IRE TRANSACTIONS

ON BROADCASTING

Volume BC-7 JANUARY, 1961 Number 1

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IRE PROFESSIONAL GROUP ON BROADCASTING

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IRE TRANSACTIONS®
on Broadcasting

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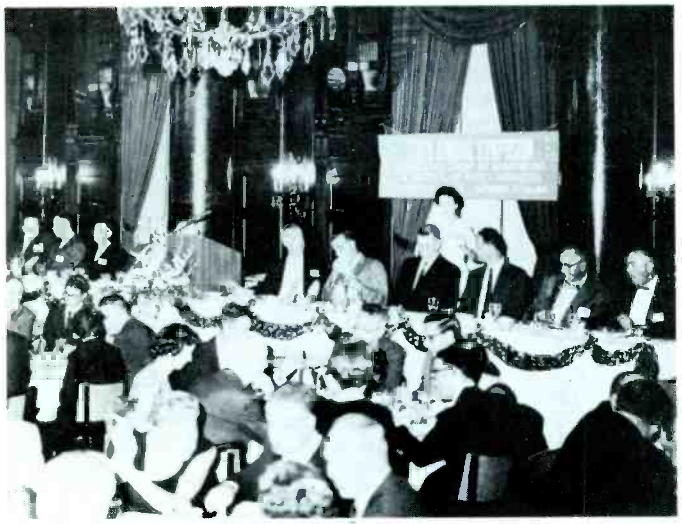
This issue of P.G.B. transactions consists primarily of some of the papers presented at the 10th Annual Fall Symposium. Included on the next page or two are scenes from the annual banquet. On the right, (from left to right) we have our amiable toastmaster Ray Guy, Mr. Henry Loomis, Director of the Voice of America, and George Hagerty, Chairman of P.G.B. Mr. Loomis gave a fascinating banquet address on the Problems of V.O.A., technical and otherwise.

On the left is a candid shot of one of the guests of honor, Dr. R. A. Heising, and Ray Guy. Dr. Heising was specially honored at the banquet in recognition of his fundamental contributions to the Institute of Radio Engineers. Dr. Heising made some interesting remarks about the early days of radio communication.

On the right, George Hagerty presents the Annual Scott Helt Award to Donald W. Peterson, the 1960 recipient.

The Washington Symposium arrangements committee is shown on the right. From left to right are: John H. Battison, Publicity; Nugent S. Sharp, Chairman; Audrey K. Gurin, Registration; Howard T. Head, Field Trip Coordinator; George C. Wetmore, Facilities; and Serge Bergen, Treasurer.



On the left is an overall view of the head banquet table plus part of the general mob scene.

The Annual P.G.B. Fall Symposium is rapidly becoming the most important technical meeting in the country devoted exclusively tc broadcast engineering. It deserves your support and attendance. Watch for new technical developments, operation techniques, and come and discuss your problems at the IRE -PGB Fall Symposium.

Editor

PLANNING AND ERECTING A 1619 FOOT TOWER FOR TELEVISION BROADCASTING

R. W. Hodgkins
WGAN-TV
Portland, Maine

It is the intent of this paper to provide a sort of "case history" of a project just completed late last year; namely the erection of a new 1619 foot tower and antenna. For those of you who have traveled this road ahead of us there will be a few smiles, for those about to start we trust there will be some helpful ideas and some measure of encouragement contained in this brief description of our experiences.

Also it would seem worthwhile at the conclusion to view this undertaking in retrospect and to draw conclusions where possible with a view to correcting the past errors and making improvements in the future.

As a starting point it would seem proper to consider just why it was decided to embark on this undertaking. Just what motivated a modest sized broadcasting business in the State of Maine to decide to proceed with an outlay in excess of one half million dollars?

As one might suspect there is no single isolated reason but rather several. In this case the previous existing transmitter plant was constructed in 1954 and utilized a 240 foot tower with a height above average terrain of 630 feet. The site was located but seven miles inland from the Atlantic Ocean. Operation from this location left much to be desired with respect to coverage. Much of the energy was radiated out over the ocean and many inland communities lacked an adequate signal. This was reflected in a poorer showing when surveys were made in terms of homes reached, or ability to receive. It was also discovered that many businesses in Portland have an outside distribution which extends to a considerable distance. Among these are such diverse interests as branch banks, soft drinks, retail foods to name a few. The lifeblood of a successful broadcast operation is the ability to furnish the prospective client with a coverage adequate to his needs. It was apparent that the entire Portland market area was not adequately served.

In addition to these compelling reasons it seemed to us that the current status of TV allocations would not remain fixed in its present form indefinitely. As of this time it was possible to apply for a change of facilities on Channel 13 in the Portland area with the expectation of approval.

It is interesting to compare this situation with the history of radio allocations. Those who waited in the earlier radio days found it increasingly difficult to improve their facilities as time went by. Some found when they did apply that it was already too late. It is for this very reason that there has never been a 50KW radio station in the State of Maine. Although it cannot be predicted exactly what will transpire the prudent course of action seemed to indicate that the increased facilities should be applied for.

Finally there is no doubt concerning the value and benefit to be derived from the increased prestige, industry acceptance, and image created by being outstanding and progressive in this business of broadcasting.

When the initial decision to proceed had been made it was apparent that before an application was filed with the Federal Communications Commission the proposed transmitter site should be cleared with the FAA.

In proceeding with the choice and acquisition of a suitable site several criteria were considered as basic requirements. These were:

1. Suitability for achieving the desired coverage.
2. There must be no reduction in previously radiated power of 316 KW ERP.
3. The signal over the center and at the far side of Portland must remain substantially the same.
4. The direction of the signal entering the city should remain about the same.
5. The site must be of sufficient size, be accessible, and have suitable power.
6. Finally it must be acceptable to the FAA and FCC.

Having these criteria in mind the problem now resolved itself to the study of maps both geological and aviation combined with field inspection trips to promising locations. Here arose the inevitable decision to option or not to option. Five different parcels were optioned before the site location was exactly determined. This is a wasteful process but probably the most prudent one considering everything unless one wants to live dangerously.

In order to erect a tower of this height it is necessary to have a plot of land of at least 100 acres approximately square in shape. The guy lines extend out to a maximum of 1,200 feet in three directions which gives an idea of the distances necessary to lay out such an installation. Even in Maine such parcels of land are not readily available except by purchasing adjacent properties and putting them together as one site. However in this case we were fortunate to find a 98 acre plot intact at an acceptable location.

At this point effort was entirely concentrated on obtaining clearance from the FAA. This is the major part of the application preparation. The process, probably familiar to many, entails the selection of what appears to be an acceptable site, requesting its clearance by formal letter to the FAA, waiting for a thirty day period for all interested parties to file comments, and eventually receiving a reply from the FAA in favor or against the particular site. If the decision is unfavorable, and it is likely to be except in the case of relatively simple proposals, the applicant has the right to request that his case be placed on the agenda for a future FAA Airspace Subcommittee meeting. The decision to do this must be based on knowledge of the reasons for the objections to the proposed site.

Three sites were considered and submitted to the FAA before one was deemed to be the least objectionable to aviation interests and to be one which could be presented at a Subspace Committee meeting with a reasonable chance of gaining approval.

The present site of the new tower at Raymond, Maine appeared to be just such a location. With this in mind, and following the receipt of a letter from the FAA containing the objections, a meeting was arranged with the subspace committee chairman. The purpose of this meeting was to informally notify the chairman that it was the intention of the applicant to request inclusion on the agenda of the airspace subcommittee meetings as early as possible. In fact, such a letter was typed and in readiness to be mailed immediately following the conference. This served to firm up the intentions of the applicant.

At this juncture the services of an aeronautical consultant were obtained. He reviewed the work to date and assisted in the preparation of material in anticipation of the airspace meeting. Up to this time the preliminary work had consumed nearly a full year of which much time was spent in travel connected with conferences in New York.

Upon notification of the exact date of the airspace meeting plans were made concerning the exact method of presentation. It cannot be emphasized too strongly that this aspect is extremely important. In this case it was arranged to arrive in New York a full day ahead of the meeting. It was decided that those testifying would be the station general manager, the chief engineer, the aeronautical consultant, and the engineering consultant who would, however, remain silent unless a specific problem arose which he alone could answer. A full afternoon was devoted to planning the presentation and rehersing it so that in the pressure of the actual meeting nothing would be omitted. Also it was mutually agreed that a good nights rest and a clear head were basic requirements.

For those who have not participated in an airspace meeting a few comments might be helpful. These meetings are attended by as many as twenty or more representatives of all segments of the aviation industry. The number, of course, depends on what is being discussed. These are intelligent, responsible men. It behooves the broadcaster who is appearing before this meeting to know his subject thoroughly. Honesty in statement, sincerity in presentation, and conviction in purpose are the strongest attributes one can carry to such a gathering. Deception, inadequate knowledge, and half heartedness almost certainly spell disaster.

The meeting which was held in New York yielded approval to construct to a height of 1619 feet above ground or to a height not to exceed 2,000 feet above mean sea level. Although we would have willingly constructed a somewhat higher tower this figure was considered adequate for our needs.

Following this a few weeks were taken up in clearing a two mile radius around the proposed site for designated antenna farm area. This required negotiations with the Canadian Government. Once this matter had been approved the Washington airspace meeting gave approval to the action of the New York group and the application was filed.

Prior to initiating the required FAA procedures a thorough study was carried out to prove that the site would provide the coverage required. Here it might be pointed out that the final site was located at a distance of approximately 20 miles from Portland. However, by good fortune the location was just inside Zone 2 which enabled the full 316 KW ERP to be retained up to a height of 2,000 feet above average terrain. This appeared to offer possibilities and an investigation concerning potential coverage was undertaken before finally proceeding. It was decided to utilize a high gain antenna with a 0.5 degree electrical beam tilt with 316 KW in the main lobe. The height was investigated from 1600 feet above average terrain to 1800 feet above average terrain.

In the course of this exploration it was quickly decided that the FCC propagation curves would not yield sufficient information with respect to specific cities. A list of some fifteen important communities within a 75 mile radius had been compiled most of which were of importance to the coverage of the station. In order to evaluate these reference was made to the work carried out by Epstein and Peterson as reported in the RCA Review, December 1956, entitled "A Method of Predicting the Coverage of a Television Station."

This approach makes use of the study of profiles from the antenna to the city in question plotted on graph paper showing the earth curvature. In order to check the validity of this method it was decided to plot such data using the old transmitter site, make the calculations, and check them by actual field intensity measurement. This was done and excellent agreement was obtained. As a result of this it was assumed that the method would be equally valid when applied to the new location. This work was carried out and the results indicated that with the exception of certain communities completely surrounded by mountains the coverage to be expected should justify proceeding with the application. Accordingly, an application was filed and subsequently granted in February of 1959.

After careful consideration of all aspects the prime contract for the tower, antenna and transmission line was placed with RCA. A Traveling Wave type antenna was selected because of the requirement of only one transmission line and its ease of obtaining high gain and required beam tilt. The null fill characteristics of this antenna were of small consideration since the area affected is sparsely populated. The transmission line is the RCA Universal 6 1/8 inch. This was selected in view of reducing losses rather than power handling ability. The tower is a Kline Iron and Steel Company product designed for a maximum wind velocity of 150 miles per hour at full loading. The subcontracting for foundations, anchors, and erection was left to the Kline people with the provision that WGAN-TV would submit a list of local contractors and approve the final choice. The land and building was the responsibility of the station.

Actual work was commenced by the Raymond Concrete Pile Company on March 2nd when test borings began at the foundation location. At this time there was a depth of from two to three feet of snow, but it was imperative to start since the whole project had to be fitted in from the time the ground was frost free until freezing weather occurred in the fall; a period of about six months. On May 18th ground was broken and the job was underway.

With a structure of this size the services of a competent civil engineer loom rather large. The first consideration is precisely locating the structure with respect to latitude and longitude. This must be done with reference to established bench marks and triangulation points. This work must be as accurate as possible. After it is completed the work should be checked by another independent civil engineering firm. The same requirement applies to the elevation of the base of the tower and to the elevation of the top when completed. A bench mark is required on the tower foundation when completed.

In addition to the above the civil engineer is responsible for setting the anchor foundations to within a tenth of an inch in one thousand feet.

As a check on the location of the anchor foundations a system of radar checking which is available through a Canadian firm was used. This device is purported to be accurate to one inch in twenty miles. It consists of setting the dish up at the center point of the tower foundation and checking each guy point by reflecting from a marker at that point. It proved to be less accurate than was stated because of the irregularities of the ground, but was of sufficient value to convince the resident engineer and civil engineer that the regular survey work contained no error. Its principal value was the time saved as compared to that required by an independent civil engineering crew.

As erection progresses the civil engineer must measure each section and prepare an affidavit that the total height of steel erected agrees with the construction permit. From this it can be seen that the best engineering firm available should be engaged.

Prior to the start of work it was discovered that unforeseen work had to be performed to make it possible to carry out the ground work in conjunction with the tower erection. Clearing for the guy lines was not enough. These cleared lanes each about 1,300 feet long had to be graded to the extent that a truck could be driven over them. An open area adjacent to, but somewhat removed from the immediate base, was required for the storage and assembly area. The working area at the base was graded and leveled so that trucks would be able to drive from the assembly area to the base. This situation was not anticipated in preliminary planning and added to the expense.

The responsibility and coordination of all other aspects fell directly under the jurisdiction of the station engineer. These included the design and placement of the transmitter building with reference to the tower, the installation of power lines, telephone, and water.

The transmitter house was constructed of brick and cinderblock, a type of construction which is less expensive and of proven durability in the State of Maine. The transmitter room was placed on the second floor of this building which enabled direct access to the bridge out to the tower. With this arrangement the security fence surrounding the tower may be locked and access controlled. This also enabled all heavy equipment to be mounted in the basement. A quarry tile floor was chosen for durability and has proven wise. No floor troughs were used; rather the interconnecting wiring was carried in trays on the ceiling of the lower floor with openings provided where required. A grid work of wood was placed on the roof for protection against falling ice.

It was found possible to work the construction crew on the transmitter house along with the erection crew on the tower. Hard hats were required for each man and each person was told to be on the alert for the warning that an object was falling. No objections were raised to working under these conditions and it served to keep the progress of these two important parts of the project abreast of each other. No difficulties were experienced.

Raymond, Maine, the location of this tower, is in the heart of an area of intense vacation activity. It was anticipated that the sight of steel workers high on this structure would be a virtual magnet for sightseers. This proved to be true and as many as five thousand spectators were tallied over a good weekend. Since this possibility was anticipated preparations were made to cope with it. Deputy Sheriffs were hired for the peak periods and the area roped off with parking provided at the top of a small ridge overlooking the entire project. As a result unwanted persons were successfully kept out of the danger area and not even a minor problem arose from this cause.

The erection crew, under contract to the Kline Company, had the responsibility for erecting the steel, painting, lighting, hoisting the antenna, and installing the transmission line. Although this has been an industry practice to lump these items together in this manner there were certain developments which led us to conclude that this is not altogether desirable. The erection of the steel under the over all supervision of the resident engineer was accomplished in an extremely satisfactory manner. Once this was completed there developed an atmosphere of impatience and a tendency to rush the antenna and transmission line installation in a slip shod fashion. The reason is undoubtedly due to the desire of the foreman to shorten the job in the interest of a wider profit margin. It required some rather plain talking to get the job done our way. As a result of this it is our conviction that the transmission line should be handled as a separate erection item and placed on a straight day work basis. On this basis there would be no tendency for haste and the installation could proceed carefully, as it should. In this installation the RCA service engineer and a factory representative from the transmission line manufacturer supervised personally each section of line as the bullets were inserted and the outer conductor clamped. This was done the entire height of the tower.

An item which merits discussion at this time is the decision concerning an elevator. It was decided to install one and the decision was based largely on interviews and conversations with the owners of other towers both with and without elevators. The best climbing time on this tower to the 1,500 foot level is a little over three hours. The descending time is equal. This adds up to six hours of non-productive work coupled with the discouraging situation which would ensue if some part or tool were left behind. Although not anticipated at the outset it has been discovered that the regular station personnel can change any other of the lamps or beacons except the top simply by stepping in the elevator and pressing a button. Other uses of an elevator are apparent.

