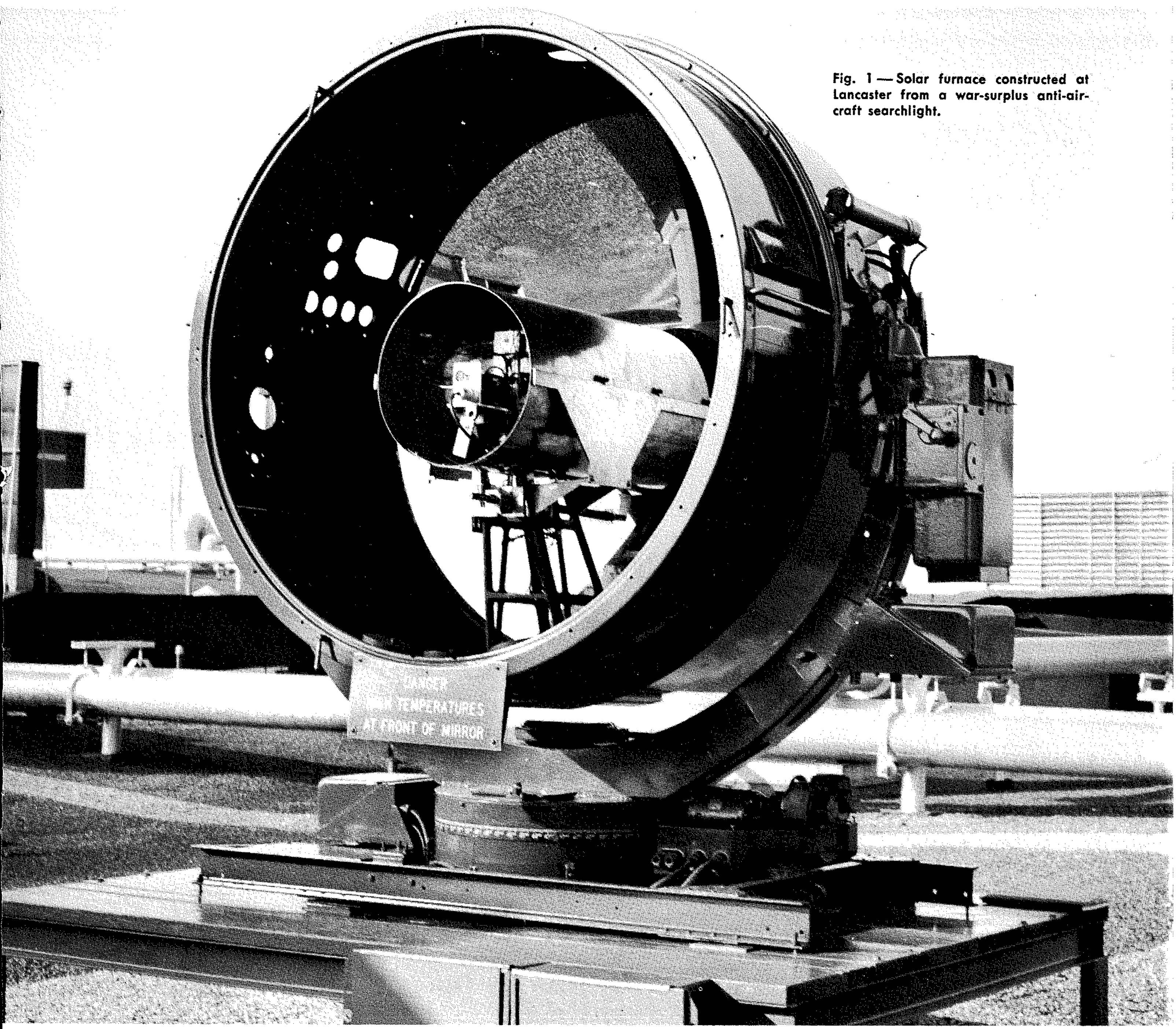


Fig. 1 — Solar furnace constructed at Lancaster from a war-surplus anti-aircraft searchlight.

DESIGN AND CONSTRUCTION OF A SOLAR FURNACE

by

Dr. PAUL G. HEROLD

Chemical & Physical Laboratory
Electron Tube Division
Lancaster, Pa.

INTEREST IN THE USE of solar energy for research and development has increased greatly in the last few years. Evidence of this increased interest is the fact that in 1950 there were only two solar furnaces in use in the United States, whereas at present there are between twenty and twenty-five. Many of these furnaces are used to produce very high temperatures needed for research in the solid-state characteristics of various materials. Although the high temperatures required for this work can also be produced by the carbon arc, by electrical-resistance heaters using molybdenum or tungsten wire surrounded by protective atmospheres, and by induction heating, the solar furnace has the advantages that it permits the using of oxidizing, neutral, or reducing atmospheres as desired, does not cause contamination of samples by foreign materials such as molybdenum, tungsten, and carbon, and permits practically instantaneous control of sample temperature. It also allows the sample to act as its own holder when it is necessary to minimize the possibility of contamination.

The Chemical & Physical Laboratory of the Electron Tube Division at Lancaster has recently constructed a solar furnace using as a foundation a war-surplus 60-inch anti-aircraft searchlight. This furnace, shown in Fig. 1, will be used in investigations of various high-melting point compounds and metal-and-oxide combinations to determine their suitability for use in tube construction.

FURNACE CONSTRUCTION

The searchlight used as the basic unit for the Lancaster solar furnace is equipped with a rhodium-plated copper reflector, and was obtained complete with its original high-speed azimuth and elevation drives and electrical control facilities.

Considerable modification was required to convert the searchlight into a solar furnace. For example, it was necessary to reduce substantially the speeds of the azimuth and elevation drive systems, and to devise means for automatically keeping the reflecting mirror pointed towards the sun. It was also necessary to devise means for holding samples to be heated, and to design a remote-control system for positioning the sample at or near the focus of the mirror, a sample-temperature control or "diaphragm" which would vary the amount of radiation reflected from the mirror to the sample, and means for measuring sample temperatures. These modifications and devices are described below.

MIRROR-DRIVE SYSTEM

The slow-speed drives which were designed to turn the furnace in elevation and azimuth are identical except for their speeds. Both employ ¼-HP, 1725-RPM reversible DC motors and gear-type speed reducers. The elevation drive, located in Box A at the right of the mirror in Fig. 1, makes one revolution in 7.75 minutes, and turns a toothed quadrant which tilts the mirror at the rate of 2.46 degrees per minute. The azimuth drive, located in Box B at the base of the mirror, has a speed of 0.925 RPM, and turns the mirror at a rate of 16.9 degrees per minute.

AUTOMATIC-TRACKING SYSTEM

Although an automatic-tracking system using the original selsyn system of the searchlight could have been built, the tracking error of such a system would have been much too great for the type of work contemplated, which required heating of samples one inch or less in diameter.*

The automatic-tracking system developed for the Lancaster furnace uses a specially designed cadmium-sulfide sintered cell as the sensing element. The cell currents actuate relays which control the operation of the elevation and azimuth drive motors. Although this automatic-tracking system uses no selsyns or feedback mechanisms and produces step-type movements of the mirror, it provides a tracking accuracy of ±0.01 inch.

The sintered cell, shown schematically in Fig. 2, is mounted on the optical axis of the mirror, 14 inches behind a metal cap containing a 1/16-inch circular aperture. Because the cadmium-sulfide sintered cell is most sensitive to light having a wavelength of 5800A, a filter having maximum transmission at this wavelength (Wratten No. 58) is mounted in front of the aperture. When the plane of the mirror is normal to the direction of the sun's rays the pencil of light passing through the circular aperture impinges on the dead spot D at the center of the cell. During the apparent upward movement of the sun before noon, the spot of sunlight on the cell moves down onto the sensitized area between terminals A and D. The resulting cell current closes a relay which energizes the elevation-drive motor in such a manner as to tilt the mirror upward. This upward movement of the mirror continues until the spot of sunlight has moved back to the dead spot at the center of

*Private communication from T. S. Laszlo, Fordham University, N. Y.: A selsyn-type automatic tracking system was used in a solar telescope built from the same model searchlight by the U S. Army Medical Corps. This system employed a four-phototube sensing device and had a tracking error of two inches.

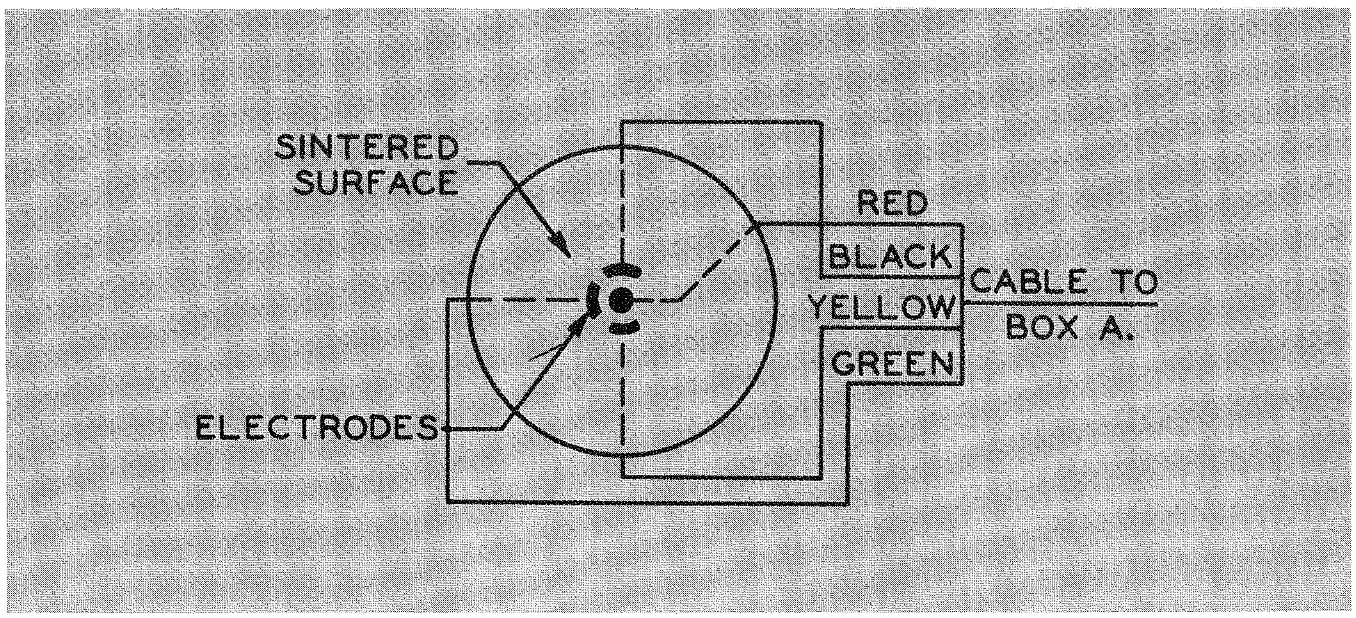


Fig. 2—Schematic representation of the specially designed cadmium-sulfide sintered photoresistive cell used in the automatic-tracking system for the furnace.

the cell, whereupon the cell ceases to conduct, the relay opens, and the elevation-drive motor stops. The mirror then remains motionless until the sun has moved upward sufficiently so that the area between A and D again conducts. A similar action, which moves the mirror downward, takes place between C and D when the sun apparently moves downward after noon. Conduction, which moves the mirror in azimuth, takes place between B and D when the sun's path is apparently horizontal.

Switches mounted on Box A permit the operator to short out the sintered cell and control the movement of the furnace in azimuth and elevation manually.

SAMPLE SUPPORT AND POSITIONING MECHANISMS

Because most of the samples to be heated in the solar furnace are fine-grained powders, it was necessary to provide some sort of receptacle as a support. The one adopted is a Transite block 3 inches high, 4 inches wide, and one inch thick, with a one-inch hole at its center. The block is placed face down on a sheet of glass, and sample powder is poured into the hole and tamped down with a glass rod. The resulting sample is densely compacted and has a flat face flush with the surface of the Transite block.

The block is then clamped to the surface of a jeweler's-lathe-type compound rest, which provides movement in two planes at right angles to the optical axis of the reflector. The compound rest is mounted, in turn, on the platform which originally held the carbon arc of the searchlight. This platform provides movement along the optical axis so that the sample can be moved in and out of the focal spot.

To permit remote control of sample position in all three planes, the two movements of the compound rest and the platform assembly are provided with motor drives. Each movement of the compound rest is connected through a flexible shaft to a 10-RPM fractional-horsepower 115-volt motor. These motors permit the sample to be moved a total of 2.31 inches laterally and 1.88 inches vertically at a rate of 0.375 inch per minute.