If an elevator is considered stress must be laid on the fact that many states and most all larger metropolitan centers have an elevator code which must be adhered to. In the State of Maine this jurisdiction falls under the Department of Labor and Industry. The Rules and Regulations are based on the American Standard Code which may be obtained from the American Standards Association, 70 East 45th Street in New York. These rules are common to many states and the strictest in use.

It was necessary to appear before the full board of elevator rules and regulations in Augusta and ask for the waiver of sixteen separate sections of the code. This situation should be taken into account when contracting for an elevator and in some manner written into the purchase agreement.

Because of the requirement of one transmission line a notch diplexer was installed. In contrast to the hybrid diplexer which was small enough to tuck under the arm the notch diplexer proved to be of considerable size. It was decided to mount this on a wall rather than the conventional ceiling mount. It is believed that this is a much better arrangement especially as some coaxial patches have been installed and are thus readily accessible.

The final phase of this project was moving the transmitter from the old location to the new. To expedite this a two kilowatt RCA Type TT-2BH transmitter was purchased and permission obtained from the Federal Communications Commission to install it at the old site. A plan was worked out with the commission engineers whereby the exciter of the regular transmitter could be moved first, secondly, the amplifiers could be moved leaving the station on low power and upon completion of tests the new installation could go on with full power. It was felt that a great deal of interest would be shown by the public concerning the performance of the new installation and that any compromise with full power would be exceedingly unwise. This proved to be a correct assumption. A week was devoted to testing after program sign off and sign on and during the last week of October regular programming was begun.

The measured performance of the installation has more than met all expectations. The VSWR of the entire system is better than 1.04 at the visual carrier frequency and no greater than 1.06 over the channel bandwidth.

Coverage has far exceeded expectations. Most of what has been learned up to this date is based on mail response, independent surveys, and actual observation. It would be conservative to state that the construction of these facilities has increased the radius of Channel 13 from a former value of 35 to 45 miles to a new distance of 65 to 75 miles. It has also made it the dominant signal in many of the communities which were judged to be important to the economy of the station. Actual field intensity measurements are scheduled to be started sometime next month.

It is obvious to the experienced engineer that a change of this magnitude is almost certain to create difficulties with reception particularly in the principal city. This was anticipated and once the change was made WGAN-TV was busy answering telephone calls and accepting the blame for any and all receiver ailments. However, now that a sufficient period of time has elapsed this trouble has gradually diminished. In most part the legitimate complaints were due to wrong antenna orientation in those sections of the city acutely affected by a required change of direction. Interestingly enough there were many areas which experience overloading due to large signal increases.

Now that there has been time to look back in retrospect it is our conviction that this undertaking has been worthwhile in all respect. There is no question that it has increased the commercial value of the station to the point where it has more than off set the cost. The sales people both national and local have expressed satisfaction with the acceptance of the facility as contrasted with the problem which existed previously. If engineering planning and accomplishment is to be tailored to effectively implement a business we sincerely believe that this new facility, the WGAN-TV 1619 foot tower and antenna has accomplished its purpose.

Some photographs taken during and after construction are shown.

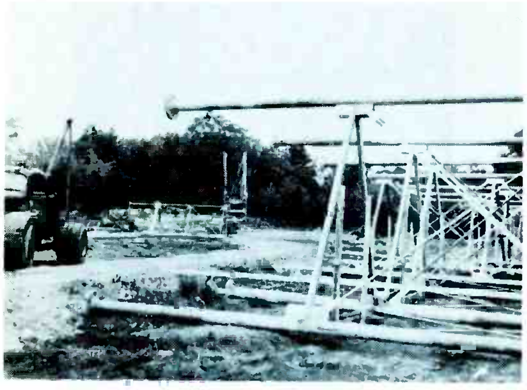


Fig. 1. Staging and assembly area

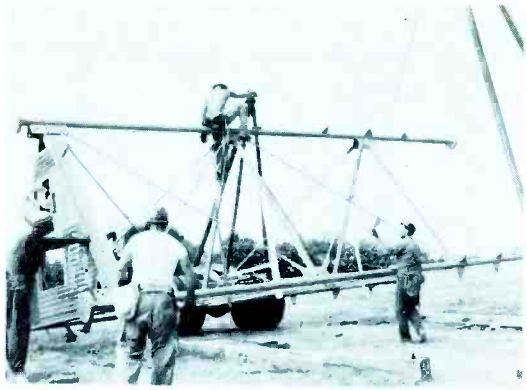


Fig. 2. Transporting assembled material to tower base

Fig. 3. Character of area at tower base

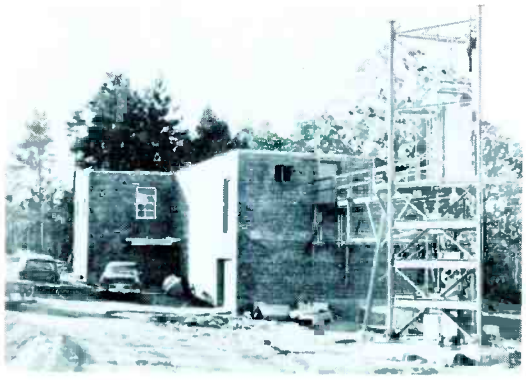


Fig. 4. House and tower

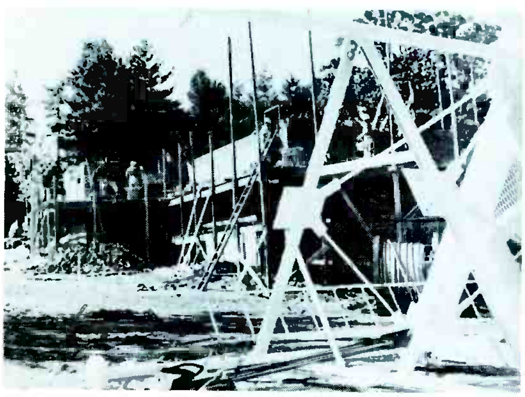


Fig. 5. Work progressing on house at same time tower was being erected

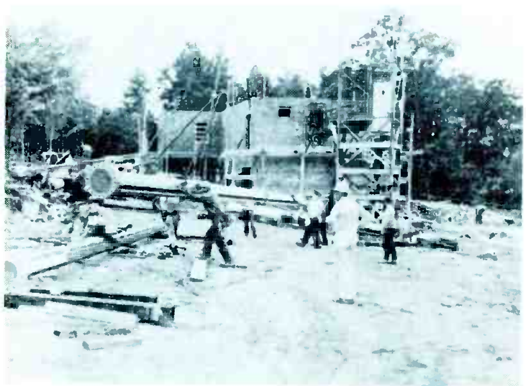


Fig. 6. Same

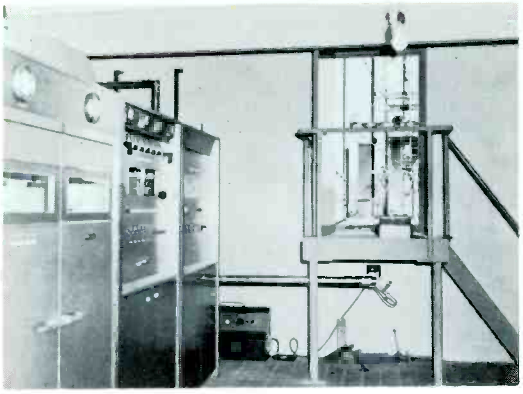


Fig. 7. Interior showing bridge doorway

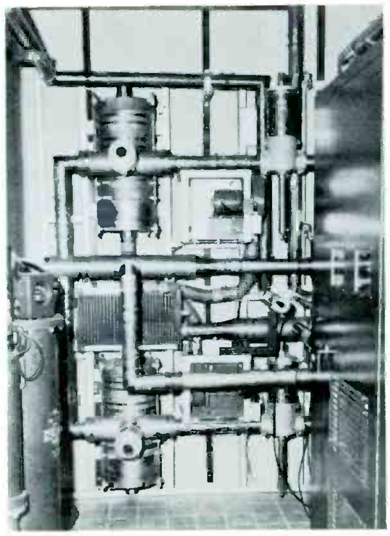


Fig. 8. Notch diplexer

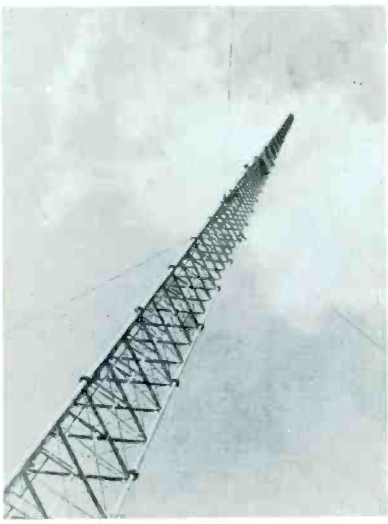


Fig. 9. Tower

Fig. 10. Guys and guy line clearing

Fig. 11. Tower - passive reflector

AN AUTOMATIC PROGRAM LOGGING SYSTEM

Robert W. Flanders
Director of Engineering
and
Robert M. Brockway
Chief Engineer, Technical
Twin State Broadcasting, Inc.

Within the past few years, the equipment manufacturers have introduced automatic program systems for AM and FM, automatic switching systems for TV, and many other devices, all of which lend themselves admirably as steps toward total automation of broadcasting stations. The results of installing automation equipment have always been beneficial to the broadcaster inasmuch as he achieves greater efficiency; smoother programming with fewer make-goods; better utilization of manpower, and in some instances, actual reduction of the manpower load.

Shortly after the establishment of WFBM-FM, on Thanksgiving Day, 1959, we found that if we had equipment to keep the program log by mechanical means, we could eliminate an expense that costs us ten thousand dollars annually. Projecting ahead slightly -- without such a device, by Thanksgiving Day, 1964, we would have spent $50,000 solely for keeping the program log. To give credance to this statement, let us briefly examine the WFBM-FM operation and it should become apparent that we are speaking very realistically.

WFBM-FM has a 19 hour daily schedule from 6:00 AM to 1:00 AM signoff. The programming is almost wholly pre-recorded tapes, the only exception being live newscasts and weather reports; however, these live portions do not require additional operating personnel, due to the fact that the microphone channel is preset and the announcer controls his channel with a key in the studio.

We currently use the Programatic Broadcasting Service, a subsidiary of Muzak. The Programatic equipment consists of two tape reproducers with associated control and amplifying equipment. The "music" tape is double-track, playing at a speed of 3-3/4 ips; each Programatic reel has enough tape to play four hours in the forward direction and four hours in the reverse direction. Announcements and local programs are prerecorded in our own plant and are played on the second tape transport full-track at 7-1/2 ips. The change-over between machines and the cueing of program material is controlled by 25-cycle tones recorded on the tapes.

In this type of operation, control room personnel is eliminated except for those occasions when the tapes must be loaded or changed. Personnel for this function is available by scheduling an engineer from one of our other three operations: AM, TV, or recording. Naturally, personnel is needed to prepare the announcement tapes and here we have integrated the FM into our recording operation at a minimal cost. We have a very active recording department which requires two 8-hour engineering shifts daily -- the preparation of FM announce tapes is done during times when the recording machines would be otherwise inactive.

Although not strictly in the sense of being automated, we have mechanized and accelerated the preparation of the announce tape by the use of a MacKenzie cartridge reproducer. Announcements such as station breaks, public service spots, program theme music, and commercial spots have been recorded on cartridges which facilitates the make-up of the daily announcement tape for FM.

Operation of the transmitter is likewise a non-expense function; the FM transmitter is in the same room with the TV transmitters and therefore, no additional manpower is needed for the FM.

By integrating all of the FM operations into our other operations, we are on the air 19 hours daily without adding personnel to either the engineering or announcing staffs. It was necessary, however, to hire personnel solely to keep the program log since in the automated mode of operation, there are neither engineers or announcers on duty. We are able to use unskilled people to keep the program log, but even at their comparatively low rate of pay, their salaries account for the ten tousand dollar annual figure.

To devise a practicable system for keeping the program log mechanically, precise timing and maintenance of timing are of paramount importance. The Programatic system provides precise timing inasmuch as it is arranged to start the music transport automatically every quarter hour by a timing device that takes precedence over all other controls. All modern, high-quality tape transports are capable of maintaining constant tape-speed so we can readily predict the starting time of any program item if we know the running time of each item.

The present FCC rules and regulations that concern program logs include the requirement that the program log show the starting and ending time of each program and announcement as broadcast. Our system complies fully with the intent of these regulations. Rule 2.386 further states that a "rough" log may be kept and the information may be transferred to the official program log. Our system proposes that a "rough" log showing elapsed, or running time be made by the recording engineer at the time the announcement tape is prepared. When broadcast, a time stamp will make a printed record of the starting time of each segment. Knowing the "running" time as indicated on the rough log and the actual starting time as broadcast, we can prepare the completed program log by interpolation.

The machine that records the actual broadcast starting time of each program segment is the Productograph P131 manufactured by the Simplex Time Recorder Company. This time stamping device, when actuated, prints on a standard adding-machine tape: the month, day of the month, hour, minute, second, and an identifying letter code. Up to six letters may be installed in a machine and by arranging the wiring, any single letter or combination of letters may be printed to give a number of identifications. The machine at WFBM-FM is equipped with letters: A, B, C, and D. In our present operation, we use A for the announcement tape, B for the music tape, and C for the microphone.

A picture of the control room is shown in Figure 1. The racks, left to right are programatic and auxiliary equipment. On the tables, from left to right, are the switching turret for program and monitor and the RCA remote amplifier being used as a studio mixer. To the right of the clock is the productograph time stamp. Figure 2 is a closeup of the console area of the WFBM-FM Indianapolis control room. At the right of center is the productograph time stamp.

Figure 3 shows the Simplex Productograph with the covers opened. At left is the takeup spool for paper tape; at the right is the supply reel of paper. The paper is fed through the stamping position in the machine under an inked ribbon. Type wheels (not visible) are behind the clock face. At the time of the printing operation, a hammer shown below the center of the clock pushes the paper against the ribbon and type-face.

Figure 4 is a photograph of two time tapes side by side. The order of timing is from bottom to the top of the left-hand tape and from the bottom to the top of the right-hand tape. Time is recorded in hours, minutes, and seconds followed by month and day of the month. Symbols A or B indicate the source of signal. Hours are shown on 24-hour time.

Figure 5 is a program log form after interpolation of time tape and rough log. The last figures in parenthesis on each line of the "Program Title" column shows running time of each item; this time is added to the starting time of each item which is indicated by means of the Productograph.

Figure 6 is a view of the two audio racks for WFBM-FM, Indianapolis, Indiana. At the left center of the picture is the Programatic rack and to its right is the auxiliary equipment rack. Behind the Programatic rack may be seen a portion of the Muzak equipment racks. Regular Muzak service is multiplexed on the WFBM-FM subcarrier to serve customers beyond the Indianapolis local telephone system. On the Programatic rack, the major units in the Programatic rack, from top to bottom, are the music tape transport, the announce tape transport, and the control panel.

Figure 7 gives the schematic for the circuits that operate the Productograph. Since the drawing was made, the symbol "C" has been added. At the top of the drawing is shown the Music Line Relay (K306) and the Announce Line Relay (K311) which are part of the Programatic control system. These relays are energized when their respective audio is being fed to the line. Below the dotted line is shown the circuitry for operating the Productograph time stamp. The block at the lower right corner represents the productograph which operates on 110 volts A-C. The terminals shown are, beginning at the top, letter "B" print, letter "A" print, hammer solenoid, and power common. The bottom string of relays, K405, K406, K407 control the announce time. When the Announce Line Relay (K311) on the Programatic is energized, 24 volts D-C is fed to the coil of K405 in the announce control string. When energized, K405 closes three NO contacts the bottom two complete the circuit from the Productograph common to the hammer and "A" print terminals through the NC contacts of K407. The third (top) NO contact of K405 puts 24 volts D-C to the thermal time-delay (K406). This is an Amperite 26NO2. In approximately two seconds K406 closes energizing K407 which opens its NC contacts thereby removing power from the

Productograph hammer and symbol solenoids. It is evident that when K311 is de-energized, so are K405, K406, and K407. The original model of this circuit did not include the time-delay relay and it was found that the pulse of power was too short to permit the hammer to make a good firm impression on the paper, therefore the time-delay was added to give a definite pulse to the Productograph. The Music circuit operates identically to the Announce circuit as far as relays K402, K403, and K404 are concerned which have identical counterparts in the latter string. The stamp function is obtained only if relay K401 is energized. The Music Line Relay, (K306) is energized whenever the music transport is running. The Programatic system is arranged to give output priority to the announce tape, which is to say that if an announcement runs past the time that the music is started by the clock which occurs every fifteen minutes, the music is faded out by a motor-driven fader until such time as the announcement is finished; at this time, the music is faded in. The fader and motor are shown in the upper left portion of the diagram. The motor operates on 110 volts A-C and limit switches are provided to control the stopping of the motor. It was convenient to "borrow" 110 volts A-C from the limit switches when the fader is at minimum attenuation. We rectified this to D-C with the bridge rectifier shown which energizes K401 whenever the fader is "up." The contact of K401 controls the 24 volts D-C to K402 and the remainder of the string.

Figure 8 is a photograph of the WFBM-FM relay panel that connects the Programatic to the Simplex Productograph. The three sockets at the left of the chassis are for the Amperite time-delay relays. The bridge rectifier elements that operate relay K401 are at the right end of the chassis. This photograph was made after the installation of the "C" symbol.

This system has been proposed in the form of an application before the FCC. Specifically, we have requested permission to keep the log in compliance to Sections 3.281 and 3.283 of the rules by mechanical means. The application includes a description of the system along with documentary evidence that this system keeps the log as accurately as by the manual method. The Commission has not yet acted on our petition, but we feel optimistically that such a system will merit FCC approval.

Figure 1

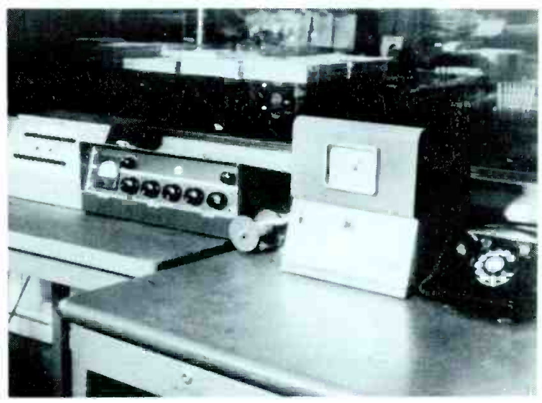


Figure 2

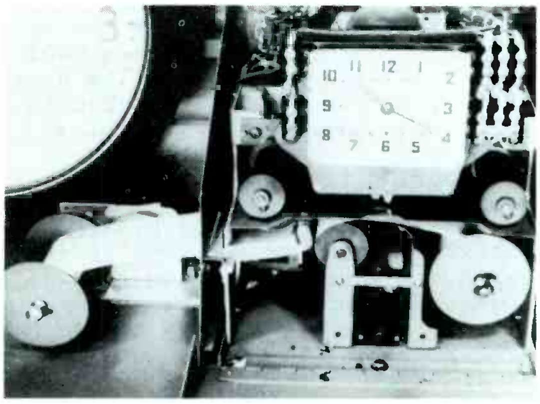


Figure 3

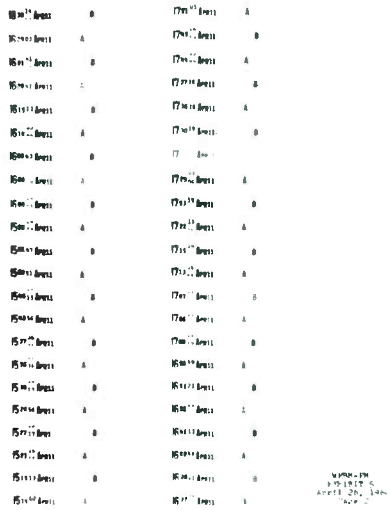


Figure 4

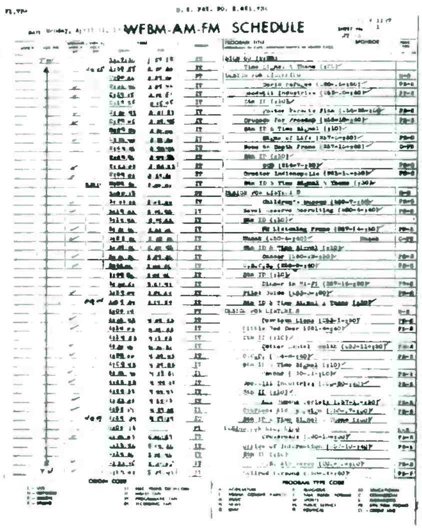


Figure 5

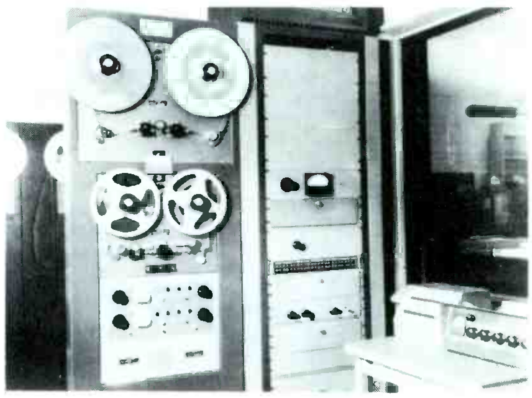


Figure 6

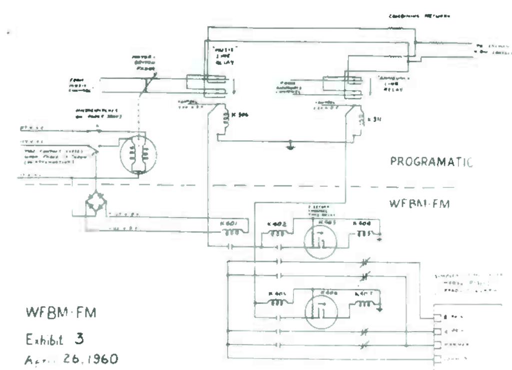


Figure 7

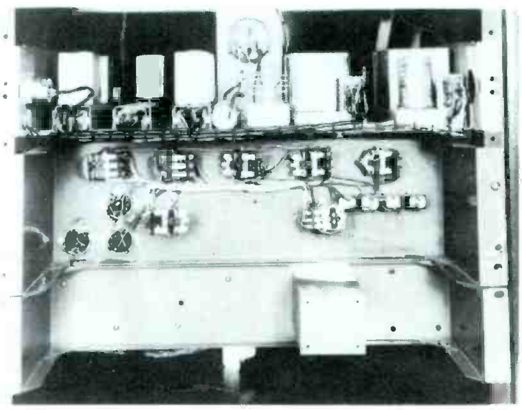


Figure 8

DESIGN CRITERIA: TRANSMITTER HIGH VOLTAGE SOLID STATE RECTIFIERS

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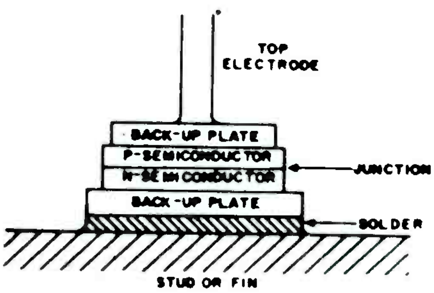
It is the purpose of this paper to set forth the problems encountered when one sets out to design a high voltage power supply using semiconductor rectifiers. Also, to indicate possible solutions to these problems.

The nature of the semiconductor itself must be understood before it can be properly applied. Despite their high efficiency, the small internal losses of the rectifiers are the prime criteria for their application. Unlike many other electrical devices such as transformers, motors and even vacuum tubes, semiconductor rectifiers have a very low thermal capacity. The P-N junction is the heart of the semiconductor rectifier and it is the temperature rise of this junction that governs the successful application of the rectifier cell. Long life and high reliability will be experienced if the junction temperature is limited to a safe value under continuous duty conditions. In addition, a satisfactory margin of safety must be maintained to enable the rectifier cell to withstand voltage and current transients that may occur during operation of the equipment.

Figure 1 shows the cross section of a typical silicon rectifier. The main elements of the device are the P and N type silicon which forms the active junction at their interface, suitable backup plates for matching the coefficient of expansion of the silicon, and the top and bottom electrodes that act both as electrical connections and a path for removing heat from the junction.



RECTIFIER CROSS SECTION

FIG 1

Heat is generated in the junction during operation of the cell due to two major losses:

1. The voltage drop across the cell due to the forward current flowing through it, and

2. the reverse current through the cell during the time it is not conducting and is subjected to its inverse voltage. I^2R losses of other portions of the cell do not become significant except under extreme overload conditions, when the cell may be conducting high foward currents.

It can now readily be seen that the major cause for cell failure is overheating of the junction. When this occurs the semiconductor material loses its rectifying properties and becomes a short circuit. It is indeed fortunate that the cell fails in this manner as it improves the reliability of series connected rectifiers because the failure of an individual cell will not result in an interruption of operation.

When one sets out to design a high voltage power supply, using semiconductor rectifiers, the prime objective is to select the proper rectifier that will result in an efficient, reliable and economical equipment. However, before an intelligent selection can be made the operational characteristics demanded of the power supply must be known and carefully analyzed.

1. What will be the maximum load voltage and current?

2. What rectifier configuration is desired?

3. Will the unit be subjected to continuous or intermittent service?

4. Will the rectifier load be steady, as in the CW transmitter or will it vary as in the case of an amplitude modulated transmitter?

5. What magnitude of voltage and current transients can be tolerated during operation?

6. What is the maximum short circuit current the supply transformer can deliver?

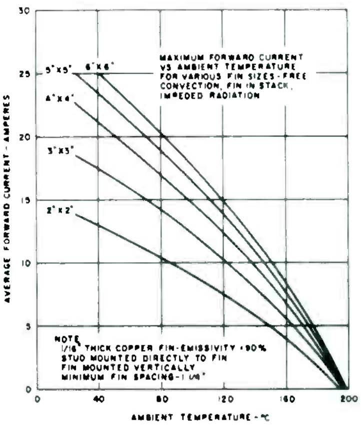
7. What environmental conditions will be encountered?

8. What will be the operating ambient temperature?

9. What method of cooling will be employed?

All of these questions must be answered before the proper rectifier cell can be selected.

The first step in selecting a rectifier for a high voltage power supply is to determine the forward current that will flow through the cell during normal operation. This is easily calculated from the full load current demanded of the supply and the desired rectifier configuration. From this information it can be determined whether a low, medium, or high current cell is required. However, the final cell type can not be selected until the method of cooling and its effects on the cells current handling ability have been determined. Obviously, a much huskier cell will be required if it is to be cooled by free convection rather than by forced air cooling in conjunction with a large fin. The current handling ability of the rectifier cell is easily obtained from the cooling data curves published by the rectifier manufacturer.



REQUIRED FIN SIZE—
FREE CONVECTION, IMPEDED RADIATION

FIG 2

Figure 2 is an example of cooling data curves for a typical silicon rectifier and relates fin size and ambient temperature to the maximum allowable average forward current in amperes. This set of curves is plotted for the single phase rectifier configuration. When the rectifier configuration is other than this the following multiplying factors must be applied to the average forward current: DC, 0.80; three phase, 1.15; and six phase, 1.4. The curves are used in the following manner:

1. Enter the graph at the horizontal axis at the expected ambient temperature.

2. Intercept the desired fin curve.

3. Read on the vertical axis the maximum allowable average forward current. Apply proper multiplying factor.

All manufacturers publish similar curves for their rectifiers. Unfortunately, however, an exact set of standards has not been established and when considering the rectifiers of several manufacturers for a particular job it is important to compare the data very carefully. Make particular note of the ambient and junction temperature at which the data curves have been prepared. It is a good idea to plot some curves of your own, comparing the parameters of interest on one graph.

In some instances, such as extremely high voltage applications, it may be desirable to employ liquid cooling of the rectifiers. This could take the form of immersing the entire rectifier assembly in a tank of oil, either by itself or in conjunction with the supply transformer. It is felt that this application will become prevalent in the future. If this method of cooling is selected the rectifier manufacturer must be consulted for his recommendation and current rating under these conditions.

When selecting a cell on the basis of its current handling abilities its surge current rating should be carefully analyzed. This parameter is one of the most important parameters of the cell that must be considered. This will be discussed in more cell detail when considering overcurrent protection requirements.

Once the current rating of the cell has been established, it remains to select the proper inverse voltage rating. It is of course assumed that the output voltage of the power supply is such that it will require connecting a number of cells in series to obtain the desired inverse voltage capability. The operating inverse voltage occurring across one rectifier leg is calculated for the no load condition taking into account the power supply regulation, commutation drop and peaking factor of the transformer. Through the use of thyrites and resistors, transient voltages occurring in the circuit can be limited to less than 150% of the D.C. voltage.

Thus, the calculated no load peak inverse voltage should be increased by a factor of 1.5 to determine the inverse voltage that each rectifier will have to withstand during operation. The use of this voltage to determine the number of rectifier cells results in the minimum safety factor. The exact safety factor chosen should be between 1.5 to 2 and will balance the rate of occurrence and magnitude of the transient voltages against the economics of initial cost.

The number of cells required per rectifier leg is now determined by dividing the total PIV (steady state plus transient safety margin) by the PIV rating of the cell selected. If, as in the case of General Electric rectifiers, a transient PIV rating is given, this value may be used to determine the number of cells required. However, if a transient rating is not given do not make allowances for one.

It is in the selection of the proper voltage rating for the cell that economics must be carefully considered. In many cases it is more economical to use a smaller number of high PIV cells rather than a large number of lower PIV cells. This comes about because the rectifier manufacturers are continually improving their manufacturing techniques resulting in much higher yields of high PIV cells. As a direct result, the cost of a rectifier using high PIV cells is lower than that of one using lower PIV cells.

After a rectifier cell has been selected and the PIV rating is known the problem remains to determine that the inverse voltage will be distributed across the cells in such a way that each cell will carry its share of the total PIV. The conditions of PIV sharing can be broken down into two cases: (1) normal PIV due to the rectifier configuration, and, (2) transient voltage conditions.

Rectifiers can be classified into two groups according to their reverse voltage characteristics. These are the sharp breakdown types and the soft breakdown types. Low and some medium current silicon rectifiers fall into the sharp breakdown group, while germanium and large area silicon rectifiers generally exhibit soft breakdown characteristics.

Figure 3 shows the reverse voltage-current characteristics of two sharp breakdown rectifiers. It should be noted that at a voltage greater than the rated PIV, the reverse current increases very rapidly for a slight increase in inverse voltage. If the reverse current in the breakdown region is not limited, intensive local heating will destroy the cell.

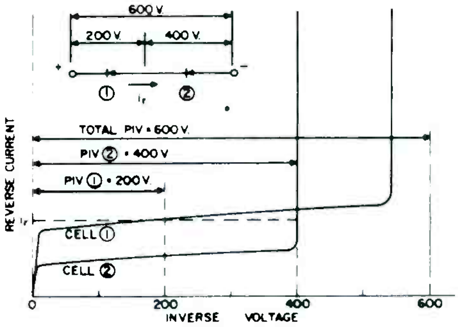


Fig. 3 Voltage sharing between series cells with sharp breakdown. (Small area silicon).

On the other hand if the reverse current in the breakdown is limited by other series cells the cell can carry its full share of the inverse voltage indefinitely with no bad effects, even though the cell is operated at greater than rated PIV. As long as the total reverse voltage across all the series cells does not exceed the sum of their respective breakdown voltages, reliable operation can result even though the reverse characteristics are completely mismatched. For this reason, series matching is usually not required for rectifiers with "sharp breakdown" characteristics.

Figure 4 shows the reverse characteristics of two unmatched cells with soft breakdown characteristics. The reverse current must be the same through both cells if no alternative parallel paths exist. Therefore, it will stabilize at a value, such that the sum of the voltage indicated by the intersection of i_r with the characteristics curves is the total impressed on the circuit. For example,

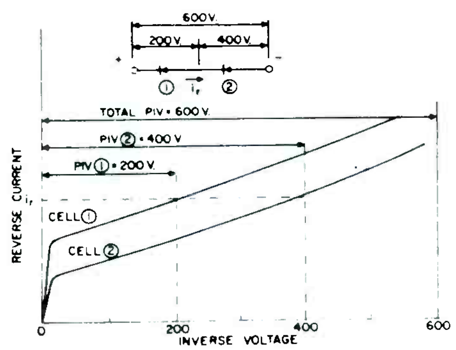


Fig. 4 Voltage sharing between unmatched series cells. (Germanium or large area silicon).

i_r intersects with the characteristic of cell 1 at 200 volts and of cell 2 at 400 volts for a total of 600. This shows the significant difference in reverse voltage sharing for series calls with dissimilar reverse characteristics.