Back-and-forth movement of the sample is also obtained from a 10-RPM fractional-horsepower motor which is coupled to the platform through a rack-and-gear mechanism. This mechanism moves the entire platform assembly a total distance of 3.75 inches at the rate of 0.632 inch per minute. Any spot on the surface of the sample can thus be positioned at any point in a region 2.31 inches wide, 1.88 inches high, and 3.75 inches deep.

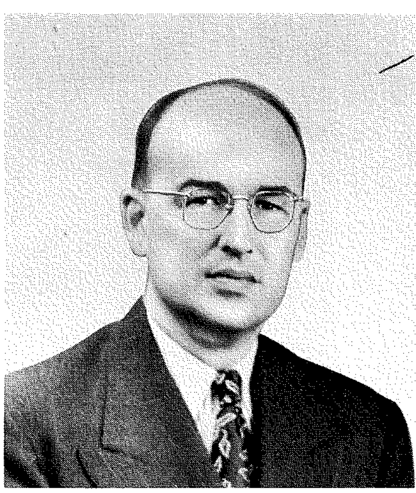
Limit switches on the three positioning mechanism prevent over-travel of the sample in any plane. The control switches for these mechanisms are mounted on the back of the furnace enclosure which is provided with a sighting hole so that the operator can observe the sample while adjusting its position.

TEMPERATURE-CONTROL MECHANISM

The "diaphragm" which controls the amount of radiation reflected from the mirror onto the sample and thus the temperature of the sample is a hollow cylinder 18 inches in diameter and 24 inches long, made of 1/16-inch brass. It is mounted on tracks and moves on an axis coincident with the optical axis of the mirror. Linear motion of the cylinder is provided by a 60-RPM fractional-horsepower motor, through a gear which floats on a slotted and threaded rod. The gear is prevented from moving laterally by two blocks, and, therefore, produces a linear motion of the threaded rod when it rotates. The rod is prevented from rotating by keys which fit the slots. The diaphragm is attached to the rod and can travel a total distance of 12.75 inches at the rate of 1.25 inches per minute.

MEASUREMENT OF SAMPLE TEMPERATURE

A problem which has not yet been solved is how to measure accurately the temperature of the sample being heated in the furnace. The difficulty involved in such measurement is that any sensing device which can be used picks up not only the radiant energy generated by the hot sample but also the solar radiation reflected by the sample. A conventional optical or radiation pyrometer does not differentiate between these two types of energy. A radiation pyrometer using two separate filters is being investigated. Until this problem is solved, the only way the temperatures produced by the solar furnace can be determined is to melt compounds having known high-temperature melting points. Thus far, chemically pure zirconium oxide, which has a melting point between 2950 and 3000 degrees, has been melted. The solar furnace, therefore, can produce temperatures at least as high as 2950 degrees.



PAUL G. HEROLD was awarded the Ph.D. degree by the Ohio State University in 1934, and the M.S. and B.S. in 1932 and 1931 respectively. His major work was Ceramic Engineering with interest in Mineralogy and Geology. Dr. Herold has served with General Motors in the Spark Plug Division, with Western Electric Company working on ceramic dielectrics, and is now with RCA, Lancaster in the Advanced Development of Phosphors. Immediately before coming with RCA, he was Chairman of the Ceramic Engineering Department of the School of Mines and Metallurgy, University of Missouri and Director of the Missouri Clay Testing and Research Laboratories. He is a Fellow of the American Ceramic Society and a member of Sigma Xi and Tau Beta Pi.

TESTING MAGNETRON JITTER

by

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THE PERFORMANCE OF AN MTI Moving-Target-Indicating) radar is determined to a great degree by the characteristics of the magnetron used in its transmitter, particularly by a characteristic called "jitter." This article describes the nature of magnetron jitter and its effect on the performance of MTI radar systems. It also describes the facilities and procedures used to test production quantities of magnetrons for jitter at the Harrison plant of the Electron Tube Division.

In conventional radars, it is frequently difficult to distinguish echoes produced by moving targets from a background of echoes produced by fixed objects. This difficulty is overcome in MTI radars, which have the ability to discriminate against echoes from fixed objects. This discrimination is achieved by the use of circuitry which subtracts each echo signal from the corresponding signal produced during the preceding pulse period. Objects producing indentical echoes on successive pulses, therefore, do not appear in the display. Successive echoes from moving objects, however, differ in phase (Doppler effect). These phase differences are converted by the MTI equipment into amplitude differences. Because successive echoes from moving objects do not cancel, such objects can be identified.

The effectiveness of an MTI radar is expressed in terms of "cancellation ratio"—the ratio between the amplitude of a fixed-target echo and the amplitude of the residual echo after subtraction. To achieve high cancellation ratios each fixed-target echo must be identical with its predecessor. This consideration imposes stringent requirements on the characteristics of the pulses applied to the magnetron oscillator in the transmitter as well as on the stability and timing functions of the receiver. These requirements are principally the concern of the equipment designer. It imposes equally stringent requirements on the performance of the magnetron. These requirements are of major concern to the magnetron manufacturer.

MAGNETRON JITTER

To achieve perfect cancellation of fixed-target echoes in an MTI radar, the transmitter magnetron must deliver r-f pulses which are identical in amplitude, starting time, duration, and frequency. A magnetron, however, is susceptible to frequency drifts, and manifests two characteristics known as "instability" and "jitter." Frequency drift results from the effects of heat on the internal geometry of the magnetron and from changes in the magnetron load impedance during the scanning action of the transmitting antenna ("pulling"). These effects are time dependent and are usually negligible in MTI radars because of the short time intervals between pulses. Instability is the term used for the occasional omission of an output pulse, or delivery of pulses of improper frequency or energy level, as the result of arcing or oscillation in an undesired mode. Instability reduces the amount of data received, as well as the cancellation ratio, because each missing pulse provides neither information nor cancellation of the following pulse.

"Jitter" is any change in timing, amplitude, or frequency occuring between successive pulses when all operating conditions are held constant. Time jitter may manifest itself as a change in the time required for oscillation to start after application of the pulse. It may also take the form of "front-edge moding," in which oscillation starts in an undesired mode and then changes to the correct mode. Either type of time jitter may affect the amplitude and frequency of the pulse, as well as its starting time and duration.

Jitter can occur as a result of instability, random changes in magnetron impedance, or any change in the shape or amplitude of the input pulse. For example, any change in magnetron impedance before or during a pulse changes the amount of energy drawn from the power supply, and thus changes the amount available for the succeeding pulse. Because the frequency of oscillation of a magnetron is affected by the anode current ("pushing"), changes in power supply voltage also result in changes in output frequency.

The cancellation ratio which can be achieved in an MTI radar system is limited by the jitter of the magnetron used. Specifications for an MTI system, therefore, are generally based on maximum acceptable jitter values for the magnetron, expressed in terms of their affect on the cancellation ratio of the system. Magnetron specifications may give maximum values for each jitter component or for the combination. The last method is preferred, because it permits the use of sliding-scale limits for the individual components. Fig. 4 is an example of a sliding-scale limit.

SYSTEM PERFORMANCE VS JITTER

Fig. 1 shows the envelope of a typical magnetron output pulse. The ripple

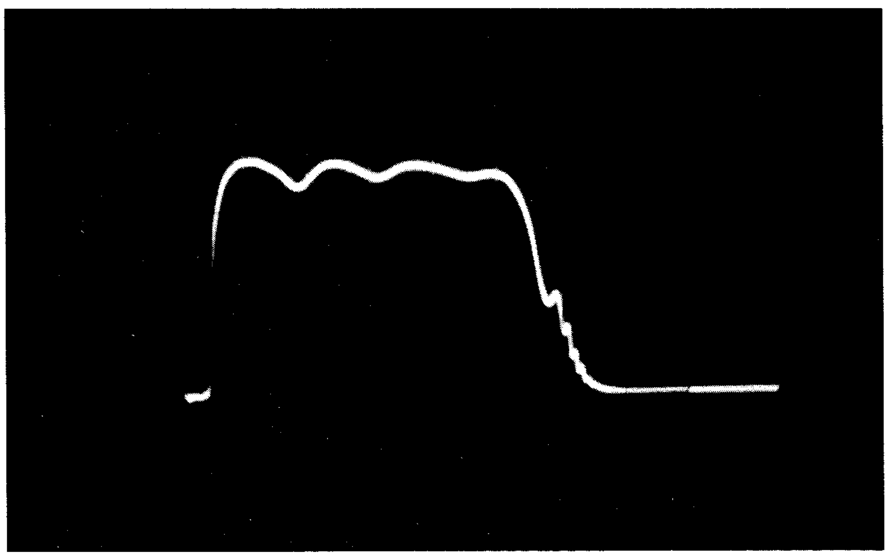


Fig. 1—Oscillogram of the envelope of a typical magnetron output pulse. Amplitude jitter is present, but is too small to be seen in the trace.

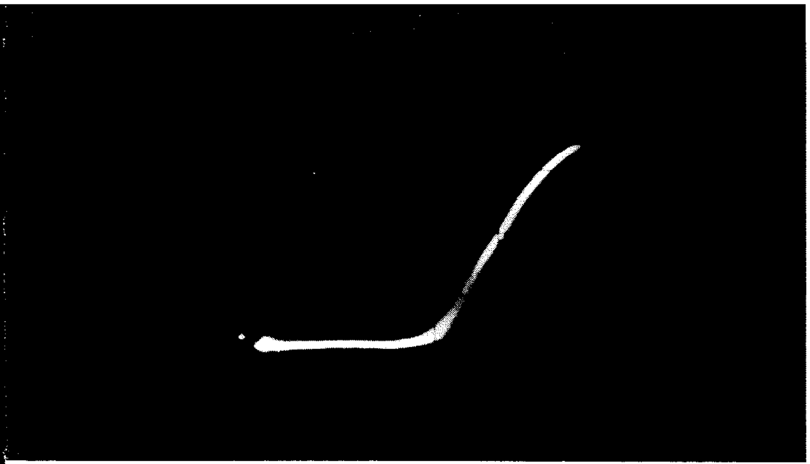


Fig. 2—Oscillogram of the leading edge of a magnetron/output pulse. The blur at the start of the rise is caused by time jitter.

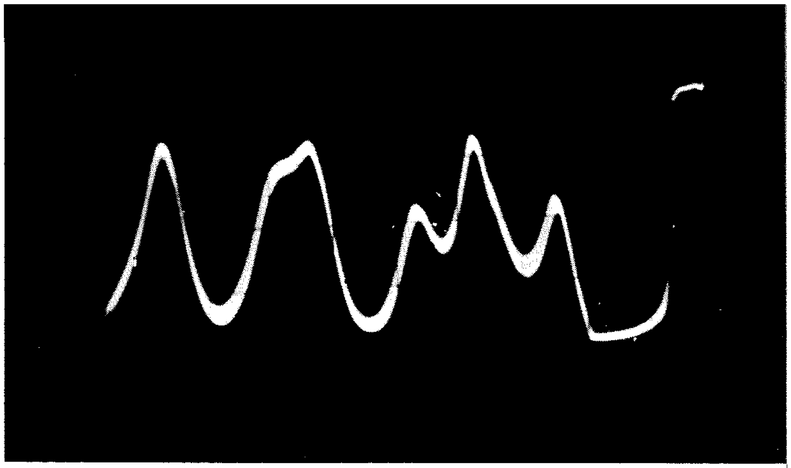


Fig. 3—Oscillogram of interferometer output pulse. The flat-topped region at the left represents the time delay of the interferometer. Frequency jitter is seen as a thickening of the trace. Ripple is the result of frequency variation during the pulse.

along the top of the pulse is caused by the pulse-forming network. The pulse varies in frequency as well as in amplitude. Because of its complexity, such a pulse is difficult to express in mathematical terms. However, equations relating cancellation ratio to amplitude, time, and frequency jitter have been developed. Because these equations are based on a rectangular pulse having constant frequency, the accuracy of the results obtained will depend upon the characteristics of the magnetron, radar system and target. They do, however, provide a practical basis for the evaluation of magnetrons by the tube manufacturer.

In these equations cancellation ratio is expressed in terms of a reciprocal voltage and, therefore, is proportional to the residual pulse voltage after subtraction. The relation between cancellation ratio and amplitude jitter is given by

$$CR_A = \frac{\Delta A}{A}$$

where ΔA is the fractional difference between two successive pulse voltages and A is the average of the two. (Amplitude jitter is usually expressed in decibels).

The relation between cancellation ratio and time jitter is more complex, and is given by

$$CR_T = 1 - e^{-\omega_o \Delta T}$$

where ω_0 is the bandwidth of the system in radians per second. The bandwith limits the cancellation ratio obtainable, because it determines the amplitude of the small spike obtained when two pulses having a small time displacement are compared.