This difference is further aggravated by the exponential increase of the reverse current characteristic with increasing junction temperature. A difference in junction temperature of only a few degrees causes a grossly unequal distribution of voltage between cells though the characteristics are identical at the same temperatures. Differences in junction temperature of several degrees must be expected in practical operation due to variations in forward voltage drop, internal thermal impedance, reverse heating and external heat dissipation.

If, for some reason, the reverse blocking characteristic of cell 2 should start to deteriorate, the characteristics of cell 2 would gradually shift upward with a simultaneous increase in slope. As the characteristics of cell 2 rises, i_r increases slightly, redistributing the voltage carried by each cell, so that cell 2 develops less voltage than initially and cell 1 develops more. Together the cells continue to share the entire 600 V supply.

Thus, a self-correcting action takes place. The cells with the lowest reverse current and the most stable reverse characteristics tend to assume a proportionally larger share of the reverse voltage than the less stable cells with the higher reverse current, imposed by the stable cells. Thus, thermal runaway and failure cannot occur unless all the cells in series in one string run away together. The chances are reduced drastically as the number of series cells increased. Overall circuit reliability is greatly improved by using cells in series.

It can be seen that it is not necessary to force each cell to take an equal share of the inverse voltage. But, rather it is better to let the cells divide up the voltage between themselves according to their abilities. The exception to this is in the case where a very small number of cells, especially of the soft breakdown type, are connected in series. Here it may be advantageous to use resistors to force the division of the inverse voltage. Also, in this case it may be necessary to match the inverse characteristics of the individual cells.

Figure 5 shows a very simple circuit that may be used to observe the reverse characteristic of a semiconductor rectifier on an oscilloscope. The voltage appearing across R_1 is applied to the horizontal deflection plates and the voltage across R_2 is applied to the vertical deflection plates. This will yield a plot of the reverse characteristics with the vertical axis proportional to the reverse current and the horizontal axis proportional to the inverse voltage. The high vacuum diode, V_1, should be a low leakage type for best results.

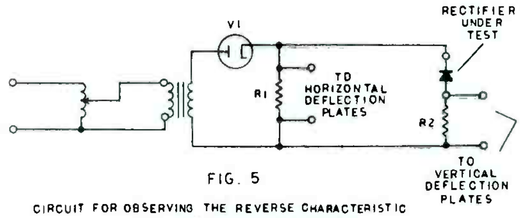


FIG. 5

CIRCUIT FOR OBSERVING THE REVERSE CHARACTERISTIC OF A SEMI-CONDUCTOR RECTIFIER

A more serious problem that must be overcome in the design of a high voltage power supply is the distribution of transient inverse voltages across individual series cells. When a steep voltage wavefront is impressed across a long string of series connected rectifiers the voltage is distributed unequally across the cells, even if they are perfectly matched according to their inverse characteristics. The distribution of the inverse voltage is determined by the stray capacitance of the cells in much the same manner as the voltage distribution occurs across a string of insulators in high voltage AC power lines. That is, the cell farthest from ground will have the highest voltage across it. The solution to the problem is the same in both cases, that is, the stray capacitance is swamped out by the addition of shunt capacity many times larger than the stray capacitance.

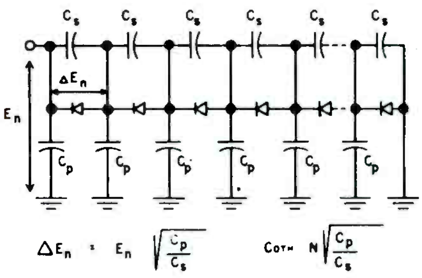
The extent of the inequality of division of the inverse voltage will depend on the number of series cells and the relative magnitude of the cell capacitance and the capacitance from cell to ground as shown in Figure 6. Assuming the rectifier cells have a very high back resistance, and the capacitance of the individual cells and capacitance between cells and ground are uniform throughout the string. Dr. R. DeBuda of Canadian General Electric, has shown that the peak voltage across the cell nearest the line, E_n, can be expressed by the equation in Figure 6 where:

E_n is the peak voltage across the entire rectifier leg.

N is the number of rectifiers in series per leg.

C_p is the capcitance between single cells and ground.

C_s is the series capacitance of a single rectifier.



STEP FUNCTION INPUT VOLTAGE
N = NUMBER OF RECTIFIERS

FIGURE 6

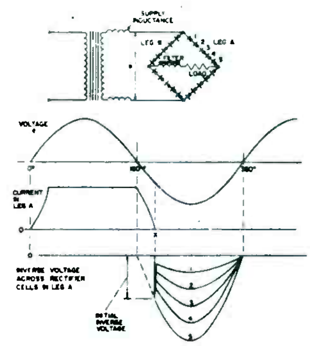
As an example, if C_s is approximately 15 uuf and C_p is in the order of 1 uuf, then if a 50,000 volt transient is impressed across 300 cells in series, the solution of the equation indicates that 12,900 volts will appear across the rectifier cell farthest from ground. This means that 25 per cent of the transient voltage appears across the first cell. Semiconductor cells available today would be destroyed by voltages of this magnitude. Proper solution of the equation will yield a value of capacitance that can be paralleled with C_s which will force the inverse voltage across the individual cells to be within their rating.

The well known causes of the transient voltages in rectifier circuits are switching the primary circuit of the supply transformer, d-c switching of the load and the operation of overcurrent protective devices. Under adverse conditions these transients can be as large as 8-10 times normal voltage. Although most rectifiers can withstand some overvoltage for a short time, they cannot withstand transient voltages of such magnitude. Under these conditions the cell will fail because of internal arcing or dielectric breakdown of the junction material. In most cases it is more economical to include circuit elements that will reduce these transients rather than increasing the rectifier PIV capability.

The maximum transient voltage occurring in the circuit can be reduced to 150 per cent of normal or less by shunting filter reactors with a resistor or thyrite resistor, using the filter capacitor to filter high frequency transients and by connecting thyrite resistors across the transformer secondary windings for the d-c bus.

The rectifier itself is also the source of a voltage transient. This transient can take on serious proportions when it occurs in a rectifier circuit employing long series strings of semiconductor rectifiers. The cause of this transient is the phenomenon called "hole storage" or "cell recovery." After a semiconductor cell conducts forward current, a brief interval (microseconds) is needed to sweep out current carriers from the base region of the semiconductor before the cell can block reverse voltage. Until the cell recovers, it behaves like a short circuit in the reverse direction. Rectifiers of given design vary somewhat in the length of time needed for recovery.

Referring to the simple bridge of Figure 7, assume cell 1 in leg A has a fast recovery and cells 2, 3 and 4 and 5 have slow, but identical recovery time. The flat top of the forward current waveshapes is due to the filter-inductance in the load. The load current flows in leg A beyond the point of supply voltage reversal due to inductance in the AC source.



DISTRIBUTION OF INITIAL INVERSE VOLTAGE ACROSS SERIES CONNECTED RECTIFIERS
FIG 7

At a rate determined by the source inductance, the load current commutates to leg B until, at some point X, the current through leg A reaches zero.

At this instant, the supply voltage has reached a large inverse value. The cell with the fastest recovery time (cell 1) absorbs this entire voltage until the other cells in turn have recovered. This may require only a few microseconds. After all cells recover, the cells in the string share the inverse voltage.

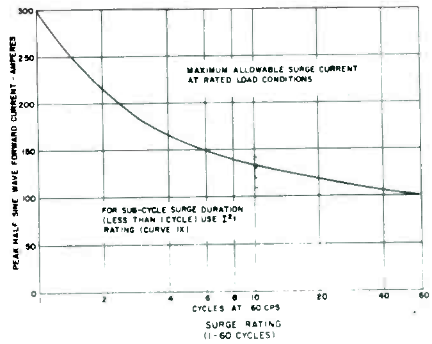
While the angle of overlap is usually quite small, when many rectifiers are in series the initial inverse voltage across a fast recovery cell can be many times the voltage across that cell at the peak of the supply voltage. This voltage spike should be kept within the continuous PIV rating of the cell.

Where the initial inverse voltage exceeds the PIV rating of a single cell, capacitors across individual cells will eliminate the voltage spike. The capacitor size depends on the difference in recovery time between cells. In any event, it need not exceed $C = 10\ I_f/E$ where C is the capacitance to distribute the recovery transient within cell PIV rating (ufd), I_f is the current in amperes flowing immediately preceeding commutation, and E the maximum continuous PIV rating of the cell.

Practice has shown that in most cases on 0.01 ufd capacitor connected across each cell will effectively divide transient inverse voltages and suppress the "cell recovery" transient. It is also possible to use a smaller value of capacity connected across a small number of cells. However, in all cases the voltage rating of the capacitor must be greater than the expected transient voltage that may appear across it.

Unequal distribution of the inverse voltage can also occur because of unequal inverse currents due to corona effects. Corona can be a serious problem when rectifiers are mounted in air, even at voltages on the order of 10 to 20 KV. Where corona appears, the air is electrically broken down and ionized so that it becomes a conductor of current. Corona forms at points of high voltage gradient, such as sharp corners, screw heads, and edges of rectifier fins. Thus all available means of counteracting the effects of corona must be taken.

Last but not least, the rectifiers must be provided overcurrent protection. As stated previously, the surge current rating of a rectifier is perhaps its most important parameter. Figure 8 indicates the surge current that a typical silicon rectifier can pass without damage. It will be noted that the current is plotted as a function of time using 60 cycles per second as units. As more cycles of current are allowed to flow through the cell, the maximum value of current must be reduced. Obviously then, in order to prevent the rectifiers from being destroyed due to current transients, the protection devices must be coordinated so that at no time does the peak current through the rectifier exceed that shown by Figure 8.



SURGE CURRENT RATING OF A TYPICAL MEDIUM CURRENT SILICON RECTIFIER

FIG 8

For surge currents of less than 1 cycle duration the rectifier is given an I^2 t rating. If surge currents are present during this interval that will exceed I^2 t rating the rectifier will be destroyed due to heating effects. The I^2 t rating is specified by the rectifier manufacturer. This rating is a function of the cell design, initial junction temperature and whether or not inverse voltage is impressed on the cell following the current surge. If the I^2 t rating is not given it can be approximated by converting the one cycle (actually one-half cycle) surge current to RMS amperes and multiplying by the time of one-half cycle (0.0083 second).

In the event that initial cost is no object, the obvious solution is to select the cell so that it has a surge current characteristic such that it will not be exceeded by the maximum surge current that can be developed in the circuit. In the majority of cases this solution is not economically feasible.

Conventional protective devices like fuses, circuit breakers and overload relays are adequate for protection beyond a few cycles, provided they are coordinated with the surge current curve and the continuous rating of the cell.

However, the worst case occurs when a low resistance short circuit fault exists in the equipment. Under such conditions the fault current will undoubtedly exceed the surge current rating of the rectifier during the few cycles required for the conventional protective devices to operate. Current limiting fuses that will interrupt the fault current before it reaches its first peak can be used under these circumstances. The current limiting fuses available (General Electric CLF or Chase-Shawmut Amp-Trap) are usually relatively low voltage types.

This mandates fusing in the primary circuit providing the transformer inrush current is not of sufficient magnitude to flow the fuse when the supply is first energized.

A more practical approach to the problem is to introduce current limiting impedances into the rectifier circuit. These can take the form of increased transformer leakage reactance, resistors or current limiting reactors. The use of such elements must be closely coordinated with the surge current rating of the rectifiers and the regulation requirements of the power supply.

Fast acting fault protection systems have been developed using vacuum switches in both the primary and the secondary of the power supply transformer. There are also available fast acting circuit breakers such as the General Electric AK series. These devices are tripped by sensitive relays and can interrupt faults within 1/2 to two cycles. However, their application will also entail the use of one or more of the current limiting methods described above.

When a prototype power supply is first tested, it is a good idea to start at approximately 25% normal voltage. This will help eliminate any catastrophic failure from unexpected transients. High speed oscilloscopes, peak reading voltmeters, and calibrated spark gaps are excellent devices for detecting and measuring transients. Metering of the inverse current flowing in each rectifier leg is a good means of monitoring the operating condition of the supply. Tests have shown that as the operating temperature of the rectifier increases, the inverse current will increase. Also, a drastic increase of current will indicate deterioration of a number of cells in the rectifier leg. Figure 9 shows a circuit that may be used to continuously monitor the inverse current during operation of the rectifier. When the rectifier leg is not conducting in the forward direction CR2 will offer a low impedance circuit to the stack inverse current and it will flow through the milliameter M-1.

The task of designing a semiconductor rectifier power supply is not difficult, but it must not be passed over lightly. Each application must be carefully considered by itself. When this is done, the result will be a power supply that will be efficient, reliable and economical to operate.

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2. "Rectifier Voltage Transients," F. W. Gutzwiller, Electrical Manufacturing, December, 1959

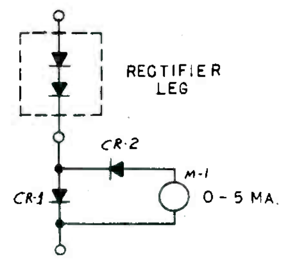

FIG. 9

CIRCUIT FOR MEASURING THE INVERSE CURRENT OF A RECTIFIER STACK

A FURTHER ANALYSIS OF TASO PANEL 6 DATA ON SIGNAL TO INTERFERENCE RATIOS AND THEIR APPLICATION TO DESCRIPTION OF TELEVISION SERVICE

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Office of the Chief Engineer
Technical Research Division
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Introduction

Panel 6 of TASO performed a monumental and very creditable task in organizing and accumulating data on the signal to interference ratios required for television service, as presented in its report. Because the Panel was uncertain as to the uses to which the F.C.C. might eventually put the data, the presentations were left in a relatively unfinished form. It is the purpose of this report to develop the data further into a form more useful for certain purposes and to develop the formulae for the application of these signal to interference ratios to the description of television service. As a by-product of this analysis it is hoped that the reader will have a better understanding of the basic concepts of quality and service. The report will be divided into two parts. In Part I, the TASO data will be reanalyzed and developed into the new form, and in Part II these results will be applied to the description of television service.

PART I: FURTHER ANALYSIS OF TASO DATA

TASO Analysis

Basically the data was taken by Panel 6 using a six point rating system. Thus, a picture was displayed with a given signal to interference ratio, R, and each viewer rated the picture as falling into one of six quality classes - Excellent, Fine, Passable, Marginal, Inferior, or Unusable. This procedure was followed for a number of discrete R ratios for each displayed picture and type of interference. Great care was taken to ensure that no bias was introduced into the results by careful viewer and picture selection. After each test the votes were added and the data could then be put into the form of a vote density table, such as Table I. Each box in the table represents the percentage of votes cast for the pertinent quality class with the given signal to interference ratio R, as listed in the first column and first row, respectively.

The data in the tables were then analyzed, interpreted and displayed in two methods, each giving different signal to interference ratios required for the various classes of service. In Method I, cumulative distributions for each R ratio were computed of the percentage of viewers voting that the displayed picture was of a given quality class or better. These data were plotted on linear-normal probability paper with the R ratio in decibels as the ordinate and the above cumulative percentages as the abscissa. Then a smooth curve was drawn through the percentages pertaining to a given class of service (see Fig. 1).

In Method II, a quality grade number from 1 through 6 was assigned to each of the above discrete classes of quality, as shown in Fig. 2A. The mean grade, m, was computed for each ratio R from density tables, similar to Table I, by taking the weighted arithmetic average of all the ratings for that ratio. Thus, the mean quality grade m is equal to the sum of the cross products of grade number and density percentage divided by the sum of the density percentage for a given signal to interference ratio R. These mean grade ratings were then plotted versus the signal to interference ratio R to give a sigmoid type of curve for each experiment.

As recognized by TASO, both Methods I and II give different answers for typical observer reaction, if they are literally interpreted. In this writer's opinion, neither type of presentation is too useful, except that the Method I distributions supply the basic data from which a more accurate and useful interpretation can be developed.