The relation between cancellation ratio and frequency jitter is given by

$$CR_F = t_p \Delta F$$

where t_p is the pulse duration and ΔF is the change in frequency between successive pulses.

Because of the random character of jitter, all values are expressed on an rms basis. The combined effects of the three jitter components, therefore, are given by

$$CR = \sqrt{(CR_A)^2 + (CR_T)^2 + (CR_F)^2}$$

Because this equation describes a sphere having a radius CR, the limits for each component can be plotted as a quadrant of a circle, as shown in Fig. 4.

TESTING JITTER

Two methods are used for the measurement of jitter, pulse-pair measurements and measurement of the overall variation of a large number of pulses. In the pulse-pair method, the amplitude, leading-edge or frequency of two successive magnetron output pulses are displayed and photographed. The value of the difference is determined from the photograph and the corresponding rms jitter value computed. It is necessary to test a large number of pairs to obtain a re-

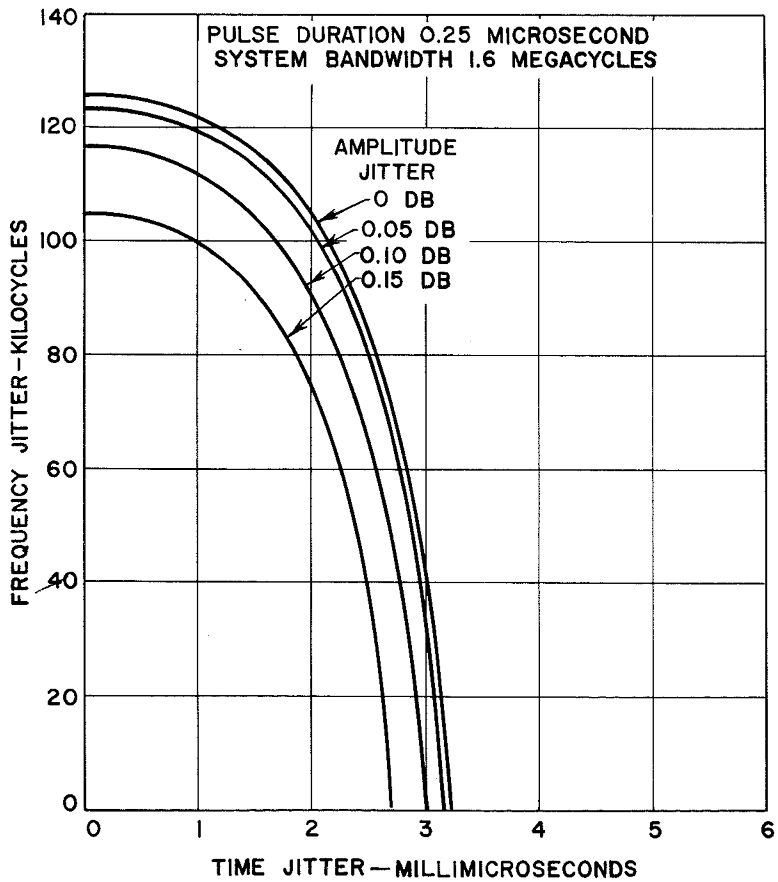


Fig. 4—Typical sliding-scale specification for magnetron pulse-to-pulse jitter, based on a magnetron cancellation ratio of 30 db.

liable value. This method is too lengthy for production work.

Overall measurements of magnetron jitter are based upon a relation between the over-all variation of a particular parameter and the pulse-to-pulse jitter value of the same parameter. Assuming random (Gaussian) distribution of jitter, the over-all jitter is equal to the pulse-to-pulse value multiplied by the square root of 2. Calculated test limits, therefore, may be converted to over-all jitter limits, or over-all jitter may be converted to pulse-to-pulse variation, depending upon the nature of the specification. Because the over-all testing method requires that the jitter of the parameter under study be truly random, power-supply ripple and other cyclic variations must be reduced to the lowest possible values. It is desirable, therefore, to use 400-cps power and three-phase rectifiers as power and three-phase rectifiers as power supplies.

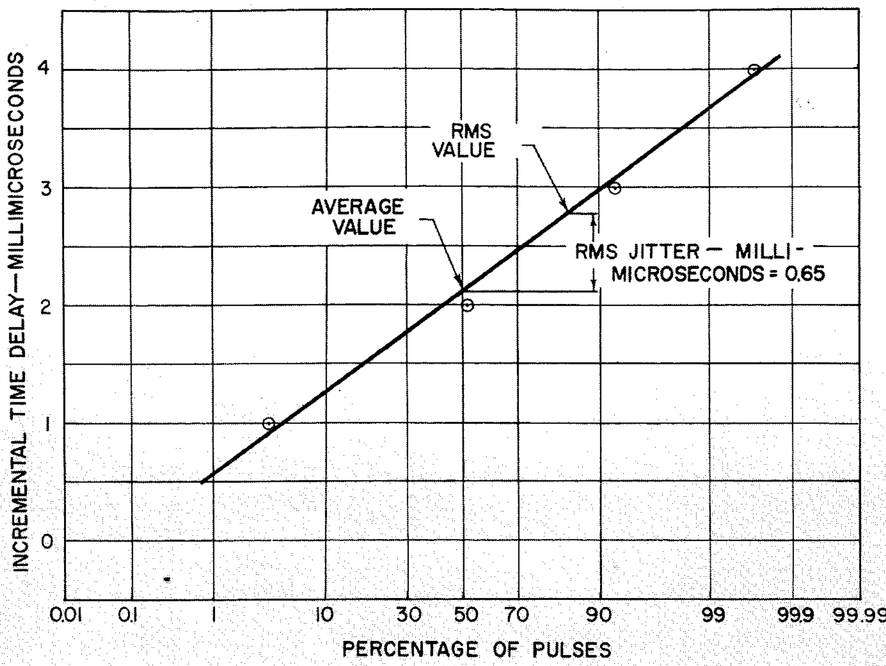


Fig. 5—Typical time-jitter characteristic chart, showing the distribution of pulse starting times.

JITTER TEST EQUIPMENT

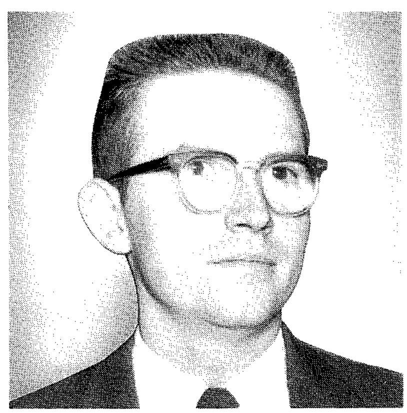
The magnetron-testing equipment used at the Harrison plant of the Electron Tube Division measures amplitude jitter, frequency jitter and starting-time jitter on an over-all basis. In this equipment each type of jitter is first studied to determine its distribution within calibrated adjustable limits; for example, such a test would be to determine the total number of pulses which start less than 3 mili-microseconds after a reference time. These numbers are converted directly to percentages by the use of electronic counters. The distributions for various test limits are then plotted on an arithmetic probability chart. This chart has a horizontal scale determined by the normal cumulative distribution (integral of the Gaussian curve). A random function plotted on this chart yields a straight line having its average value at 50 percent and its rms values (one sigma) at 15.87% and 84.13%. The rms value of jitter is read from the plot as the difference between the 50% and the 84.13% points.

In the measurement of amplitude jitter, attenuated magnetron output pulses are applied to a crystal detector. Because of the square-law characteristic of the crystal, the amplitude of the detector output is proportional to the pulse power. The resulting voltage pulse is applied to a delay-line amplifier which delivers a 2-microsecond pulse having an amplitude proportional to the peak value of the input pulse. This 2-microsecond pulse is then applied to a pulse-height analyzer which delivers output to the counter only when the amplitude of its input falls within pre-determined limits. Jitter percentages are measured against increments within these limits. The incremental resolution of the measurement is approximately 0.001 db of amplitude jitter.

Time jitter and frequency jitter are measured by means of a wide-band cathode-ray oscilloscope, and a multiplier phototube. The screen of the oscilloscope is provided with a mask having a narrow slit, and the position of the trace is varied to control the number of pulses seen by the phototube through the slit. The output of the multiplier phototube is then counted, and converted to percentage. Figs. 2 and 3 show the display of time and frequency jitters.

In time-jitter measurement, the r-f, pulse is detected by a crystal and the resulting signal is applied through a fixed-delay network to the vertical input of the oscilloscope. A voltage pulse from the magnetron pulse transformer which has passed through a calibrated variable delay line is used to trigger the oscilloscope sweep. With this arrangement, the position of the leading edge of the pulses can be varied horizontally in time delay increments of one millimicrosecond. The slit is placed horizontally so that the multiplier phototube reads the percentage of pulses having leading edges within the desired range. The rms values of time jitter can be read to fractions of a millimicrosecond.

Frequency jitter tests are performed with the aid of a microwave frequency discriminating circuit. Because a discriminator containing high-Q reactive elements would be difficult to tune and might also be susceptible to ringing, a waveguide interferometer is employed for this purpose. The heart of the interferometer is a hybrid tee. This four-terminal waveguide device has no coupling between its two tee arms, but each



JAMES E. SIMPSON received the B.S. degree in Electrical Engineering from Pennsylvania State University in 1955. He joined RCA in the same year as an engineering trainee assigned to the Microwave Application and Test activity in Harrison, N. J. In this group, he was concerned with many problems of tube operation, including jitter problems. He has recently been transferred to the test engineering unit of this activity.

Mr. Simpson is a Member of the Institute of Radio Engineers and the Army Reserve.

tee arm has equal coupling to both end arms. As a result, when a signal is applied to one tee arm, the output of the other tee arm is proportional to the vector sum of the reflections from the two ends.

In the interferometer, one end arm of the tee is connected through a variable attenuator to precision adjustable short-circuit which can be positioned by means of a micrometer adjustment. The opposite arm of the tee is connected to a waveguide approximately 50 feet long which also has an adjustable short circuit at its far end.

Because this waveguide is several hundred wavelengths long, the phase of the reflection from its far end is extremely sensitive to frequency changes. The attenuator of the shorter circuit arm is used to compensate for the attenuation of the long waveguide and thus make the reflections of both arms equal in amplitude. The adjustable short circuits permit the phase of the reflections in the two arms to be adjusted for cancellation of the output signal. When these conditions are satisfied, a null condition is obtained each time the electrical length of the long arm changes by one-half wavelength. The output of the crystal detector increases with frequency deviations up to approximately 3 megacycles and is linear over approximately 1.5 megacycles. Deviations of more than 3 megacycles approach the next null. The sensitivity of the system can be calibrated in units of kilocycles per 0.001 inch of micrometer travel. The frequency range of the interferometer is limited only by the cross-sectional dimensions of the waveguide employed. The unit at Harrison is usable from 8.2 to 12.4 Kmc.

In tests for frequency jitter, the interferometer is first adjusted to produce a null. Either short circuit is then moved until the average frequency of the magnetron output and all jitter frequencies are located on the same rising slope of the detector output vs. frequency curve. The height of each trace on the oscilloscope screen is then a function of its frequency. The slit of the mask is placed vertically so that each trace is intercepted at the same relative time near the center of the pulse. The center is used because the leading and trailing edges are distorted by the time delay of the long waveguide. The number of traces reaching the multiplier phototube is controlled by movement of one of the adjustable short circuits, thus raising all traces on the screen. At 9600 mc, the sensitivity of the interferometer is approximately 0.6 kilocycles per 0.001 inch micrometer reading.

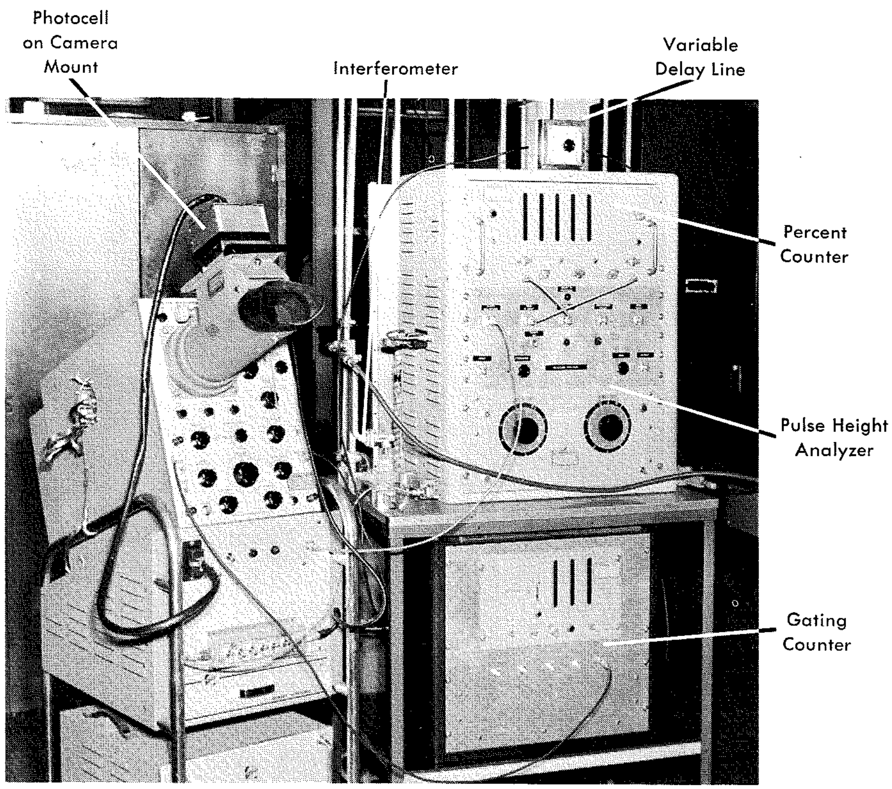


Fig. 6—Mobile jitter-test equipment at Harrison.

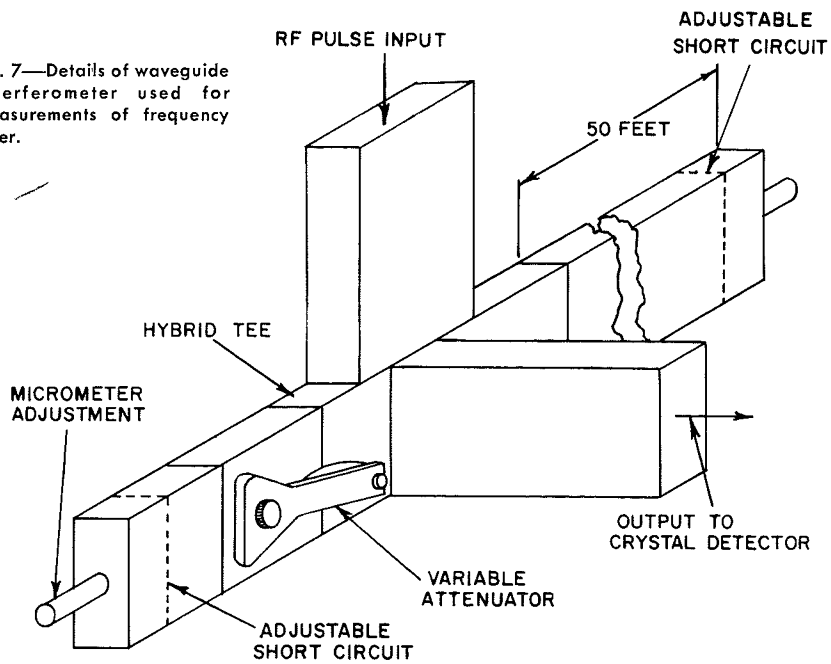
Fig. 4 shows a plot of magnetron-jitter limits established to provide a 30 db cancellation ratio in an MTI radar system having a pulse duration of 0.25 microsecond and an effective display bandwidth of 1.6 megacycles. The plot defines limits of frequency jitter and time jitter for various values of amplitude jitter.

Fig. 5 shows the results of time-jitter measurements performed on an RCA type 7110 tunable X-band magnetron operating at 9600 mc. The rms over-all time jitter is 0.65 millimicrosecond, which is equivalent to 0.9 millimicrosecond on a pulse-to-pulse basis. The frequency jitter of this tube was 25 kilocycles pulse-to-pulse. Amplitude jitter was less than 0.1 db. The tube, therefore, meets the requirements of Fig. 4.

CONCLUSIONS

The test equipment and test methods described provide a satisfactory means for determination of magnetron jitter on a production basis. Similar equipment can be used to determine the performance of a complete radar system. Such equipment would provide combined information on the magnetron and the jitter of other components such as the thyratron which contributes a considerable amount of time jitter. The basic principles employed can also be adapted to the measurement of any random varying function.

Fig. 7—Details of waveguide interferometer used for measurements of frequency jitter.



AN INFRARED PICKUP TUBE

By

G. A. MORTON AND S. V. FORGUE
RCA Laboratories
Princeton, N. J.

THE FIRST PRACTICAL infrared imaging device was the image tube developed during World War II and it found application in the Snooperscope, Sniperscope, and a variety of signaling telescopes. The image tube employed a Cs-Cs-O-Ag (S-1) photocathode as the image sensing surface. Electrons from this photocathode were focused by means of an electrostatic electron optical lens system onto a fluorescent screen where they produced a visible image. The long wavelength limit of these image tubes was determined by the response of the photocathode which had its maximum sensitivity between 0.8 and 0.9 microns and a negligible response beyond 1.25 microns.

The next logical step in the development of infrared imaging is that of carrying the response to a longer wavelength. However, since no known photocathode has a longer wavelength response than the S-1 cathode, it is necessary to employ an entirely different method of imaging in order to accomplish this end. A number of photoconductors, in particular the lead chalconides, are known to be sensitive to long-wavelength infrared radiation. Of these, lead sulfide was selected as the most promising material for the initial attempt at extending the long-wavelength limit of infrared imaging devices.

There are a number of ways in which a photoconductor can be used as the radiation sensing surface of an image-forming device. The most promising of these were examined in detail during the early phases of research on this problem. The method selected was the principle employed in the television pickup tube now known as the vidicon. The pickup tube contains a sensitive target in the form of a thin layer of the photoconductor on a transparent window forming one end of the tube. For reasons that will become apparent, the photoconductor employed must have a very high resistance when the material is in darkness. At the other end, there is an electron gun producing a low-velocity beam of electrons. Electrons returning from the target enter a secondary emission multiplier which is coaxial with the gun and the greatly amplified return current is supplied to the signal lead. Fig. 1 shows the arrangement of this tube. The electron beam is focused by an axial magnetic field and deflected by a system of orthogonal deflecting coils producing fields at right angles to the motion of the beam.

The operation of this type of pickup tube as shown in Fig. 2 is as follows. First, assuming the tube in complete darkness, any small element of area of the photoconductor under the beam receives electrons and becomes increasingly negative until it reaches approximately the potential of the gun cathode. Thereafter, the beam electrons can no longer reach this element but are turned back by the negative charge on it and are collected by the multiplier. As soon as the beam moves away from this element in the course of its scanning cycle, the dark current flowing between the conducting substrate, which is maintained at a positive potential, and the surface tends to charge the surface positive. This charging continues until the beam returns to the element at the start of the next frame when it is again returned to cathode potential. If, now, radiation falls on the target in the area in question, the surface charges positive more rapidly due to the photoconduction of the material and reaches a higher positive potential during the period of one frame. Consequently, when the beam passes over this area and returns it to its equilibrium (gun cathode potential), more electrons will be extracted from the beam and fewer returned to the multiplier. It is evident, then, that if the radiation image is focused onto the target, the output current from the multiplier will fluctuate as the beam passes over the illuminated and unilluminated areas of the image, the current being larger for the dark areas and smaller for the illuminated regions. This is the video signal output of the pickup tube.

An important point to notice in connection with this type of operation is that every picture element of the target which is illuminated conducts a photocurrent during the entire time and stores the accumulated information as a positive surface charge for the frame period while the beam is elsewhere on the target. This storage operation leads to a gain in signal-to-noise ratio proportional to the square root of the number of picture elements in the image area as compared to the same photoconductor used in a system where point-by-point scanning is employed (e.g., where the photoconductor is used with a Nipkow disk or other similar system). For a high-definition picture (e.g., a 400-line picture as is produced by the tube under discussion), the gain in signal-to-noise ratio is of the order of 500 times.

The critical element of the infrared pickup tube is the photoconductive target which must satisfy two rather conflicting requirements, namely, it must be of a material which is sensitive to relatively long-wavelength infrared radiation, yet it must have the high resistivity required for storage operation. A simple calculation reveals that for a target of material having a dielectric constant of 3, the resistivity must be of the order of 10^{10} ohm

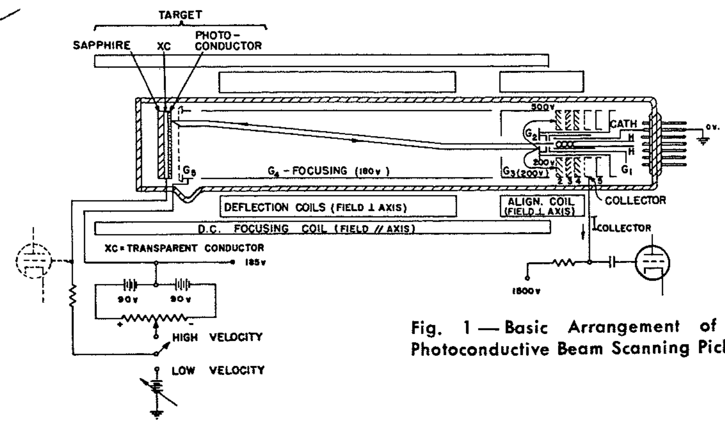


Fig. 1 — Basic Arrangement of Infrared Photoconductive Beam Scanning Pickup Tube.

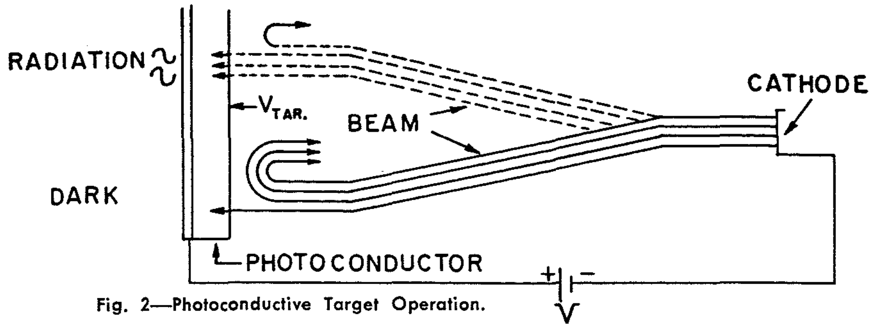
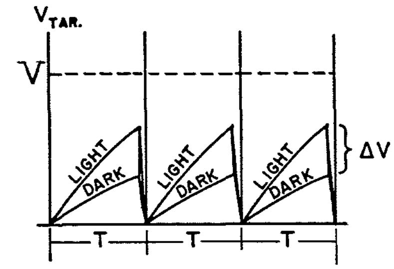


Fig. 2—Photoconductive Target Operation.



centimeters. In order to make clear the difficulty which arises in attempting to satisfy these two conditions, it is necessary to examine briefly the physics of photoconductivity.

A photoconductor is a material whose conductivity increases when electromagnetic radiation of appropriate wavelength is incident upon it. They are members of the class of substances which are known as semiconductors. In these substances, which are in general crystalline in nature, the conduction electrons (and holes) are weakly bound to their parent lattice atoms, thereby differing on the one hand from an insulator where the binding is strong and on the other hand from a metal where the conduction electrons are free. At low temperatures and in the absence of radiation, semiconductors have very high resistance. However, electromagnetic radiation, of short enough wavelength and therefore constituted of photons of sufficient energy, can cause the release of charge carriers and consequently cause conductivity. The relationship between radiation, wavelength in microns, and photon energy in electron volts is:

$$E = \frac{1.234}{\lambda}$$

If a photoconductor is to be sensitive to radiation of 2-micron wavelength, the binding energy of the charge carriers must be 0.617 ev or less. A normal semiconductor with an activation or binding energy as small as this, will have a very low resistivity at room temperature. Therefore, for application in a storage type pickup tube, the basic material must be prepared in very special ways. The resistivity of normal lead sulfide at room temperature is only a few ohm-centimeters. This, as has been shown above, is 9 or 10 orders of magnitude lower than the resistivity required for storage operation; therefore, the lead sulfide must be greatly modified for use in this type of pickup tube.

Targets for the tube under discussion are prepared by evaporating on an appropriate substrate layers of lead oxide which are then activated with sulfur and a suitable thermal treatment followed by a final layer of lead oxide. This results in a surface film which has a very high resistance and has an extremely complex makeup in terms of a solid-state model. The fraction of lead sulfide centers in the layer is relatively small but sufficient so that the optical absorption of the film is adequate for the purpose. The presence of the lead oxide increases the ionization energy of the basic lead sulfide and, furthermore, it introduces barriers in the form of p-n junctions.

The completed tube with the modified lead sulfide target is shown in Fig. 3. It fits into a focusing coil and deflecting yoke which is very similar to that used for the image orthicon and, except for the fact that it does not require image section voltages and a higher target voltage is used, the voltages applied to the tube electrodes are also approximately those used with the image orthicon.