Interpretation of TASO Results

In order to develop a better understanding of the concept of quality and as to what information is desired from the TASO experiments, imagine several hypothetical experiments carried out with a very large group of viewers. The first experiment would be one in which the signal to interference ratio R is varied over a very wide range in small incremental steps. At every step each viewer rates whether the ratio R is too large, too small, or just right for a given quality class of picture. When as many of the viewers say that the ratio R is too large as say that it is too small, then the pertinent R ratio is that required for the given quality class by the median or typical observer. This type of test is run for the middle four classes - Fine, Passable, Marginal and Inferior - and the R ratios required for the median observer are the typical levels for quality Grades 2, 3, 4 and 5, respectively. Grades 1 and 6 would be the conditions of no interference and no desired signal, respectively. It will be shown in a later section that the above interpretation of Grades 1 and 6 fits the statistical structure of the data, in addition to which similar work in the field of psychometrics 2,3,4/ also fits this type of interpretation for the extremal grades of quality.

Now imagine a similar experiment in which the signal to interference ratio R is again varied in incremental steps but the observer rates the quality of the pictures using the six point class system of Fig. 2. Then, at the R ratio for which half of the observers rate the picture Excellent and the other half rate it as Fine or worse, the quality must be half-way between Grades 1 and 2 or Grade 1.5. Similarly, when half of the observers rate the picture as Fine or better and the other half rate it as Passable or worse, the pertinent R ratio corresponds to Grade 2.5. Thus, from this type of experiment the R ratios for Grades 1.5; 2.5; 3.5; 4.5; and 5.5 could be established for the median or typical observer. These grade numbers are recognized as those which separate the adjacent quality classes.

From the above hypothetical experiments it could be established that quality increases continuously as the R ratio is increased, as evidenced by the fact that the percentage of viewers voting for a better grade increases continuously. Now, returning to the individual viewer, it is obvious that each of the six classes of quality which he uses for voting (Excellent, Fine, Passable, etc.) must cover a range of R ratios, which ranges are contiguous for adjacent classes of quality and usually not the same for different viwers. Therefore, each class embraces a range of quality, which the viewer may or may not recognize individually. Thus, in the range from just barely Passable to very Passable but not quite Fine, the viewer will vote Passable. In other words, the Passable class includes the range of quality from Grade 3.5 to Grade 2.5. By similar reasoning the grade number ranges for each of the classes may be derived. With respect to the extremal Excellent and Unusable classes these are limited by the highest and lowest grade numbers. In other words, the Excellent class includes the range of quality from Grade 1.5 to Grade 1 and the Unusable class extends from Grade 6 to Grade 5.5. The grade number ranges covered by the six classes are shown in Fig. 2B.

Returning to the TASO Method I form of presentation, as illustrated in Fig. 1, it becomes evident that these are not distributions of quality reaction by the median viewer for the average quality of each class. Thus, in computing the percentage of viewers rating a picture as Passable or better, all the votes for Passable were naturally counted, including those from viewers who thought that the quality of the picture was just barely Passable. In other words, this Passable distribution represents more precisely the percentage of viewers voting for Grade 3.5 or better and not Grade 3 or better. It therefore becomes apparent that the cumulative distribution for each class of quality represents the distribution of observer ratings above the highest grade number (or lowest quality) for the class. Thus, the Excellent, Fine, Passable, Marginal and Inferior distributions of Method I are actually distributions of viewers rating the picture quality as of Grades 1.5; 2.5; 3.5; 4.5; and 5.5 or better, respectively. Any signal to interference ratio R obtained from the Method I curves would, therefore, not represent the median viewer reaction for the average quality of the pertinent class but rather the reaction of the median viewer for the lowest quality of the class.

The TASO Method II form of analysis suffers from two defects. First, as recognized in the TASO Report, it assumes that the various grades are equally spaced in quality, which assumption is not appropriate except in a limited region, as will be evident later. Secondly, it assumes that Excellent extends upward to a Grade 0.5 and Unusable downward to a Grade 6.5. It will be shown later that the statistical structure of the observer reaction best fits the concept that Grades 1 and 6 are the extremities. Since the above two assumptions are not valid except possibly in a limited range, the Method II average grades, m, are not quite correct, the discrepancies increasing as the averages approach the extremities for high or low R ratios.

Further Analysis

Since the concept of a continuously variable quality must be accepted, it is necessary to find an analytical parameter for the quality which fits the statistical structure of the data. Furthermore, since the original distributions of votes were obtained by fixing the R ratio and using quality as a variable, any regular distribution and pattern should be developed with quality as the variable.

On the basis of analogous work carried out in psychometrics, a plot of the mean grade, m, of Method II versus the R ratio in decibels is expected to give a sigmoid type of curve, as it does, characteristic of a logistic function. 2,3,4/ It has been found that a transformation from m to

$$(1) \qquad M_o = \log \frac{6 - m}{M - 1}$$

converts the sigmoid curve into a straight line. The dependent variable M_o may be recognized as the logarithm of the ratio of the probability of a favorable rating (Passable, Fine or Excellent) to the probability of an unfavorable rating (Marginal, Inferior or Unusable) for the six point rating system.

It was then decided to try a similar transformation to a parameter of the type in (1). Accordingly, each grade number of Fig. 2A was transformed into an equivalent quality index M by:

$$(2) \qquad M = \log \frac{6-q}{q-1}$$

where q is the quality grade number (not the mean grade m). Fig. 3 shows a set of cumulative distributions of the M factors for the various R ratios for Table I. It is noted that the distributions are approximately normal and parallel, the variations from normal being what might be expected for limited finite samples. In drawing these distributions, the data were plotted at Grades 1.5, 2.5, 3.5, 4.5 and 5.5, corresponding to the classes Excellent, Fine, Passable, Marginal and Inferior, respectively. These distributions are all combined in Fig. 4 to get an average normal distribution by plotting the deviations from the medians of the curves of Fig. 3. The best fit line through the data is drawn in Fig. 4 and this line determines the standard deviation. The medians of the individual distributions of Fig. 3 were then plotted versus the pertinent signal to interference ratios R in Fig. 5 to provide a nice linear relationship. This latter curve may be expected to depart somewhat from linearity at the extremities, since in these areas some of the observers may tend to rate the quality of the picture on factors other than interference-- i.e., picture content. At any rate, there appears to be no doubt as to the appropriateness of the normal distribution for the quality index M, nor as to the linearity of the median M versus the signal to interference ratio R in the useful range. A somewhat better fit might have been achieved in Figs. 4 and 5 had the mean, $\bar{M}$, been used in place of the median, but the computation of a mean $\bar{M}$ would have been laborious without yielding much better results.

Similar plots were made, but are not shown here, under the assumption that the grade numbers of Fig. 2B extended from 0.5 to 6.5 and from 0 to 7. Neither of these approaches gave anywhere near as coherent or linear results. Since the normal or Guassian distribution is probably the most basic in statistics, it is reasonable to presume that the M index of (2) is the basic quality parameter and that Grades 1 and 6 are the extremal values.

To complete the proof, table II was computed from the mean normal distribution of Fig. 4 and the linear relationship of Fig. 5. The technique for the computations is outlined in the next section of this report. It is observed that the agreement between the observer reaction density Tables I and II is quite good considering that the number of observers involved constitues a relatively small sample, statistically.

Analytic Form

It is now possible to put the results in an analytic form so that a single equation is sufficient for the prediction of quality in the presence of a given type of interference.

It has been shown that for a given interference the viewer response may be described by a simple normal distribution. The normal distribution is, of course, given by:

$$(3) \qquad Q(\omega' \geq \omega) = \frac{1}{\sqrt{2\pi}} \int_{\omega}^{\infty} \mathcal{E}^{-\frac{\omega'^2}{2}} d\omega'$$

where ω is the standard normal variable and $Q(\omega' \geq \omega)$ is the probability that ω' is greater than or equal to the value ω. For convenience, Q vs ω is plotted in Fig. 30.

From the plots of Figs. 3 and 4, it has been shown that the quality index M is normally distributed with a mean $\bar{M}$ and standard deviation σ_v and may be put into the standardized normal form as:

$$(4) \qquad \omega_v = \frac{M - \bar{M}}{\sigma_v}$$

$$M = \log \frac{6-q}{q-1}$$

where

q = the quality grade rating number, as shown in Fig. 2B

$M \equiv$ the quality index

(5) σ_v = the standard deviation of viewer reaction in quality rating the pictures for the given type of interference

$\overline{M} \equiv$ the mean value of M for a given signal to interference ratio R

$R \equiv$ the signal to interference ratio in decibels

It has been shown that the median or average (both are equal for the normal distribution) quality index $\overline{M}$ is linearly proportional to R, so that

$$\overline{M} = \frac{1}{b}(R - R_o) \quad (6)$$

where R_o is the value of R for $\overline{M}$ equal zero (q = 3.5). In other words, at this level half of the observers would be expected to vote for a favorable rating (Passable or better) and the other half for an unfavorable rating (Marginal or worse). Eq. (4) and (6) may be combined to give

$$\omega_v = \frac{M - \frac{1}{b}(R-R_o)}{\sigma_v} = -\frac{R-(R_o+bM)}{b\sigma_v} \quad (7)$$

$$= \frac{\log\left(\frac{6-q}{q-1}\right) - \frac{1}{b}(R - R_o)}{\sigma_v}$$

Eq. (7) shows that not only is the viewer quality index M normally distributed for a given ratio R but so should be the viewer response to the signal to interference ratio R deemed necessary for a given grade of service. Eq. (7) also shows that

$$Q(\omega' \geq \omega_v) = Q(M' \geq M) = \quad (8)$$

$$Q(q' \leq q) = Q(R' \leq R)$$

where q is the quality grade number corresponding to M. In other words, the percent of viewers who rate the picture as of a given grade or better for a given R ratio is equal to the percent of viewers who think that the pertinent R ratio or smaller is needed for the given grade of picture quality q. The latter statement becomes obvious with a little thought.

The question arises then as to why some of the TASO Method I plots do not show up as more linear, as they should be on the basis of (7). This lack of linearity probably occurs for the following reasons.

First, from the plots of $\overline{M}$ versus R there sometimes appears to be other factors which affect the viewer quality rating at the high and low signal to interference levels. Thus, for high R ratios the quality may not increase as rapidly as in the middle R ranges, and for low R ratios the quality may seem to increase faster than normal, most likely, the result of the viewers rating the picture on the content, rather than interference. These departures are indicated on the $\overline{M}$ versus R type plots by the dashed lines. The apparent linearity of these departures indicates that these extremal trends also have a similar statistical structure. At any rate, these departures from normal tend to bow the R distributions. A second reason for the lack of linearity in some of the R distributions may lie in the sample size and the method of sampling. In other words, the data were taken under conditions for which the R ratio was held constant and the quality ratings were variable. The departures from a normal distribution to be expected for a relatively small sample of observers would then be in quality grading observations M rather than R. The distribution identified by (6) is one in which the ratio R is varied continuously for a given observer and he selects the average level at which he thinks that a given grade of quality occurs. Thus, each observer should really vote only once per quality grade.

Fortunately, the distribution in R is relatively unimportant. The distribution of quality and the linearity of $\overline{M}$ versus R in the range of quality grades 2 through 4 are the important trends which are used for TV service description, as discussed in Part II.

On the basis of the above arguments it appears that at least the midranges of the ratio R should be normally distributed for a given quality grade. For this reason, the median R values from plots of the TASO Method I type were also used in the $\overline{M}$ vs R plots (see Fig. 5) to give more data in determining the best fit line for these trends.

Returning to (7) again, this equation may be used in conjunction with (3) for computing the ratio R required to provide a given grade of quality or better to a given percentage of the viewers for a given type of interference. Thus, the quality grade and the percentage of viewers would determine M and ω_v, respectively, and knowing b, R_o, and σ_v the value of R may be computed from (7). Conversely, given a value of R, the distribution of viewer rating may be calculated from (7). Table II, which has been mentioned previously, was derived in this fashion. Each of the discrete class ratings was considered to contain the sum of the viewer ratings (or more precisely, viewer probabilities) between the limits of the class in grade numbers as shown on Fig. 2B. Thus, if V_{q1} is the percentage of viewers rating the picture as of Grade q_1 or better, and V_{q2} is the percentage of viewers rating the same picture as of Grade q_2 or better, then $|V_{q1} - V_{q2}|$ is naturally the percentage of viewers voting in the quality range between q_1 and q_2. In computing Table II the quality grade ranges of Table III were used.

For more details as to the application of (3) and (7) to the description of TV service, where the signal to interference ratio R varies both with location and time, the reader is referred to Part II of this report. It will be shown that the simple linear results developed here blend very well with the analytic relationships already established for the variation of signal strength with time and location.

Another advantage to the simple linear relationships developed accrues from the fact that in the future a smaller number of measurements will be required in measuring observer responses to interference of the same or other types, since it is much easier to fit a straight line to data than an unknown curve.

Cochannel Interference

Rather than draw individual M distributions and curves for all the individual tests compiled for the TASO report, it was decided to combine the density tables into the desired output combinations where possible, and then evaluate the pertinent trends. Table III lists the various cochannel offset frequencies and the nearest odd or even multiple of the frame rate frequency. For those not familiar with the F.C.C. standards, the standard frame rate is 1/525 of the horizontal scanning frequency, or 29.97 cps, but for monochrome transmissions a nominal frame rate of 30 cps is permitted.

It is noted from Table III that the 9985 cps offsets for both frame rates may be combined, since this frequency is only 5 cps away from the worst offset condition (odd number of frame rates) in both cases. The 19,995 cps offset for 29.97 cps is exactly at the worst condition, whereas for a 30 cps frame rate it is only half way between the worst and best (even number of frame rates) conditions. Therefore it was decided not to combine the data for the 19,995 cps offset, 30 cps frame rate, with the 19,995 cps offset, 29.97 cps frame rate, or with the 9985 cps offsets, since these latter combinations represent the worst conditions only. In a similar fashion, it was decided to use only the 10,010 and 20,020 cps offsets with the 29.97 cps frame rate as representative of the best offset conditions. With the 30 cps frame rate, the 10,010 and 20,020 cps offsets were 10 and 20 cps, respectively, away from the optimum condition, too far to be really optimum.

Density tables, similar to Table I, were derived for all the pertinent offset combinations from the cumulative distributions of the Method I displays in the TASO Panel 6 Report. Then, when possible, the tables were combined by averaging the percentage densities for each box to obtain density tables for the desired combinations.

The results for the 9985 cps offset, both scenes and frame rates pooled, have already been described in Figs. 4 and 5. The corresponding curves for 19,995 cps offset, 29.97 cps frame rate with scenes pooled, are shown in Figs. 6 and 7. These two sets of figures represent the worst offset conditions for the nominal 10 kc and 20 kc offsets respectively. The two sets of data were then combined on an equal weighting basis in Figs. 8 and 9 to obtain the overall combined results for the worst offset conditions. The variance -- σ_v^2 -- of Fig. 8 was derived by averaging the variance of Figs. 4 and 6, whereas the line of Fig. 9 was obtained by averaging the constants b and R_0 of Figs. 5 and 7. Both the 9985 cps and 19,995 cps offset data are displayed along with the curves to show the fit of the data. The basic density tables for the 9985 cps and 19,995 cps offsets could not be averaged because the R ratios for the two sets of data were not generally the same. It is apparent that the cochannel interference with a 19,995 cps offset is a bit more severe than with the 9985 cps offset.

The results for the best offset conditions 10,010 cps, 29.97 cps frame rate, and 20,020 cps, 29.97 cps frame rate, are shown in Figs. 10, 11, 12, and 13. It is apparent from the range of the dashed lines that at the lower signal to interference ratios other factors were influencing the quality rating more than for the upper R ranges.

The density tables for the above two offsets were averaged to give Figs. 14 and 15. The individual data for the 10,010 cps and 20,020 cps offsets are also plotted on Figs. 14 and 15.

Figs. 16 and 17 show the viewer responses to the best "on-frequency" operation, normally called "very precise offset," for an offset frequency of 360 cps. Fig. 17 seems to indicate that the viewer response as reflected in $\bar{M}$ changed quite rapidly up to a quality of about Grade 2, after which some other factor caused the viewer response to change much more slowly as the R ratio increased still further. It is this influence which caused the relatively poor fit of the data to a normal distribution in Fig. 16. That something unusual was happening is also apparent from the original Fig. 46 of the TASO Panel 6 Report, which indicated very little change in the quality rating for signal to interference ratios between 27 and 57 db. This type of interference is not expected to occur frequently and when it does occur it will usually be secondary to the cochannel "precise offset" type of interference.

Probably the worst cochannel interference occurs with an offset of 604 cps. Figs. 18 and 19 show the results for this offset condition. This condition has been assumed by the Commission for computing the interference between stations operating "on frequency" with no very precise frequency control.