In addition to the 2-inch size tube shown in the preceding figure, smaller tubes of the 1-inch vidicon size were also made. The tubes of this size did not have a multiplier and employed standard vidicon basing so that they could be used directly in ITV cameras. Fig. 4 shows a side-by-side comparison of the 2-inch and 1-inch size tubes.

In order to evaluate these tubes, a field camera based on a closed loop ITV unit was constructed. This camera is shown in Fig. 5. The spectral response of the system is shown by the curve given in Fig. 6. The response reflects the contributions of a form of lead-oxide response having its maximum in the middle of the visible spectrum and the lead-sulfide response which peaks in the near infrared and extends to about 2.1 microns.

The sensitivity of these tubes is sufficient to image objects which are at 150°C, by their own radiation. Fig. 7 shows the reproduced image of a soldering iron operated at 200°C. The long-wavelength limit extends far enough into the infrared so that it is possible, with the use of an appropriate infrared filter (a combination of Corning 2540 and 4060 passing beyond 1.2 microns) and an illuminator,

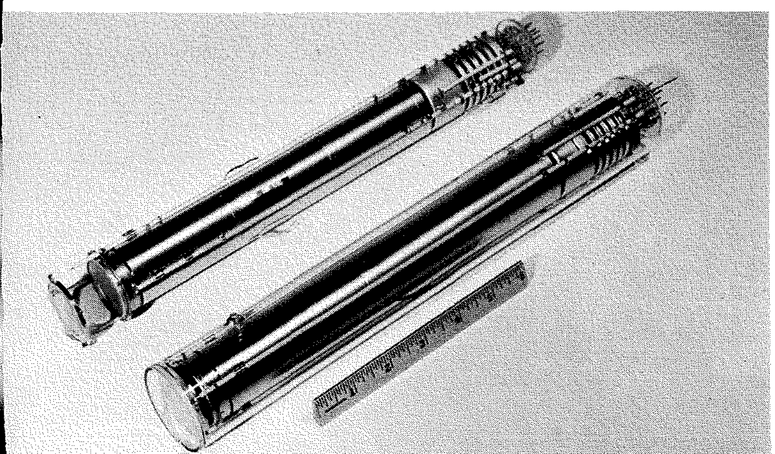


Fig. 3—Infrared Beam Scanning Pickup Tube (2" non-cooled).

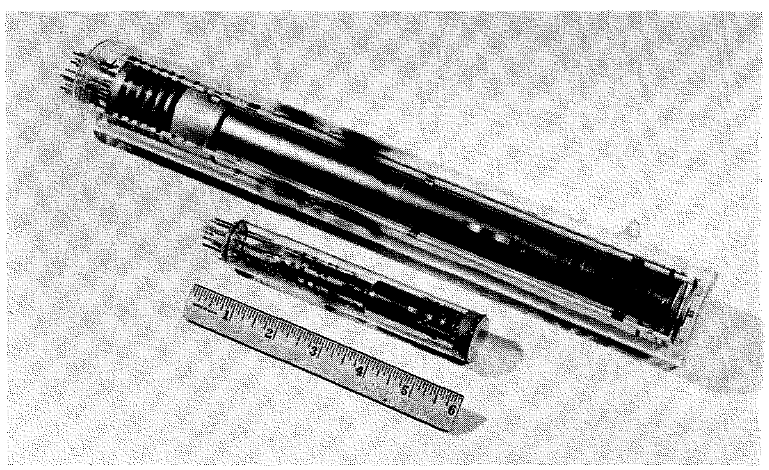
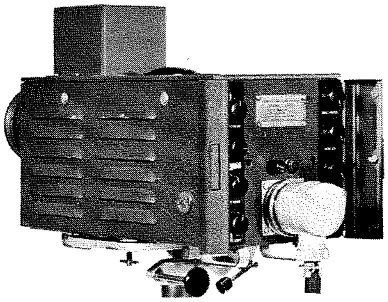


Fig. 4 — Infrared Pickup Tubes using Modified Lead Sulfide (2" and 1" sizes).

to see with radiation which is invisible to the World War II image tubes. Fig. 8 shows a human subject illuminated with such an illuminator. It is interesting to note that the flesh tones are completely black due to the fact that there is a strong water absorption band in the vicinity of 1.8 microns with the reflectivity very low.

The sensitivity and long-wavelength response of tubes of this type are sufficient so that they can be used for the study of the thermal area distribution of objects operated at a relatively high temperature such as boilers, nuclear reactor cores, and certain types of electrical equipment. With an appropriate illuminator, they may be used in the preparation and processing of infrared films since such films have a long-wavelength cut-off considerably above the cut-off of the tubes in question. Another interesting application of these tubes is in the examination of the semiconductor germanium. Germanium becomes transparent at 1.8 microns. Thus, these tubes can be used together with appropriate optics for examining strain patterns, making microscope studies of the material, etc. They have also proved to be a useful tool for rapidly adjusting near infrared optical systems for maximum performance. A final example of the application of these tubes might be cited in their employment by spectroscopists for the rapid study of near infrared spectra out beyond the wavelength that can be covered either with an image converter tube or by photographic plates.



ACKNOWLEDGEMENT

The writers wish to acknowledge the contributions of G. Krieger, G. Bain and Dr. M. Schultz to the development of this tube. The program of research at RCA Laboratories which led in 1952 to the development of this infrared pickup tube was sponsored by the Engineer Research and Development Laboratories, Army Corps of Engineers, Ft. Belvoir, Va.

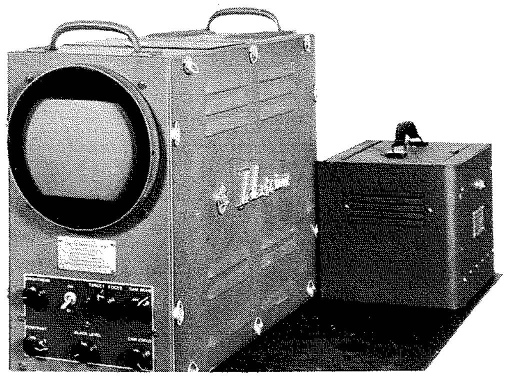


Fig. 5—Infrared Field Camera Chain.

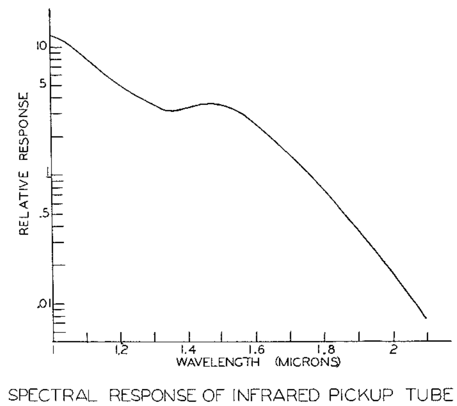
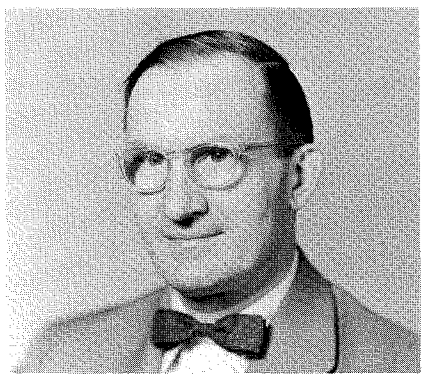


Fig. 6—Spectral Response. of Infrared Pickup Tube.



STANLEY V. FORGUE received the B.S. and M.S. degrees in Physics and the B.EE. degree from Ohio State in 1939-40. During two more years of graduate work until the war, he was a Graduate Assistant in Physics and a Research Fellow. Since 1942, he has been with RCA Laboratories at Harrison and Princeton, being a research project leader since 1952.

His primary field of research experience at RCA has been that of TV pickup tubes including image orthicons, orthicons and vidicons. He developed the photoconductive surface basic to the standard commercial vidicons and also has patents and publications in the fields of storage tubes, photoconductive cells and surfaces, color pickup tubes, color kinescopes and infrared. He has received four RCA Laboratory Research Awards in these fields.

He is a member of IRE (Senior Member), Sigma Xi, American Physical Society, Tau Beta Pi, American Association for the Advancement of Science, Sigma Pi Sigma and Pi Mu Epsilon, and is a Registered Professional Engineer.

GEORGE A. MORTON received his B.S. in E.E., his M.S. in E.E., and his Ph.D. in Physics from the Massachusetts Institute of Technology. From 1933 to 1941 he was a research engineer at the RCA Manufacturing Company in Camden, and from 1942 to 1946 he was a member of the Technical Staff of RCA Laboratories in Princeton. In 1946, on leave from RCA, he was employed as a nuclear physicist at the U. S. Atomic Energy Commission in Oak Ridge. In 1947 Dr. Morton returned to RCA Laboratories and from 1955 to the present time he has been Associate Director of the Physical and Chemical Research Laboratory.

During World War II and after, he served as a member of the National Defense Research Committee, AAF Scientific Advisory Board and the Research Defense Board.

He is a fellow of the IRE and American Physical Society, and a member of Sigma Xi, American Association for the Advancement of Science and the AIEE.

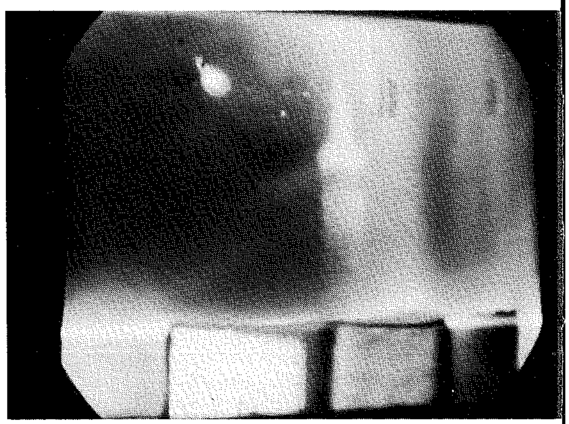


Fig. 7—Soldering Iron at 200°C.

Fig. 8—Human Subject Illuminated with Radiation beyond 1.3 microns (Corning 2540/4060 combination).

Patents Granted
TO RCA ENGINEERS

Based on Summaries Received over a period of about two months

DEFENSE ELECTRONIC PRODUCTS

Moorestown, N. J.

Transistor Sweep Circuit

Pat. No. 2,863,069—granted Dec. 2, 1958 to M. J. Campanella.

Frequency Control Circuit

Pat. No. 2,864,059—granted Dec. 9, 1958 to T. T. N. Bucher.

Camden, N. J.

Radar Systems

Pat. No. 2,858,531—granted Oct. 28, 1958 to A. C. Stocker.

Stabilized Transistor Amplifier

Pat. No. 2,860,193—granted Nov. 11, 1958 to J. E. Lindsay.

Binary Devices

Pat. No. 2,866,178—granted Dec. 23, 1958 to W. A. Helbig and A. W. Lo, Princeton Labs.

Los Angeles, Calif.

Magnetic Heads and Replaceable Pole Cap Assemblies Therefor

Pat. No. 2,861,135—granted Nov. 18, 1958 to M. Rettinger.

ELECTRON TUBE DIVISION

Harrison, N. J.

Beam Convergence Apparatus for Tri-Color Kinescope

Pat. No. 2,837,207—granted June 3, 1958 to I. S. Solet and R. L. Waer, no longer with RCA.

Apparatus for and Method of Automatic Assembly of Electron Tube Parts to Form An Electrode Cage

Pat. No. 2,842,832—granted July 15, 1958 to J. A. Chase, F. J. Pilas, R. K. Wolke and D. Battstone, Cincinnati, Ohio Plant.

Electron Discharge Tube and Electrode Therefor

Pat. No. 2,858,469—granted Oct. 28, 1958 to F. J. Pilas.

Plural Turret Machine

Pat. No. 2,857,787—granted Oct. 28, 1958 to H. E. Natalis.

Apparatus for Making Electron Device Stems

Pat. No. 2,857,711—granted Oct. 28, 1958 to P. Maurer.

Apparatus for Coating Simultaneously a Plurality of Separate Metal Articles

Pat. No. 2,861,936—granted Nov. 25, 1958 to D. W. Colasanto.

Scribing Apparatus

Pat. No. 2,862,300—granted Dec. 2, 1958 to P. Maurer and J. DiMauro.

Method of Making an Electron Tube

Pat. No. 2,866,120—granted Dec. 23, 1958 to C. M. Morris and N. E. Pryslak.

Lancaster, Pa.

Electron Beam Controlling Apparatus

Pat. No. 2,859,365—granted Nov. 4, 1958 to A. M. Morrell.

Gas Pressure Testing and Control Apparatus

Pat. No. 2,861,861—granted Nov. 25, 1958 to E. E. Hoffmann.

Method of Manufacturing Electron Sensitive Mosaic Screens

Pat. No. 2,865,784—granted Dec. 23, 1958 to T. A. Saulnier, Jr.

Cincinnati, Ohio

Apparatus for and Method of Automatic Assembly of Electron Tube Parts to Form An Electrode Cage

Pat. No. 2,842,832—granted July 15, 1958 to D. Battstone, and J. A. Chase, F. J. Pilas and R. K. Wolke, Harrison, N. J. Plant.

RADIO & "VICTROLA" DIVISION

Cherry Hill, N. J.

Transistor Amplifier with Overload Protection

Pat. No. 2,860,196—granted Nov. 11, 1958 to J. B. Schultz.

RCA VICTOR TELEVISION DIVISION

Cherry Hill, N. J.

Apparatus for Deriving Signal Information From a Modulated Wave

Pat. No. 2,858,428—granted Oct. 28, 1958 to A. J. Torre.

Transistor Control Circuit

Pat. No. 2,863,123—granted Dec. 2, 1958 to W. R. Koch.

Color Kinescope Adjunct

Pat. No. 2,864,021—granted Dec. 9, 1958 to A. G. Lazzery.

Fine Tuning Control System for Television Receivers Having Same Range On Each Channel

Pat. No. 2,864,946—granted Dec. 16, 1958 to J. C. Achenbach.

Automatic Gain Control Circuits

Pat. No. 2,864,888—granted Dec. 16, 1958 to H. C. Goodrich.

INDUSTRIAL ELECTRONIC PRODUCTS

Camden, N. J.

Stabilized Cathode-Coupled Multivibrator

Pat. No. 2,858,427—granted Oct. 28, 1958 to A. C. Luther, Jr.

Detector for Vestigial Sideband Signals

Pat. No. 2,861,180—granted Nov. 18, 1958 to R. W. Sonnenfeldt.

Television Transmitter System Employing Components in Parallel

Pat. No. 2,864,082—granted Dec. 9, 1958 to T. U. Foley and O. O. Fiet, no longer with RCA.

Feedback Clamping Circuit Arrangements

Pat. No. 2,863,943—granted Dec. 9, 1958 to A. C. Luther, Jr.

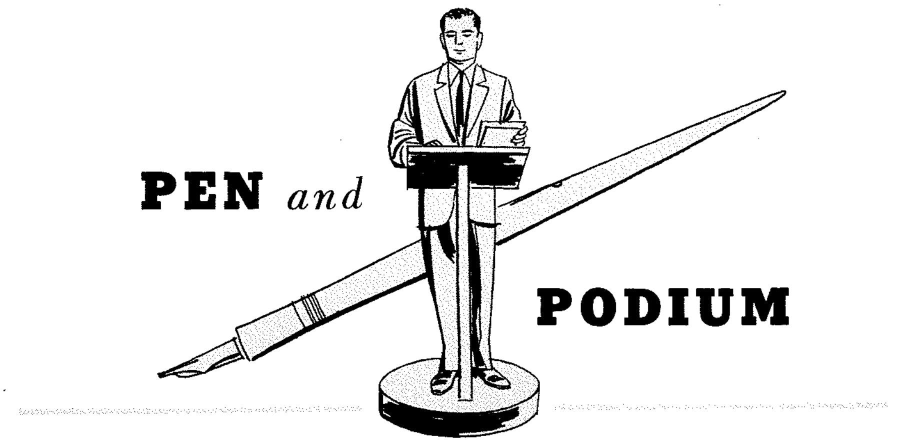
Pulse Generator

Pat. No. 2,863,942—granted Dec. 9, 1958 to R. S. Jose.

Web Reeling System

Pat. No. 2,864,621—granted Dec. 16, 1958 to A. Stavrakis and C. J. Kennedy, no longer with RCA.

PEN *and* PODIUM



BASED ON REPORTS RECEIVED OVER A PERIOD OF ABOUT TWO MONTHS

DEFENSE ELECTRONIC PRODUCTS

Moorestown, N. J.

Enhanced Real-Time Accuracy for Instrumentation Radar by Use of Digital Hydraulic Servos
By R. P. Cheetham and W. A. Mulle: Presented at Wescon (IRE Conf.) Aug. 1958. A system is described which enhances radar data accuracy by correcting for systematic errors.

Reliability Course Survey for AF Resident Inspectors
By R. M. Jacobs: Presented at WPAFB Conf., Dayton, Ohio, Oct. 1958: Reliability theory, design practices, cost, management, manufacturing and field report activities are described.

Reliability Management
By M. M. Tall: Presented at 5th Annual Symp. on Reliability at Phila., Pa., Jan. 1959. A tutorial paper which conveys the principles of reliability management.

A Reliability Cost Optimization Procedure
By P. R. Gyllenhool and J. E. Robinson: Presented at 5th Nat'l. Symp. on Reliability, Phila., Pa., Jan. 1959. Calculable cost sensitivity vs. reliability technique leads to optimized reliability and minimized cost.

Time Phasing of a Reliability Program
By G. Ashendorf and G. Beckhart: Presented at 5th Nat'l. Symp. on Reliability, Phila., Pa., Jan. 1959. Reliability planning for very large radar system with continuous operation is described.

A Time Multiplexing Technique
By E. Rodwin: Presented to Nat'l. Simulation Conf., Dallas, Tex., Oct. 1958. This multiplexer is useful when dynamic operation to be shared involves expensive electromechanical gear.

Mechanical Design Reviews
By D. P. Simonton: Published in Jan. 1959 *Product Engineering*. The importance, makeup and functions of a mechanical design review are described. Better team effort and better equipment result.

Camden, N. J.

Basic Reliability Considerations
By M. P. Feyerherm: Presented at 5th Nat'l. Symp. on Reliability, Phila., Pa., Jan. 1959. Causes of unreliability, reliability measures, definitions, concept formulas, value analysis and standardization are discussed.

Magnetic Head for Stereo or Half-Track on 1/8" Tape
By H. R. Warren: A magnetic record-reproduce head for magnetic tape is described. Cross talk isolation better than 55 db, response 15 kc, tape speed 3¾ IPS.

Coincident Current Applications of Ferrite Apertured Plates
By W. G. Rumble and C. S. Warren: Presented at IRE Western Electronic Convention, Aug. 1958, Los Angeles, Calif.

Air Traffic Control for the Jet Age
By R. E. Davis: Presented Oct. 1958 to PGANE, Dayton IRE Sect., Dayton, Ohio. Present air traffic control problems are reviewed and extended into the jet age traffic picture.

Making a Multi-Plant Supplier Rating System Produce
By P. J. Goldin: Presented at 5th Nat'l. Symp. on Reliability, Jan. 1958, Phila., Pa. Concrete improvement in Quality and Reliability and cost reductions made possible by a supplier rating system are described.

Preliminary Planning for Optimized Thermal Design of Forced-Air Cooled Equipment
By T. C. Reeves: Presented at 1st Symp. on Military Electronics Reliability, RADC, Griffiss Air Force Base, N. Y., Nov. 1958. A working procedure is given for determining the cooling requirement to support the required ground equipment reliability.

Solid State Devices in Power Applications
By F. C. Putzrath: Presented at AIEE-IRE lecture series NYC, Nov. 1958. Differences between high and low power transistors and development of a series type 45-watt amplifier are described.

Some Beneficial Effects of Nuclear Radiation on Electron Devices
By J. R. Hendrickson: Presented to Prof. Group on Nuclear Science IRE, San Mateo, Calif., Nov. 1958. Limited doses of nuclear radiation benefit many electron devices such as transistors, crystal diodes, photoconductors, tubes and thermocouples.

How Much Ear Protection
By L. Weinreb and M. L. Touger: Presented at Acoustical Soc. of Amer. Mtg., Chicago, Ill., Nov. 1958. Measurements and variations of "real-ear attenuation" are discussed for four grossly different types of ear protectors.

The Army Micro-Module Design Concept
By J. P. Gilmore: Presented at joint mtg. of PGCP and PGPT at NYC, Oct. 1958 and at Modular Electronic Packaging Conf., July 1958, at Redstone Arsenal. The concept is described wherein tiny elements of uniform shape and size are combined into the module to perform circuit functions. A complete 28-page brochure edited by Mr. Gilmore is available to describe the Micro-Module Concept.

INDUSTRIAL ELECTRONIC PRODUCTS

Camden, N. J.

Design of the RCA 501 System
By T. M. Hurewitz and J. G. Smith: Presented Dec. 5, 1958 at Eastern Joint Computer Conf., Phila., Pa. This paper describes manner in which problem requirements have affected the balance of design emphasis in the RCA 501 electronic accounting system.

A Magnetic Disk Recording and Reproducing System
By G. A. Singer: Presented at Audio Eng. Soc. Conv., Oct. 1958, NYC. Pre-grooved disks of iron oxide combine advantages of magnetic recording with handling ease of disks for manual or automatic broadcasting of short selections.

Magnetic Head for Grooved Magnetic Recording Disks
By H. R. Warren: Presented at Audio Eng. Soc. Conv., Oct. 1958, NYC. The design and development of a magnetic record-reproduce head for operation with magnetic grooved disks is described.

The RCA 501 System Characteristics
By J. W. Leas: Presented at IRE Prof. Group on Electronic Computers, Nov. 1958, Wash., D.C. This paper described the highlights of the all-new RCA 501 Data Processing System, with emphasis on design features related to practical situations.

Handling Dark Current and Operating Techniques in the Vidicon
By J. H. Roe: Presented at IRE Prof. Group on Broadcast Transmission Systems, Sept. 1958, Wash., D.C. A practical description of vidicon operating techniques.

Transistorized Video Switching
By J. W. Wentworth: Presented at IRE Prof. Group on Broadcast Transmission Systems, Sept. 1958, Wash., D.C. Transistorized Video Switching equipment is described.

RCA SERVICE CO.

Cherry Hill, N. J.

Support Costs vs. Reliability and Maintainability
H. D. Voegtlen: Presented at 5th Nat'l. Symp. on Reliability, Phila., Pa., Jan. 1959. Measured support costs over a two-year period are related to parts, design and maintenance practices.

RCA RADIO AND "VICTROLA" DIVISION

Cherry Hill, N. J.

High Fidelity Packaged Music at Lower Cost
By D. R. Andrews: A low-speed magnetic tape system with narrow tracks is combined in tape-cartridge operation for a high-quality, low cost product.

RCA VICTOR TELEVISION DIVISION

Cherry Hill, N. J.

Transistor Noise Factor Tester

By J. J. Davidson: Published in Jan. 1959 *Semiconductor Products.* The simplification of the measurement of the audio noise factor of transistors is reduced to one adjustment and pushing of one button.

Design Nomograms for Transistor Narrow-Band Amplifiers

By L. M. Krugman: Published in *Electronic Industries,* Oct. 1958. Nomographs are given for quick determination of transistor performance as a narrow-band amplifier.

Color Television—Past, Present and Future

By A. J. Torre: Presented at IRE Conf. at Chicago, Ill., Nov. 1958. A description is given of the considerable progress and design experience attained by RCA since 1953 when the system was first approved by FCC. A continuing growth pattern is predicted.

Enclosing Loudspeakers

By R. L. Libbey: Presented to IRE Prof. Group on Audio, Nov. 1958. A comparison of several types of loudspeaker enclosures was shown. In each the effect of the enclosure in the low- mid- and high-frequency range was given.

RCA CORPORATE STAFF

Camden, N. J.

Communications in Quality Control

By H. E. Schock: Presented Sept. 1958 at 3rd Annual Quality Control Symp. at Drexel Institute, Phila., Pa. An outline is given of communication of information pertaining to the general field of Quality Control.

Standardization and Simplification Reduces Cost at RCA

By S. H. Watson: Published in Nov. 1958 issue of *Assembly & Fastener Engineering.* Two simple examples were given of widely used fasteners normally supplied in hundreds of styles and sizes, now reduced to a basic 3 or 4.

Cost of Failure Is Greater Than Cost of Reliability

By S. H. Watson and D. Ward: Published in Oct. 1958 *Assembly and Fastener Engineering:* The RCA "Quintlock" nut is described with emphasis on importance of failproof fasteners in reliable design.

SES RESEARCH AND EDUCATION PROGRAM

By M. S. Gokhale: Presented at Standards Engineers Soc. 7th Annual Mtg. (1) Prepare a handbook on standardization subjects; (2) establish roster of qualified speakers and; (3) create a scholarship of a standardization course.

ELECTRON TUBE DIVISION

Harrison, N. J.

Vacuum-Tube Requirements in Vertical-Deflection Circuits

By K. W. Angel: Published in IRE *Transactions* on Broadcast and Television Receivers, Sept. 1958. Linearity and efficiency problems to be considered in selection of an output tube for a vertical-deflection power amplifier are discussed.