Adjacent Channel Interference

The same M parameter works equally well for adjacent channel interference. Figs. 20 and 21 show the Upper Adjacent Channel interference. The Lower Adjacent Channel interference is shown in Figs. 22 and 23 for the presently normal condition of the sound power down 3 db below the video peak power. Figs. 24 and 25 show the interference for the conditions in which the (present) sound power is further reduced by 7 db so that it is 10 db below the video peak power. It is noted that the mean curves of $\bar{M}$ vs R in Figs. 23 and 25 for the two levels of sound power are approximately parallel and separated by about 5.5 db.

The average of the interference curves for the upper adjacent channel and the normal (sound power 3 db down) lower adjacent channel interference is shown in Figs. 26 and 27. These lines were also obtained by averaging the σ_v^2, b, and R_o.

Noise

The interference from random noise is shown in Figs. 28 and 29. Only the data from the Miss TASO scene (see original TASO Fig. 38) was used since this test represented the largest number of viewers. Actually, the distribution of ratings for Fig. 39 of the Panel 6 Report with seven scenes pooled but with a much smaller number of viewers is close to that of TASO Fig. 38 so that had the results of these two figures been combined the resulting curves would have been substantially the same.

PART II

Description of Television Service

The theory will be developed here whereby the simple quality formulae, developed in Part I, may be applied to the description of television service for the practical case where both the desired signal and interference may be varying in amplitude both with time and from location to location.

The instantaneous field strength from a station may be described analytically by:

(9) $$F = [F - F_T(50)] + [F_T(50) - F(50,50)]$$

$$= x_i + y_i + F(50,50) \text{ dbu}$$

where

$F_T(50) \equiv$ the average field strength at a given location in decibels above one microvolt per meter (dbu) over a long period of time.

(10) $F(50,50) \equiv$ The average field strength in dbu, both in time and from location to location for a given distance, antenna height, power, frequency, etc.

$x_i \equiv [F - F_T(50)]$ represents the variation with time at a given location.

$y_i \equiv [F_T(50) - F(50,50)]$ represents the variation of time average field from location to location.

Because it is not practical to predict the individual variations for every location and instant of time, it is necessary to treat these amplitude variations on a statistical basis. Thus, a statistical field strength variable is introduced:

(11) $$F(L,T) = x_i + y_i + F(50,50) \text{ dbu}$$

where F(L,T) is the field strength level exceeded for T percent of the time at L percent of the locations or better. Another way of considering F(L,T) is to define a T percent field, F(T), as the field strength exceeded for T percent of the time at a given location, then F(L,T) becomes the field strength level exceeded by T percent fields at L percent of the locations.

It is known from measurements that the time variable x_i is approximately normally distributed 5,6,9/ with zero mean and standard deviation, σ_{Ti}, which varies with distance, frequency and antenna height. Likewise for reasonable sized areas the variation with location y_i is also approximately normal with zero mean and standard deviation, σ_{Li}, which varies with at least frequency. The usual assumption is that σ_{Li} is independent of distance or antenna height. The statistical variables x_i and y_i may be represented as

(12) $$x_i = \omega_{Ti}\ \sigma_{Ti}$$
$$y_i = \omega_{Li}\ \sigma_{Li}$$

where, of course, ω_{Ti} and ω_{Li} are standard normal variables related by (3) or Fig. 30 to the probabilities that x_i and y_i, respectively, are exceeded.

The receiver input power in decibels above one watt is related to the field strength at the receiving antenna by:

(13) $$P = F + G - 20 \log f_{mc} - P_e - 105.1 \text{ dbu}$$

$G \equiv$ the receiving antenna power gain for the pertinent direction in decibels above that for a half wave dipole.

(14)

$f_{mc} \equiv$ the frequency in megacycles per second

$P_e \equiv$ the receiving installation transmission line loss in decibels

$F \equiv$ the field strength in decibels above 1 microvolt per meter (dbu)

Substituting (11) and (12) into (13) the statistical power input variable is obtained.

(15) $$P(L,T) = x_i + y_i + F(50,50) + G - P_e - 20 \log f_{mc} - 105.1$$
$$= \sigma_{Ti}\,\omega_{Ti} + \sigma_{Li}\ \omega_{Li} + F(50,50) + G - P_e - 20 \log f_{mc} - 105.1 \text{ dbu}$$

Here P(L,T) is the level of power input to the receiver exceed for T percent of the time at L percent of the locations or better -- corresponding to F(L,T). In the case of noise power generated at the receiver input.

(16) $$P_n = 10 \log ktB + NF$$
$$= 10 \log B + NF - 204.0 \text{ dbu}$$

where

(17)

$B \equiv$ the bandwidth of the receiver in cycles per second

$NF \equiv$ the receiver noise figure in cycles per second

$t \equiv$ the temperature in degrees Kelvin

$k \equiv$ Boltzman's constant (1.38×10^{-23})

The numerical value assumed for k t at room temperature is 4×10^{-21}. In computing TV service, noise is generally assumed to have negligible time fading or variation from location to location, so that P_n is assumed to be constant for a given frequency and type of service.

The ratio R in decibels of a desired signal to interference at the receiver input then becomes

(18) $$R = P_d - P_u = (x_d - x_u) + (y_d - y_u) + F_d(50,50) - F_u(50,50) + G_d - G_u - 20 \log \frac{f_{mcd}}{f_{mcu}}$$
$$= R_{oo} + x + y \text{ db}$$

where

(19) $$x = x_d - x_u$$
$$y = y_d - y_u$$
$$R_{oo} = F_d(50,50) - F_u(50,50) + G_d - G_u - 20 \log \frac{f_{mcd}}{f_{mcu}}$$

In the above, the d and u subscripts refer to the desired and undesired signals, respectively. R is also recognized as a statistical variable or level which could have been labelled as R(L,T). x represents the variation with time of the ratio of the desired signal to interference and y the variation of this ratio from location to location.

It is known from the theory of statistics that the sum or difference of two normal variates is also normally distributed. Thus.

(20) $$\omega_T = \frac{x_d - x_u}{\sigma_T} = \frac{x}{\sigma_T}$$

$$\omega_L = \frac{y_d - y_u}{\sigma_L} = \frac{y}{\sigma_L}$$

$$\sigma_T = \sqrt{\sigma_{Td}^2 + \sigma_{Tu}^2 - 2\rho_T \sigma_{Td}\sigma_{Tu}}$$

$$\sigma_L = \sqrt{\sigma_{Ld}^2 + \sigma_{Lu}^2 - 2\rho_L \sigma_{Ld}\sigma_{Lu}}$$

where, again, ω_T and ω_L are standard normal variates, related by Fig. 30, to the percentages T and L for which the service variables x and y, respectively, are exceeded. Measurements 9,10,11/ have shown that for most practical cases the correlation coefficients ρ_T and ρ_L are negligible and may be assumed as zero.

Substituting (20) into (18),

(21) $$R = R_{oo} + \sigma_T \omega_T + \sigma_L \omega_L$$

For the special cases where the time fading of one of the signals is at least several times greater than that of the other, some simplifying approximations may be applied, Thus

(22) $$F_u(50,50) + \sigma_T \omega_T \cong F_u(50,100-T)$$

$$R_{oo} + \sigma_T \omega_T \cong F_d(50,50) - F_u(50,100-T) + G_d - G_u - 20 \log \frac{f_{mcd}}{f_{mcu}}$$

The Commission makes use of this approximation by specifying that the service at any location is not acceptable unless it exists for 90% of the time or better (T = 90%). Under this definition of service, most cochannel interference problems resolve themselves into determining R from the ratio $F_d(50,50) - F_u(50,10)$

Similarly, for adjacent channel interference in which the time fading of the undesired signal is usually much smaller than that of the desired signal

$$F_d(50,50) + \sigma_T \omega_T \cong F_d(50,T)$$

(23) $$R_{oo} + \sigma_T \omega_T \cong F_d(50,T) - F_u(50,50) + G_d - G_u - 20 \log \frac{f_{mcd}}{f_{mcu}}$$

$$\left| \sigma_{Td}^2 \gg \sigma_{Tu}^2 \right.$$

And with a 90% time criterion for service, the adjacent channel interference problems are usually solved by determining the ratio R from $F_d(50,90) - F_u(50,50)$.

When receiver noise is the interference

$$X = X_d \qquad \sigma_T = \sigma_{Td}$$

(24) $$Y = Y_d \qquad \sigma_L = \sigma_{Ld}$$

$$R_{oo} + \omega_T \sigma_T = F_d(50,T) + G_d - P_e - 20 \log f_{mcd} - 10 \log B - NF + 98.9$$

(25) $$R = P_d - P_m = R_{oo} + X + Y$$

$$= R_{oo} + \sigma_T \omega_T + \sigma_L \omega_L$$

$$= F_d(50,T) + G_d - P_e - 20 \log f_{mcd} - 10 \log B - NF + \sigma_L \omega_L + 98.9 \text{ db}$$

And for the 90% service time requirement the computation of service in the presence of receiver noise becomes one of determining R from $F_d(50,90)$.

It has also been shown in Part I that the quality index M is normally distributed with a standard deviation σ_V about the mean $\bar{M}$ as given by (6), so that

$$R = R_o + bM - b\sigma_V \omega_V$$

(26) $$= R_o + bM - Z$$

$$Z = b\sigma_V \omega_V$$

Since ω_V is the standard normal variate and $b\sigma_V$ is constant, Z must be normal with zero mean and standard deviation $b\sigma_V$. The observer or televiewer response to TV signals may then be derived by equating (26) with (18) or (25) to give

(27) $$bM = (R_{oo} - R_o) + X + Y + Z$$

$$= (R_{oo} - R_o) + \sigma_T \omega_T + \sigma_L \omega_L + b\sigma_V \omega_V$$

In (27) there are four normal variables -- x, y, and M. X describes the fluctuations of the signal to interference ratio R with time, y the variation of R from location to location, z the variation in viewer response with R, and M the variation in picture quality. Only three of the above variables can be considered as independent, the fourth being related to the other three by (27). It is obvious that an infinite number of combinations of T, L, q and V (percent of time, percent of locations, quality grade number and percent of viewers) will describe the same signal to interference ratios. In practice, it is customary to standardize three of the variables - usually M, x and z; i.e., T, q and V, - so that only the percent of locations L varies for a given type of service. In defining distance contour limitations of service all four of the variables are preset. Standard receiving installations are normally assumed which may be different for different types of service.

In any practical situation for which TV service is to be estimated the observers or viewers are randomly located, so that it is usually desirable to combine the variation in viewer response with the variation in R from location to location. Thus,

$$(28) \qquad bM = (R_{oo} - R_o) + X + u$$

where $u = Y + Z$

$$(29) \qquad \sigma_{VL}^2 = \sqrt{\sigma_L^2 + b^2 \sigma_V^2}$$

In the above, u describes the viewer response when the viewers are randomly distributed at different locations. Now, there are only three normal variables - x, u and M - of which only two are independent. In practice, it is likely that x and M - i.e., T and q - will be preset to describe a given type of service.

In order to show the actual procedure for the computation of service, several numerical examples will be carried through and the procedural steps tabulated.

Example I

Consider the problem of computing the percentage of rural viewers getting a Grade 3 picture or better 90% or more of the time in the presence of receiver noise at a distance of 40 miles from a Channel 4 TV station radiating 100 kw from a 1000 foot transmitting antenna. The receiving antenna is assumed to be a height of 30 foot with a gain of 3 db above that for a half wave dipole. Further, it is assumed that the average receiver noise figure is 7 db and that the transmission line loss is 2 db. From these given values and the available field strength curves the procedure in computing the desired service results may be tabulated.

Factor	Value	Reference
$F_d(50,90)$	64 dbu	Ref. No. 6
$\sigma_L = \sigma_{Ld}$	8.28 db	Ref. No. 7
10 log B	66 db	B = 4,000,000

(Continued)

Factor	Value	Reference
G_d	3 db	Given
P_1	2 db	Given
20 log f_{mc}	36.5 db	f_{mc} = 67.25 mc/s
NF	7 db	Given
σ_V	0.356	Fig. 28
b	12.3 db	Fig. 29
R_o	27.8 dbu	Fig. 29
σ_{VL}	9.37 db	(29)
M	0.176	(4)
$R_{oo} + \sigma_T \omega_T$	54.4 db	(24)
ω_{VL}	-2.60	(28)
V (Percent of viewers)	99.5%	Fig. 30

Example 2

As another typical example, it is desired to compute the service range on a line between stations of the above TV station, as limited by a similar cochannel station at a separation of 170 miles and employing a 10,101 cps offset with a 29.97 cps frame rate. Further, the service under consideration is to be for Grade 2 picture or better for 90% of the time or more to at least 70% of the viewers. The receiving antenna is assumed to have a 5 db front to back ratio. No other sources of interference are assumed to exist. For multiple interference considerations the reader is referred to Vol. II of the Ad Hoc Report. This problem may be solved by using the approximation (A14) and computing the required value of $F_d(50,50) - F_u(50,10)$. Then this ratio of median desired to 10% undesired fields is found for several distances from the available propagation curves and the required distance to the specified service contour is interpolated. The computation procedure may be tabulated as follows:

Factor	Value	Reference
$\sigma_{Ld} = \sigma_{Lu}$	8.28 db	Ref. N. 12
σ_L	11.71 db	(20)
$G_d - G_u$	5 db	Given
$20 \log \frac{f_{mcd}}{f_{mcu}}$	0 db	Given

(Continued)

Factor	Value	Reference
b	16.0 db	Fig. 11
R_o	15.7 db	Fig. 11
σ_V	.481	Fig. 10
σ_{VL}	14.01 db	(29)
ω_T	-1.28	Fig.30(T=90%)
ω_{VL}	-.525	Fig.30(V=70%)
M	.602	(4)
$R_{oo} + \sigma_T \omega_T$	32.7 db	(28)
$F_d(50,50) - F_u(50,10)$ required	27.7 db	(22)
$F_d(50,50)$ at 40 miles	66.5 dbu	Ref. No. 6
$F_u(50,10)$ at 130 miles	37 dbu	Ref. No. 6
$F_d(50,50) - F_u(50,10)$	29.5 dbu	Ref. No. 6
$F_{d2}(50,50)$ at 45 miles	62.5 dbu	Ref. No. 6
$F_{u2}(50,10)$ at 125 miles	37.5 dbu	Ref. No. 6
$F_{d2}(50,50) - F_{u2}(50,10)$	25.0 db	

By interpolating between 40 and 45 miles, the required service contour is found to be 42 miles.

Conclusion

In Part I of this report a more precise interpretation of the TASO Panel 6 signal to interference ratio data is developed. By transformation to a new quality index M, the viewer reaction to any given type of interference can be described as a continuous variable having a basic normal distribution. Further, a simple linear relationship has been developed between the average quality index $\bar{M}$ and the signal to interference ratio R.

The above relationships are combined in Part II with the known variability of TV signals, both with time and from location to location, to provide useful analytic relationships which permit a fairly complete prediction of TV service.