Unusual Tube Effects Cause Circuit Troubles

By W. E. Babcock: Published in *Electronics,* Sept. 12, 1958. Possible causes, effects, and solutions of circuit problems such as sleeping sickness, blackout and spook interference are described.

Worksheet Simplifies Factorial Design

By C. H. Li: Presented to American Statistical Assoc., NYC, Nov. 6, 1958. This paper describes the use of a 16-test worksheet in the setting up of various types of factorial experiments.

Protecting Metal Surfaces Subjected to Repeated High-Temperature Pulses

By E. J. Homer and A. Cohen: Presented to Amer. Soc. of Mechanical Engineers, NYC, Nov. 25-30, 1958. This paper discusses the analytical determination of the temperature of the resonant structure of a magnetron, and its protection.

Recommended Tube Types for Amateur Short-Wave Receivers

By L. W. Aurick and P. B. Boivin: Published in QST, Nov. 1958. A chart of receiving-type tubes recommended for various applications in amateur equipment is presented.

The Use of Miniature Tubes in Class C Circuits

By A. Dzik: Presented to IRE Conf. on Vehicular Communications, Chic., Ill., Dec. 4-5, 1958. This paper discusses Class C operation and considerations for obtaining reliable operation in straight-through amplifiers.

On the Quality of Color-Television Images and the Perception of Color Detail

By O. H. Schade, Sr.: Published in *RCA Review,* Dec. 1958. This paper shows how contrast range and color saturation obtained with commercial tricolor kinescopes provide a larger color space than provided by color motion pictures.

Princeton, N. J.

Electrostatically Focused Microwave Tubes

By W. R. Beam: Presented to NY Chapter of IRE Prof. Group on Electron Devices, NYC, Dec. 18, 1958. This paper discusses the use of electrostatic focusing in traveling-wave tubes to reduce weight and power consumption.

Pulse Amplifier with Sub-Millimicrosecond Rise Time

By F. Sterzer: Published in *Review of Scientific Instruments,* Dec. 1958. This paper describes a pulse amplifier having a power gain of 20 and a rise time of approximately 0.7 millimicrosecond. A conventional S-band traveling-wave tube is used.

Two Backward-Wave Oscillator Tubes for the 29000-to-74000-Megacycle Frequency Range

By D. J. Blattner and F. Sterzer: Published in *RCA Review,* Dec. 1958. This paper describes two experimental voltage-tunable oscillator tubes having useful power output over very wide frequency ranges at millimeter wavelengths.

Lancaster, Pa.

Tension Stresses in Glass Coatings and in Glass-Metal Seals in the Annealing Range

By J. C. Turnbull: Published in *Amer. Ceramic Soc. Journal,* Sept. 1958. This paper describes the effects of baking tube parts on the stresses in the glass-metal seal.

3-Dimensional TV System

By L. I. Mengle: Published in *Radio & TV News,* Oct. 1958. A simple, all-electronic three-dimensional television system which uses standard camera equipment and a standard color receiver is described.

Design of Screen-Grid Resistive Bleeder Networks

By J. M. Forman: Published in *Electronic Design,* Oct. 15, 1958. This paper discusses the influence of screen-grid emission on complex networks using tetrodes.

Status of Multiplier-Phototube Development for Scintillation Counters

By W. Widmaier: Published in *IRE Transactions* on Nuclear Science, Dec. 1958. This paper describes a number of recent multiplier phototubes design features and their application in several RCA types.

Recent Work on Photoemission and Dark-Emission Problems

By R. W. Engstrom, R. G. Stoudenheimer, H. L. Palmer, and D. A. Bly: Published in *IRE Transactions* on Nuclear Science, Dec. 1958. This paper discusses some new photocathodes used in multiplier phototubes for scintillation counters.

SEMICONDUCTOR AND MATERIALS DIVISION

Somerville, N. J.

A Review of the State-of-the-Art and Future Trends in Electro-Chemical Battery Systems

By C. K. Morehouse: Presented at Seminar on Advanced Energy Sources and Conversion Techniques, Los Angeles, Calif., Nov. 3-7, 1958. This paper covers a survey made of materials used in electro-chemical cells and describes the limitations.

Infrared Studies of Birefringence in Silicon

By S. R. Lederhandler: Presented to Amer. Phys. Soc., Chicago, Ill., Nov. 28-29, 1958. This paper discusses the analysis of residual stresses in silicon crystals grown by the Czochralski technique.

Needham, Mass.

Some Crystallographic and Magnetic Properties of Square-Loop Materials in Ferrite Systems Containing Copper

By A. P. Griefer and W. J. Croft: Presented at Conf. on Magnetism and Magnetic Mat'ls., Phila., Pa., Nov. 17-20, 1958. This paper discusses rectangular hysteresis loops found in ferrite systems containing copper, and presents data for a copper-ferrite, magnesium-ferrite system.

Magnetic Properties and the Structure of Some Spinel-Type Oxides

By W. J. Croft: Presented to Dept. of Geology at Columbia Univ., NYC, Dec. 17, 1958. This paper reviews the types of magnetism and discusses technological applications of ferrite spinels.

Engineering NEWS *and* HIGHLIGHTS

D. F. SCHMIT APPOINTED TO C STELLARATOR ASSOCIATES

Dominic F. Schmit, Vice President, Product Engineering, RCA, has been appointed Senior RCA Representative, C Stellarator Associates, according to a recent announcement by Dr. Douglas H. Ewing, Vice President, RCA Research and Engineering.

C Stellarator Associates is the management and engineering organization established by RCA and the Allis-Chalmers Manufacturing Company to design and build a large new research facility for Princeton University and the Atomic Energy Commission for advanced studies in the control of thermonuclear fusion for power production. The project, based on a concept of Dr. Lyman Spitzer, Jr., Chairman of the Department of Astronomy at Princeton University, is now under construction at the University's James Forrestal Research Center at Princeton and is scheduled for completion during 1960.

In his new position, which is in addition to his continuing duties as Vice President, Product Engineering, Mr. Schmit will direct RCA's activities and will work with Leonard J. Linde, Project Manager, in the overall management of C Stellarator Associates. Mr. Linde is associated with Allis-Chalmers and was Director of Electrical Engineering, Industries Group, of that company before assuming his present position. As the senior

RCA representative in the project, Mr. Schmit succeeds Edward W. Herold, who has resumed his duties as Director, Electronic Research Laboratory, RCA Laboratories.

C Stellarator Associates includes a staff of about fifty technical specialists from the two companies, operating at the James Forrestal Research Center in close cooperation with the Princeton University group under Dr. Spitzer. Its activities include the design, development and installation of highly specialized electronic and electrical equipment fabricated in RCA and Allis-Chalmers plants (see articles this issue on pages 34 and 36 by Smith and Lawson).

BRUSTMAN ELECTED IRE FELLOW

Seventy-six leading radio engineers and scientists from the U.S. and other countries were named Fellows of the IRE by the Board of Directors at its November 18 meeting held in Atlanta, Georgia.

Recognition of the awards will be made by the President of the IRE at the Annual Banquet on March 25, 1959 at the Waldorf-Astoria Hotel in New York City during the 1959 IRE National Convention.

Among those honored was Joseph A. Brustman, Manager, Product Development and Design Engineering, Electronic Data Processing, IEP Camden, "for contributions in the development of digital computing systems."

Joseph A. Brustman was born in Vienna, Austria, where he also received his education. In 1932 he graduated from the Realgymnasium and completed studies at the Technical University in Vienna in 1938. In 1938 Mr. Brustman joined the American Television Corporation in New York City. As Chief Engineer he directed the development and design of TV camera equipment, TV receivers, and communication equipment for marine vessels.

In 1941 Mr. Brustman joined Remington Rand in the capacity of Assistant Chief Engineer of the Electronic Division. In 1942 he became Chief Engineer of the Equipment Section, responsible for the development and design of various airborne television equipments for use in guided airplanes and missiles.

Mr. Brustman became associated with RCA in 1952 as Manager of the BIZMAC Product Development and Design activity for electronic data processing equipment. As Engineering Manager, he is responsible for the functional guidance of the entire

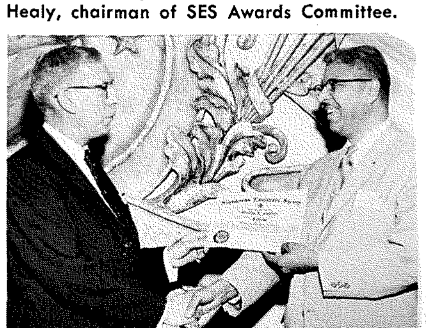
Engineering Program in the Electronic Data Processing Engineering Department.

Mr. Brustman represents RCA in the EIA Subcommittees for Digital Data Transmission and for Computer Tubes. He is a Senior Member of the IRE, a member of the Professional Group for Engineering Management, Professional Group for Electronic Computers, and the Association for Computing Machinery. —*T. T. Patterson*

GOKHALE ELECTED SES FELLOW

The Standards Engineering Society held its seventh Annual Meeting at the Benjamin Franklin Hotel, Phila. in late September, and honored four men by advancing them to the degree of Fellow. Among these was Madhu S. Gokhale, Mgr. DEP Mechanical Engineering Standards, the first RCA employee so honored, who was made Fellow "in recognition of his services to standardization and his deep interest in the standards engineering profession."

M. S. Gokhale (right) receives Standards Engineering Society's Fellow award from W. L. Healy, chairman of SES Awards Committee.



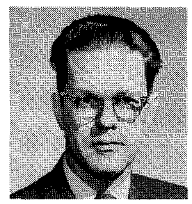
ENGINEERS IN NEW POSTS

In DEP, **Harry R. Wege** is appointed Gen'l Mgr of the newly-formed Missile & Surface Radar Div. In addition to the M&SR Dep't at Moorestown, the new Div. includes the former West Coast Electronic Products Dep't, now to be the West Coast M&SR Dep't under **A. N. Curtiss,** reporting to Mr. Wege . . . **G. F. Breitwieser** becomes Chief Engineer, M&SR Eng. under H. R. Wege.

IEP's **A. F. Inglis,** former TV Systems Eng. Mgr. becomes Closed Circuit TV Marketing Mgr . . . **J. N. Marshall, R. W. Sonnenfeldt** and **M. C. Kidd** plus essentially all of IEP Adv. Dev. were transferred to Electronic Data Processing in Nov. . . . Marshall reports to Ch. Eng. **J. W. Leas . . . D. L. Nettleton** (from Adv. Dev.) becomes Mgr., Systems and Standards under **J. A. Brustman,** EDP . . . **J. L. Owings** promoted to Mgr., Special Data Processing Equip. Eng. under **P. T. O'Neil . . . R. E. Wallace** is responsible for R&D and Special Project Sales under J. W. Leas.

Electron Tube Div's Microwave Eng. Mgr. **H. K. Jenny** announces **G. G. Carne** as Mgr., Tube Processing Systems Dev.

RCA SCIENTIST ELECTED PRESIDENT OF AMERICAN ASTRONAUTICAL SOCIETY



Dr. George R. Arthur was elected president of the American Astronautical Society at the society's annual meeting in the Statler Hotel, Washington, D. C., on December 27, 1958.

Dr. Arthur is Manager of Design Engineering, Airborne Systems Department, DEP, Camden, N. J., where he is engaged in programs on missiles, infrared and television for the military. He joined RCA in 1956.

For the past year Dr. Arthur has been First Vice President of the American Astronautical Society, whose annual meeting is being held in conjunction with the 125th meeting of the American Association for the Advancement of Science.

Dr. Arthur is a graduate of Yale University. Following several years of graduate work and teaching in engineering at Yale, he earned his doctorate in 1952. He served with the U. S. Navy in World War II.

—*Dr. A. H. Benner*

MEETINGS, COURSES AND SEMINARS

TWO PAPERS WIN IRE AWARDS

"Some Properties of the Gravitational Field and Their Possible Application to Space Navigation," by Joseph C. Crowley, Stanley Kolodkin, and Alan M. Schneider of Missile Electronics & Controls Department, DEP Burlington, Mass., was chosen the outstanding paper at the Fifth Annual IRE East Coast Conference on Aeronautical and Navigational Electronics. A one hundred dollar prize was awarded the authors at the Honors Night Dinner which was held in Baltimore on October 27, 1958.

—*R. W. Jevon*

Neubauer Honored

J. R. Neubauer, BMEWS Internal Communications Projects Group, Surface Communications Engineering, received the "Honorable Mention" award of the IRE National Professional Group on Vehicular Communications at the Chicago Conference on December 4, 1958 for his paper presented at WESCON 1957 and published in the 1957-58 Transactions entitled "Qualitative Performance Evaluation of Land-Mobile Systems." This was one of two awards made for outstanding papers by this Professional Group this year.—*E. O. Selby*

Microwave Techniques

The Microwave Subcommittee of the Harrison Engineering Education Committee has announced a series of meetings for Microwave Engineering personnel. The members of the subcommittee are B. Kleinman, Chairman, J. Simpson, J. Jacobs, and H. J. Wolkstein. The meetings scheduled for the series are as follows:

Dec. 9 Dr. L. S. Nergaard, "The Cathode and its Environment"
Jan. 13 Dr. Wittke, "Masers"
Feb. 18 C. L. Cuccia, "Spiral Beam Devices"
Mar. 10 Dr. K. K. N. Chang, "Theory of Parametric Amplifiers"
April Dr. J. T. Wallmark, "Physics of Development on Computers"
Dr. W. Beam, "Noise and Electron Beams"
Dr. F. Sterzer, "Ferrites and Microwave Frequencies"

—*H. J. Wolkstein*

Guidance Councilling

Mr. J. A. Howells, engineer in Radio and "Victrola" Advanced Development Engineering at RCA Cherry Hill, participated in a dinner program given for Delaware Valley secondary school principals and guidance counselors. The dinner was hosted by prominent alumni of Drexel Institute of Technology, and was given at the Union League of Philadelphia on November 25, 1958.

The purpose of this program was to acquaint high school guidance counselors in the Delaware Valley area with Drexel curricula, entrance requirements, scholarships, and the like; and with the recognition afforded by industry to the Drexel graduate. Mr. Howells was one of two evening college students who presented the salient features of the evening degree program, and who discussed the recognition of the evening graduate in industry.

Engineering Management

"Competitive Fixed-Price Creativity" was the subject of a panel discussion at the Philadelphia Chapter meeting of the IRE Professional Group on Engineering Management on January 22, 1959 at the Moore School of Electrical Engineering. The problem of obtaining maximum inventiveness from technical personnel within prescribed money budgets and time schedules was discussed in the three environments of Military Development, Research Effort and Product Development. J. Wesley Leas, Chief Engineer, Engineering Department, Electronic Data Processing Division, represented the Product Development environment.

—*T. T. Patterson*

Digital Conversion of Speech

A symposium on Digital Conversion of Speech sponsored by Digital Communications Engineering, Surface Communications, was held on December 9, 1958. Its purpose was to bring together those interested in the application of digital techniques to speech transmission and conversion. The program presented is listed below.—*E. O. Selby*

Program of Activities

Topic	*Speaker*
1. Present System for Digital Speech Transmissions	S. Wald
2. Military Requirements for Digital Speech Transmissions	Dr. R. Guenther
3. Comparison of Theoretical Transmissions Rates in Digital Speech Transmission Systems	A. A. Meyerhoff
4. Vocoders and Formoders	W. F. Meeker
5. Proposed System for Digital Transmission of Speech at 400-800 bits per second	Dr. H. N. Crooks
6. Digital Speech Systems and Word Recognition	H. Belar
7. Use of Computers in Development of DST Systems	H. W. Nordyke
8. Future Implications of Present Trends in Digital Speech Techniques	A. H. Kettler

MOORESTOWN HOST FOR ESC MEETING

The RCA Moorestown Analog Computation and Simulation Group was the recent host of approximately 75 members of the Eastern Simulation Council on December 15, 1958. The theme of the day's discussion was "Sampled Data Systems in Analog Simulation". Mr. J. R. Levitt, Engineering Leader in Charge of the Moorestown Analog Facility, presided at the technical sessions.

Mr. I. N. Brown, Manager, Computation, Simulation and Administration, opened the meeting with a welcome address to the members after which they were conducted on a tour of the Moorestown Plant, and the Analog Computer Facility. The technical papers, in the order presented, were:

1. "A Survey of Analog-Digital Conversion Techniques for the Analog Computer", by V. R. Coates (RCA).
2. "Analog Study of Frequency Modulated Discriminator", by O. J. Palumbo and E. A. Sevian (RCA).
3. "Simulation of Time Varying, Nonlinear Systems with Sampled Data Transducers", by C. G. Blanyer (Hydel).
4. "A Digital Function Generator for use in Analog Computers", by Dr. W. Seifert (M.I.T.).
5. "Analog Instrumentation of Transfer Functions by Inspection", by E. A. Sevian and S. Cottrill (RCA).

—*I. N. Brown*

Reliable Electrical Connections

The Third EIA Conference on Reliable Electrical Connections was held in Dallas December 2-4. Active in the three-day program were H. R. Sutton, Component Part Design and Application, DEP, who gave a talk titled "Printed Circuit Connectors," and Dr. Leopold Pessel, Central Services and Engineering, DEP, who moderated the session on Manufacturing and Processes. Among the RCA engineers present at the conference was I. K. Munson, Mgr. Central Engineering, DEP.

Creativity

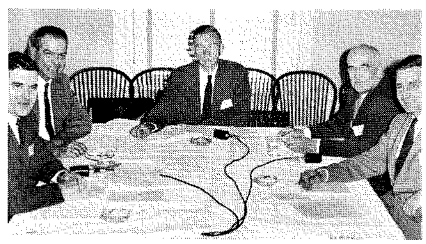
C. M. Sinnett, Mgr. Advanced Development, Television Division, Cherry Hill, spoke on "Teaching Creativity" at the American Management Seminar, New York, on December 16, 1958. Mr. Sinnett also participated in a Colloquium on "Creative Thinking" at RCA Laboratories, Princeton on December 1, 1958.—*D. J. Carlson*

Creativity—Marion

The development of creativity among engineers is the subject of a lecture series sponsored by the Marion Engineering Training Committee in conjunction with the Administrator of Training, J. M. Hemli. The series is being presented at Marion.

The two instructors teaching the course are W. L. C. Hui, Manager of Black and White Kinescope Advanced Development, and R. E. Salveter who is responsible for Manufacturing Process Engineering. The purpose of the course is to increase the individual's awareness of his creative ability, and to study creative processes to aid engineers to use their creative talent more effectively.—*Jan deGraad*

DR. JOLLIFFE IN PANEL TALK



On November 11, Vice President and Technical Director, RCA, Dr. C. B. Jolliffe participated in a round table discussion on "Military Electronic Systems Reliability". This event was tape-recorded for presentation on the "Meet the Engineer" program sponsored by AIEE over Philadelphia radio station WFLN-AM/FM on Saturday, January 3, and Saturday, January 10, 1959 at 12:45 P.M.

Dr. J. G. Brainerd, Director of the Moore School of Electrical Engineering, University of Pennsylvania, moderated the forum which is promoting the 5th National Symposium on Reliability and Quality Control in Electronics.

Panel members (L to R) are: R. V. D. Campbell, DEP. Director, Burroughs Corporation, Research Center; D. B. Smith, Vice-President-Research, Philco Corporation; Dr. J. G. Brainerd; Dr. C. B. Jolliffe, Vice-President and Technical Director, Radio Corporation of America; Mr. A. Robinson, Deputy Manager, Missile and Space Vehicle Dept., General Electric Company.

NEW EDITORIAL REPRESENTATIVES APPOINTED

In the Electron Tube Division, Industrial Tube Products at Lancaster under W. G. Fahnestock has been divided into Power Tube Operations, to be represented by Harold S. Lovatt, and Conversion Tube Operations, represented by W. G. Fahnestock.

In the Semiconductor and Materials Division at Somerville, R. E. Rist has retired as Editorial Representative because of other duties. Rhys Samuel will represent Micromodule Engineering and Hobart Tipton will represent Semiconductor Devices Engineering.

Harold S. Lovatt received his B.S. Degree in E.E. from Drexel Institute of Technology in 1920. He served with the West Penn Power Company of Pittsburgh until 1929, when he joined the Westinghouse Corp. as a Power Tube Design Engineer. He was transferred to RCA in December 1929 in this same capacity at Harrison, N. J. He became associated with the Standardizing activity in 1932 and was later made supervisor of the construction data group. He moved to Lancaster in 1943 when Lancaster Standardizing was set up and in 1954 was made Manager of this activity. In 1956 he was promoted to his present post as Manager of Engineering Services of Industrial Tube Products.

Hobart Tipton received the degree of B.S. in M.E. in 1942 at Kansas State College and joined the RCA Manufacturing Company the same year. From 1945 to 1951, he was employed as project engineer for the Barber-Colman Company. In 1951, he returned to the RCA Electron Tube Division as an engineer in the Receiving Tube Development Shop. He has been with the Semiconductor and Materials Division since its formation in 1956, and is presently engaged in the development phases of germanium and silicon single crystals. Mr. Tipton is a Member of ASME, the Electrochemical Society and Pi Tau Sigma.

Rhys Samuel received the B.S. Degree in Journalism from Northwestern University in 1950. He joined Commercial Engineering of the RCA Electron Tube Division in Harrison, N. J. in 1951. Until transferring to Modules Engineering of the Semiconductor and Materials Division in Somerville, in Dec. 1958, he was engaged in writing and editing instruction books and other material on RCA test equipment. He is a Member of the IRE.

COMMITTEE APPOINTMENTS

IEP TV Equipment Engineering

R. N. Hurst has been appointed to the IRE Subcommittee 23.1 on Video Definitions.

J. H. Roe has been appointed Chairman of the EIA Subcommittee TR 4.2 on Television Relay Systems.

DEP Airborne Systems Engineering

E. W. Keller has become a member of the IRE Papers Committee, Circuit Theory Group, Phila. Chapter.

Dr. W. C. Curtis has been appointed to represent RCA on a combined industry-military committee on high-resolution radar.

—*A. H. Benner*

IEP Data Processing

J. Wesley Leas, Chief Engineer, Electronic Data Processing, IEP, has been appointed session chairman for the IRE PG on Electronic Computer's session on "Instrumentation for High Speed Data Acquisition" at the IRE National Convention, March 26, 1959, New York City. —*T. T. Patterson*

E. M. WASHBURN RETIRES

Over one hundred friends and associates attended the retirement dinner for Edward M. Washburn, Manager of IEP's Frequency Control Engineering. The dinner was held on November 20, 1958 at Shillig's Black Horse Farm, Mt. Ephraim, N. J., with Arnold K. Weber as Master of Ceremonies. Speakers included Dr. G. H. Brown, N. M. Brooks, V. E. Trouant, J. E. Eiselein, A. G. Cattell, and J. E. Young. Mr. Washburn was presented with a tape recorder and portable radio.

Edward M. Washburn received his B.S. degree in E.E. from the University of Vermont in 1916. He was employed by the Votey Organ Co. until the end of 1929, first as Chief Draftsman and later as Assistant Superintendent. He joined RCA early in 1930, starting as draftsman and progressively working up to engineer on Broadcast and Police Transmitters. In 1941 he was appointed manager of Frequency Control Engineering where he has served to his retirement. Mr. Washburn is a Senior Member of the IRE and Secretary of the RETMA subcommittee SQ-1 on quartz crystals.

REGISTERED PROFESSIONAL ENGINEERS

The following name has been added to the RCA ENGINEER list of registered professional engineers:

DEP, Camden

Name	*State*	*Licensed As*	*License No.*
J. R. Hendrickson, Sr.	Pa.	Prof. Eng.	4661-E

ENGINEERING MEETINGS AND CONVENTIONS

February, March, April 1959

FEBRUARY 17-20
Western Audio Convention, Audio Eng. Soc., Biltmore Hotel, Los Angeles.

MARCH 3-5
Western Joint Computer Conf., AIEE, ACM, IRE, Fairmont Hotel, Los Angeles.

MARCH 5-7
Western Space Age Conf. and Exhibit, L. A. Chamber of Commerce, Great Western Exhibit Center, Los Angeles.

MARCH 15-18
National Assoc. of Broadcasters, Annual Convention, Conrad Hilton Hotel, Chicago.

MARCH 23-26
Institute of Radio Engineers, IRE National Convention, Coliseum & Waldorf-Astoria Hotel, New York City.

MARCH 31-APRIL 2
Millimeter Waves, Symposium, Polytechnic Inst. of Brooklyn, USAF, ONR, IRE, USA Signal Research, Engineering Societies Bldg., N.Y.C.

APRIL 5-10
Nuclear Congress, sponsored by over 25 major engineering and scientific societies, Public Auditorium, Cleveland.

APRIL 13-15
Protective Relay Conf., A&M College of Texas, College Station, Texas.

APRIL 14-15
Industrial Instrumentation and Control Conf., PGIE of IRE, Armour Research Foundation, Illinois Inst. of Tech., Chicago.

APRIL 16-18
Southwestern IRE Conf. and Electronics Show, SWIRECO, Dallas Memorial Aud. & Baker Hotel, Dallas.

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RCA ENGINEER

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