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TABLE I

Cochannel Interference, 9985 cps Offset, Frames and Scenes Pooled
(TASO Figs. 46, 48, 50, 52)
Measured Percent of Viewers Voting for Various Quality Classes

Class R in db	10	14	18	22	26	30	34	38
Excellent	____	____	0.75	3.25	10.5	21.75	36.75	63.0
Fine	____	0.75	7.25	19.25	38.75	45.0	45.75	26.5
Passable	2.25	8.0	27.5	37.75	31.0	18.5	12.0	7.25
Marginal	9.0	28.0	35.0	28.5	13.5	9.75	4.75	3.0
Inferior	40.25	39.5	20.0	11.0	5.25	4.75	0.75	0.25
Unusable	48.5	23.75	9.5	0.25	1.0	0.25	____	____

TABLE II

Cochannel Interference, 9985 cps Offset, Frames and Scenes Pooled

Computed Distribution of Viewer Votes from Figs. 4 and 5

Class R in db	10	14	18	22	26	30	34	38
Excellent	____	0.1	0.6	2.8	9.3	23.2	44.1	67.0
Fine	0.9	3.7	10.7	24.0	39.4	47.8	43.1	28.8
Passable	5.1	12.6	23.3	30.7	29.4	20.3	10.2	3.7
Marginal	16.8	26.8	31.4	26.6	16.2	7.2	2.3	0.52
Inferior	47.8	43.5	29.5	14.8	5.5	1.5	____	____
Unusable	29.4	13.3	4.5	1.1	0.2	____	____	____

TABLE III

Quality Class	Upper Limit Grade q_1	Lower Limit Grade q_2	Percentage Voting For Class
Excellent	1	1.5	$V_{1.5} - V_1$
Fine	1.5	2.5	$V_{2.5} - V_{1.5}$
Passable	2.5	3.5	$V_{3.5} - V_{2.5}$
Marginal	3.5	4.5	$V_{4.5} - V_{3.5}$
Inferior	4.5	5.5	$V_{5.5} - V_{4.5}$
Unusable	5.5	6	$V_6 - V_{5.5}$

TABLE IV

Cochannel Offset Frequencies as Related to Frame Rates

Offset Freq. (cps)	Nearest Multiple of Frame Rate 29.97 cps		Nearest Multiple of Frame Rate 30 cps	
	Frequency	Multiple	Frequency	Multiple
360	359.64	12	360	12
604	599.4	20	600	30
9,985	9,980	333	9,990	333
10,010	10,010	334	10,020	334
19,995	19,995	667	20,010	667
20,020	20,020	668	20,010	667

TABLE V

SUMMARY OF NUMERICAL CONSTANTS

Type of Interference	Offset (cps)	Frame Rate (cps)	Interference Condition	σ_v	R_o	b	Grade 2	Grade 3	Grade 4
Cochannel	9985	29.97, 30	Worst	.465	20.7	15.0	29.6	23.3	18.0
"	19,995	29.97	Worst	.398	25.9	19.1	37.5	29.3	22.6
"	Average of above two			.433	23.3	17.0	33.6	26.3	20.3
"	10,010	29.97	Best	.481	15.7	16.0	25.4	18.5	14.7
"	20,020	29.97	Best	.487	17.5	14.6	26.4	20.2	15
"	Average of above two			.484	16.5	15.3	25.9	19.3	14.9
"	360	29.97	Best	.493	23.0	7.3	29.1	24.4	21.7
"	604	29.97, 30	Worst	.438	41.2	23.0	55	45.2	37.2
Upper Adjacent Ch.	---	---	---	.617	-26.8	9.7	-20.9	-25.1	-28.6
Lower Adjacent Ch.	(Sound down 3 db)			.448	-26.5	13.6	-18.4	-24.1	-28.9
Adjacent Channel	Average of above two			.538	-26.6	11.6	-19.7	-24.6	-28.7
Lower Adjacent Ch.	(Sound down 10 db)			.360	-32.1	13.5	-24.1	-29.8	-34.5
Random Noise	---	---	---	.356	27.8	12.3	35.2	30.0	25.6

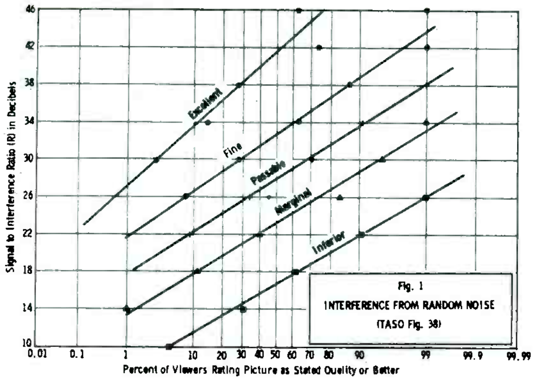


Fig. 1
INTERFERENCE FROM RANDOM NOISE
(TASO Fig. 38)
Excellent
Fine
Passable
Marginal
Inferior
Signal to Interference Ratio (R) in Decibels
Percent of Viewers Rating Picture as Stated Quality or Better

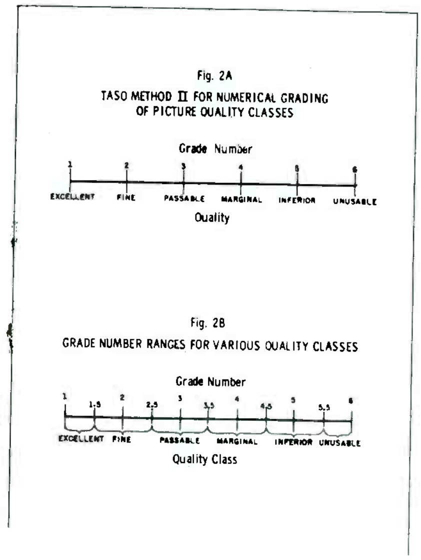


Fig. 2A
TASO METHOD II FOR NUMERICAL GRADING
OF PICTURE QUALITY CLASSES
Grade Number
EXCELLENT
FINE
PASSABLE
MARGINAL
INFERIOR
UNUSABLE
Quality
Fig. 2B
GRADE NUMBER RANGES FOR VARIOUS QUALITY CLASSES
Grade Number
Quality Class

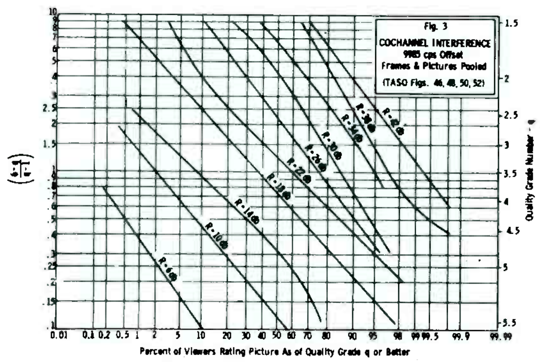


Fig. 3
COCHANNEL INTERFERENCE
9985 cps Offset
Frames & Pictures Pooled
(TASO Figs. 46, 48, 50, 52)
Quality Grade Number - q
Percent of Viewers Rating Picture As of Quality Grade q or Better

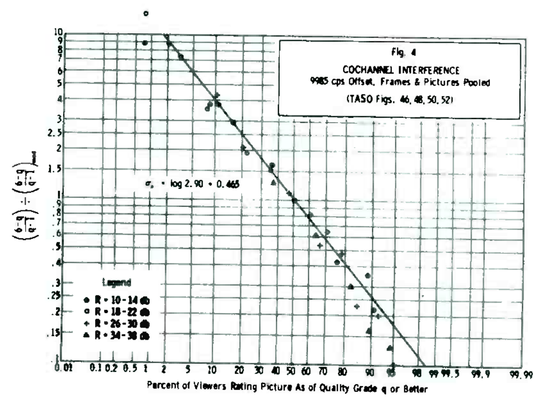
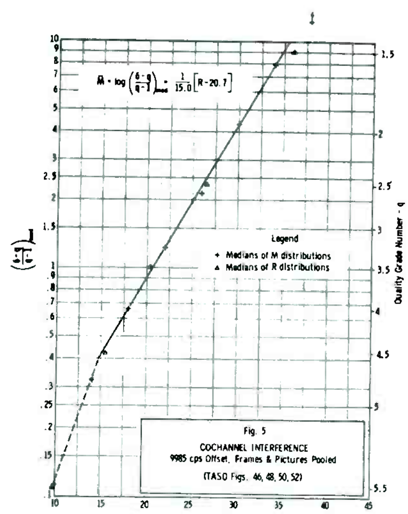


Fig. 4
COCHANNEL INTERFERENCE
9985 cps Offset, Frames & Pictures Pooled
(TASO Figs. 46, 48, 50, 52)
Legend
Percent of Viewers Rating Picture As of Quality Grade q or Better


Legend
Medians of M distributions
Medians of R distributions
Fig. 5
COCHANNEL INTERFERENCE
9985 cps Offset, Frames & Pictures Pooled
(TASO Figs. 46, 48, 50, 52)
Quality Grade Number - q
Signal to Interference Ratio (R) in Decibels

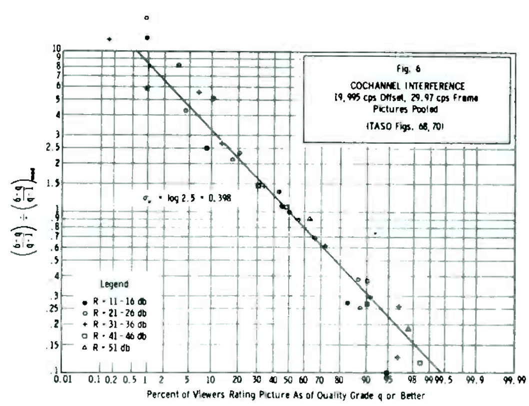
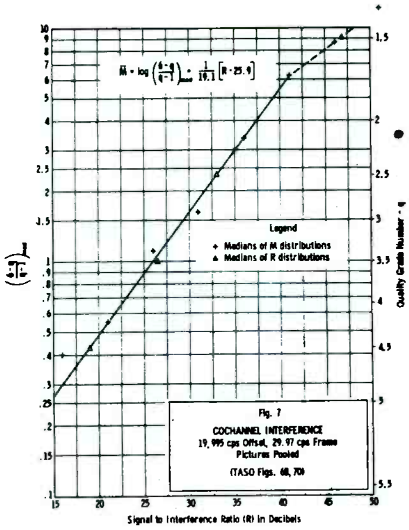


Fig. 6
COCHANNEL INTERFERENCE
19,995 cps Offset, 29.97 cps Frame
Pictures Pooled
(TASO Figs. 68, 70)
Legend
R - 11 - 16 db
R - 21 - 26 db
R - 31 - 36 db
R - 41 - 46 db
R - 51 db
Percent of Viewers Rating Picture As of Quality Grade q or Better


Legend
Medians of M distributions
Medians of R distributions
Fig. 7
COCHANNEL INTERFERENCE
19,995 cps Offset, 29.97 cps Frame
Pictures Pooled
(TASO Figs. 68, 70)
Signal to Interference Ratio (R) in Decibels
Quality Grade Number - q

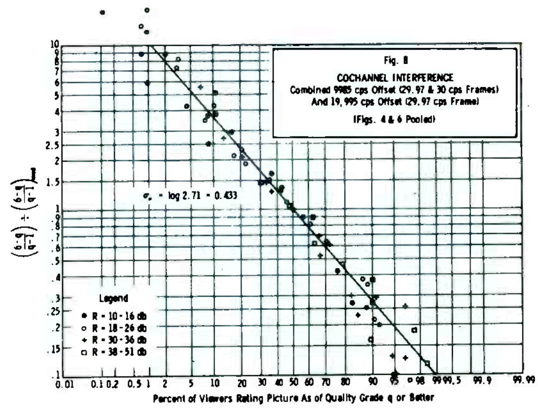
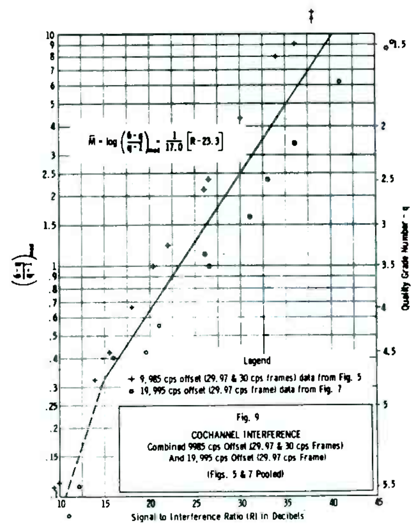


Fig. 8
COCHANNEL INTERFERENCE
Combined 9985 cps Offset (29.97 & 30 cps Frames)
And 19,995 cps Offset (29.97 cps Frame)
(Figs. 4 & 6 Pooled)
σ = log 2.71 = 0.433
Legend
R = 10 - 16 db
R = 18 - 26 db
R = 30 - 36 db
R = 38 - 51 db
Percent of Viewers Rating Picture As of Quality Grade q or Better


Legend
9,985 cps offset (29.97 & 30 cps frames) data from Fig. 5
19,995 cps offset (29.97 cps frame) data from Fig. 7
Fig. 9
COCHANNEL INTERFERENCE
Combined 9985 cps Offset (29.97 & 30 cps Frames)
And 19,995 cps Offset (29.97 cps Frame)
(Figs. 5 & 7 Pooled)
Signal to Interference Ratio (R) in Decibels
Quality Grade Number - q

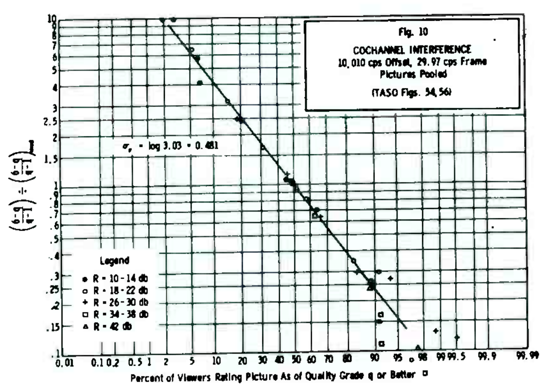
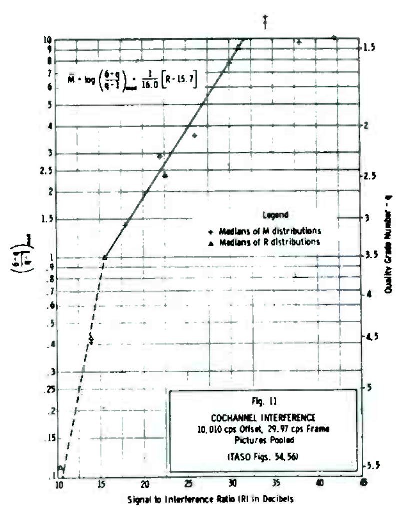


Fig. 10
COCHANNEL INTERFERENCE
10,010 cps Offset, 29.97 cps Frame
Pictures Pooled
(TASO Figs. 54, 56)
σ = log 3.03 = 0.481
Legend
R = 10 - 14 db
R = 18 - 22 db
R = 26 - 30 db
R = 34 - 38 db
R = 42 db
Percent of Viewers Rating Picture As of Quality Grade q or Better


Legend
Medians of M distributions
Medians of R distributions
Fig. 11
COCHANNEL INTERFERENCE
10,010 cps Offset, 29.97 cps Frame
Pictures Pooled
(TASO Figs. 54, 56)
Signal to Interference Ratio (R) in Decibels
Quality Grade Number - q

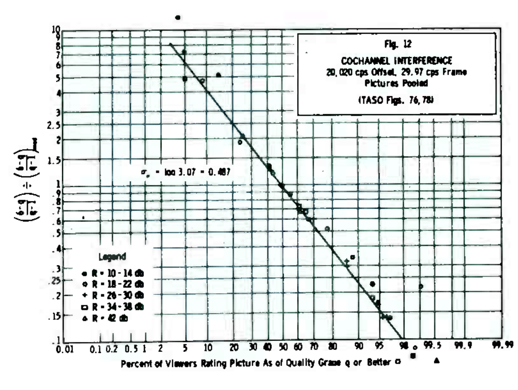


Fig. 12
COCHANNEL INTERFERENCE
20,020 cps Offset, 29.97 cps Frame
Pictures Pooled
(TASO Figs. 76, 78)
σ = log 3.07 = 0.487
Legend
R = 10 - 14 db
R = 18 - 22 db
R = 26 - 30 db
R = 34 - 38 db
R = 42 db
Percent of Viewers Rating Picture As of Quality Grade q or Better

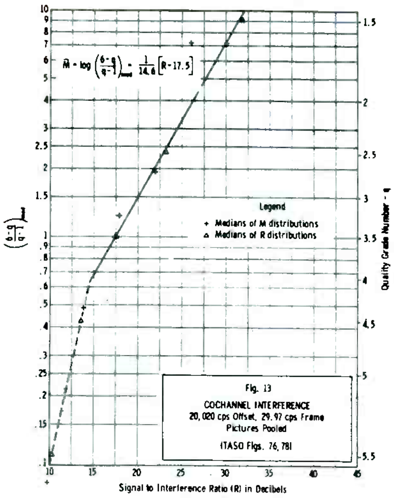


Fig. 13
COCHANNEL INTERFERENCE
20,020 cps Offset, 29.97 cps Frame
Pictures Pooled
(TASO Figs. 76, 78)

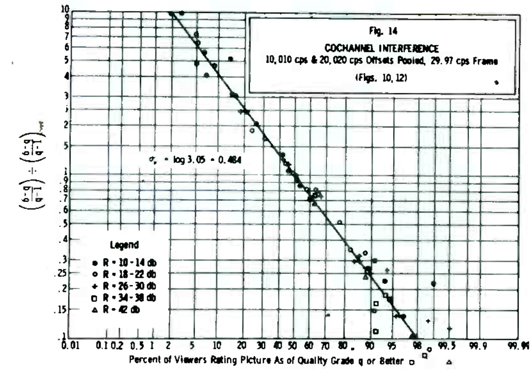


Fig. 14
COCHANNEL INTERFERENCE
10,010 cps & 20,020 cps Offsets Pooled, 29.97 cps Frame
(Figs. 10, 12)

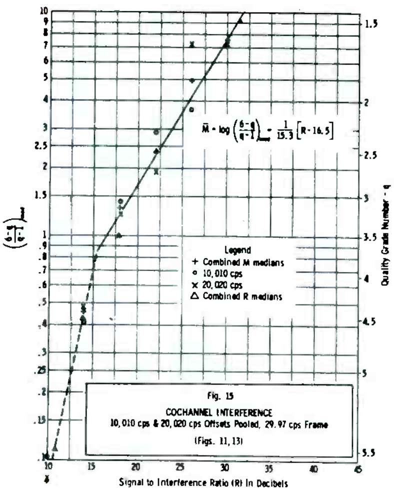


Fig. 15
COCHANNEL INTERFERENCE
10,010 cps & 20,020 cps Offsets Pooled, 29.97 cps Frame
(Figs. 11, 13)

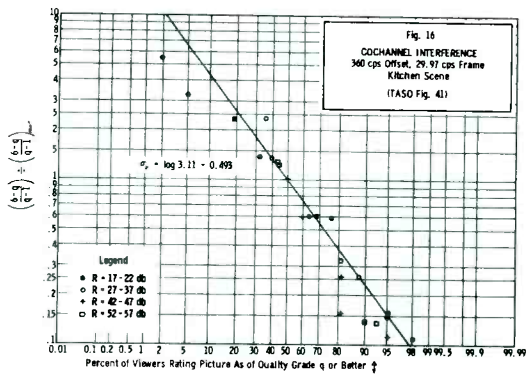


Fig. 16
COCHANNEL INTERFERENCE
360 cps Offset, 29.97 cps Frame
Kitchen Scene
(TASO Fig. 41)

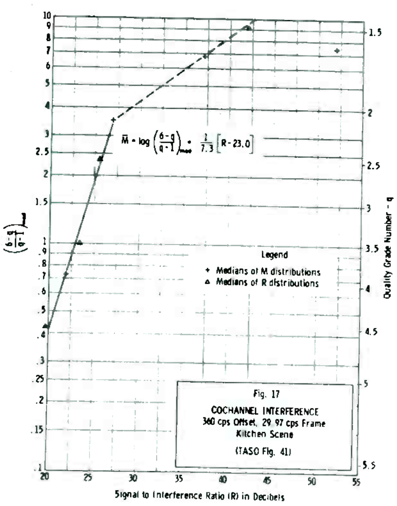


Fig. 17
COCHANNEL INTERFERENCE
360 cps Offset, 29.97 cps Frame
Kitchen Scene
(TASO Fig. 41)

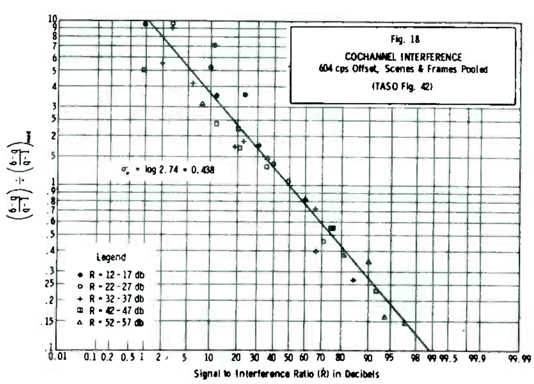


Fig. 18
COCHANNEL INTERFERENCE
604 cps Offset, Scenes & Frames Pooled
(TASO Fig. 42)

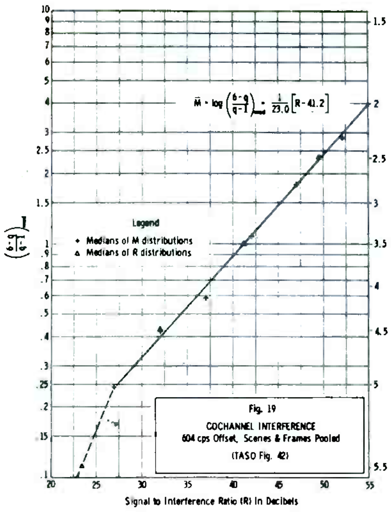


Fig. 19
COCHANNEL INTERFERENCE
604 cps Offset, Scenes & Frames Pooled
(TASO Fig. 42)

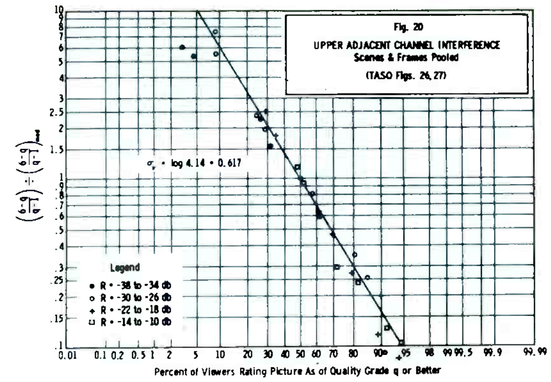


Fig. 20
UPPER ADJACENT CHANNEL INTERFERENCE
Scenes & Frames Pooled
(TASO Figs. 26, 27)

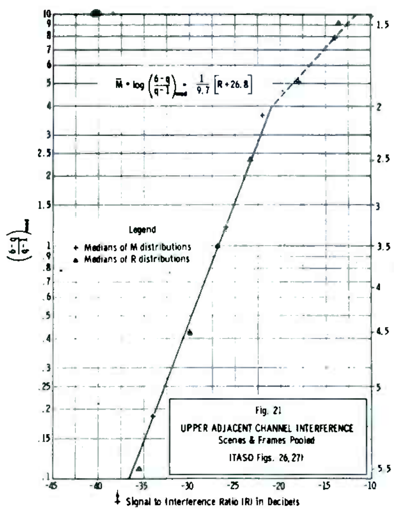


Fig. 21
UPPER ADJACENT CHANNEL INTERFERENCE
Scenes & Frames Pooled
(TASO Figs. 26, 27)

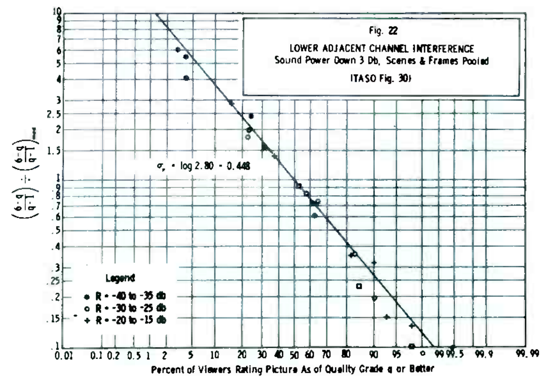


Fig. 22
LOWER ADJACENT CHANNEL INTERFERENCE
Sound Power Down 3 Db, Scenes & Frames Pooled
(TASO Fig. 30)

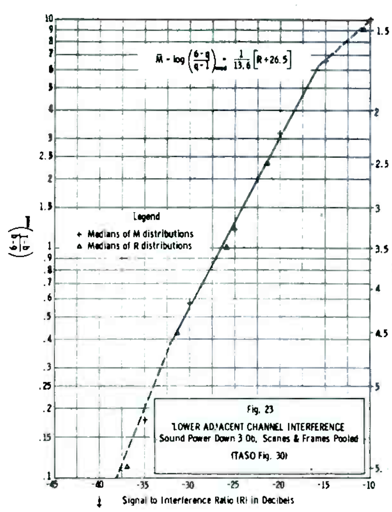


Fig. 23
LOWER ADJACENT CHANNEL INTERFERENCE
Sound Power Down 3 Db, Scenes & Frames Pooled
(TASO Fig. 30)

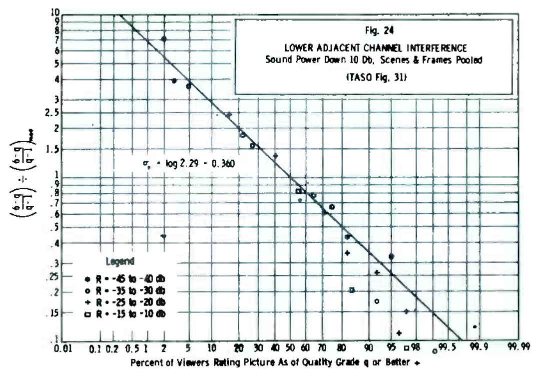
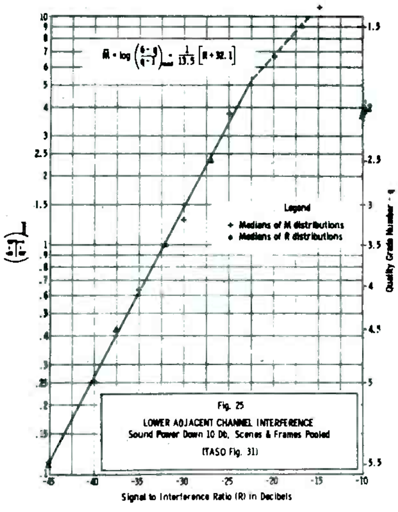
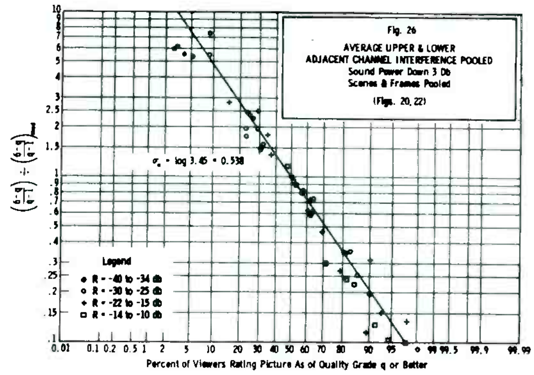
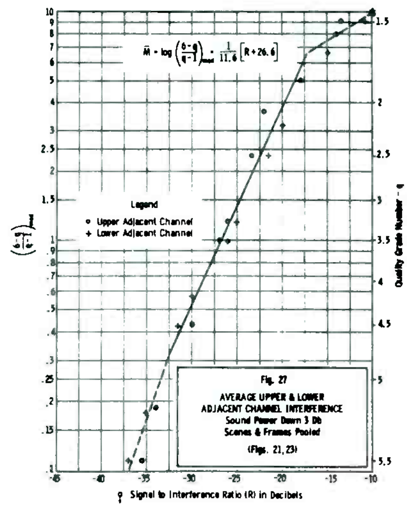
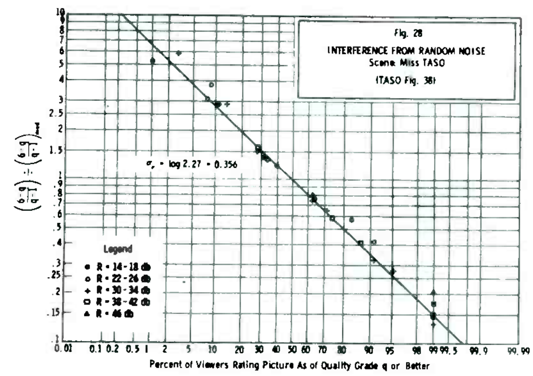


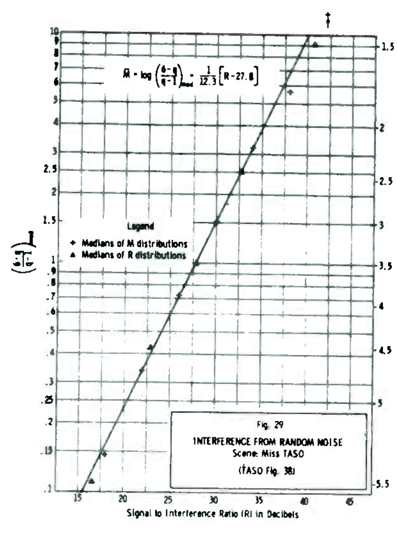
Fig. 24
LOWER ADJACENT CHANNEL INTERFERENCE
Sound Power Down 10 Db, Scenes & Frames Pooled
(TASO Fig. 31)

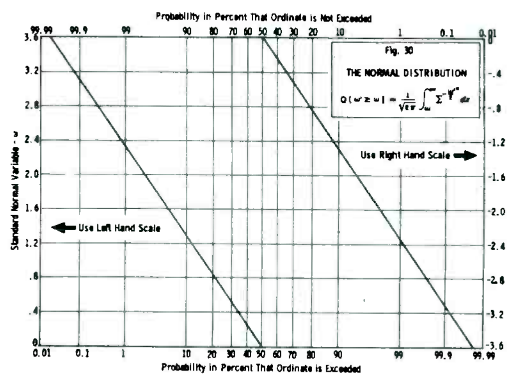












Acknowledgement

The drafting in this Report was done by Mr. Braxton Peele of the Federal Communications Commission.

TELEVISION PROGRAM AUTOMATION

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There is a mushrooming revolution under way in general industry, caused by the advent of computers and data processing. This may now seem remote to you like thunder over the horizon. However, within the next few years this revolution will directly affect the technical department of every major TV operation. The alert chief engineer should prepare his technical domain to utilize the advantages to be gained by so-called "automation" and more importantly to prepare the way for the possibility and use of systems which will likely effect far greater savings and increased efficiency in other station departments than the technical one which he supervises.

The automation of showing on the air material is the next big step in most important TV centers. Properly approached it will act as the catalyst in improving the work-flow and integration of all departments for greater efficiency to result in greater profits from gross revenues. The chief engineer is the lead-off man in this new phase of telecast station operation. It will be essential that the chief engineer prepare not only technical facilities planning but also prepare himself in understanding the field of automation in order that he can consult and advise management and other department heads in the consideration of automation systems for the station.

To state this in another way, automation is coming; all departments of TV station operation will be affected; the chief engineer will be the key man in advising management as to how to reap the benefits which are possible, as the most important phase of any automation system is its practical application.

How far should the station go in automation is a common question, nowadays. Should we plan for a station break only or for a machine capable of handling all day programming? Should we use the computer approach or special purpose equipment? Actually, the ultimate consideration of how far a station goes into automation is not really directly concerned with the equipment selected for the initial operation. The real question is how far and how fast the automation system will spread throughout the entire station, from its initial beginning in the technical department. Eventually in most major operations it will extend from the programming and sales departments through the on-air operation to the actual billing and accounting functions.

From the previous papers given at this session (Tenth Annual Broadcast Symposium, September 23-24, 1960), and in other sessions, similar to this, you can see the variety of approaches to the automation system. At Visual we have worked to provide the hardware and building blocks from which almost any type system may be devised. In order to help convey how a typical system works we have set up a demonstrator equipment. (Shown at Symposium)

Now, let's take a look at the automation picture. The beginning of the on-air portion of the automation operation is the program log which in effect is the prescribed schedule of events to be put on the air. A look at the log gives us the key to the important facts concerning each event or series of events to be automatically put on the air as scheduled. We specify the picture source and the audio source and either its time of duration or the actual clock time at which it is to begin, or provide a feed back system for switching to the next event once the current event has been completed. From a look at this log, you can see that the important information concerned with the station break at seven o'clock are those items which are circled.

In considering our automation storage capacity in which we must store this information to effect automatic handling, we find it most convenient to divide this into two sections. First, an active storage section which is located in the master control to (a) provide storage and read-out of the next series of upcoming events, (b) contain all the necessary circuitry for automatic pre-rolls of projectors, video-tapes, etc., (c) automatic picture preview, etc. Second, is the prestorage which will have far greater storage capacity for handling the entire day's operation and possibly many other related functions. The active storage is so designed that it accepts a serial input rather than parallel input, meaning that it can be fed from a prestorage of punched tape, punched cards, magnetic tape, computer, or whatever other device might be usable for storage.

Simplest and most direct, as well as least expensive, prestorage is punched paper tape. To demonstrate the utilization of this, we may consider that the traffic department will be provided with a Friden flexowriter and the master control operator with a local control room punch as well as one or more control room readers for feeding prestored information into the active storage.

The punch paper tape prestorage is accomplished at the same time as the typing of the program log by using a Friden flexowriter. This unit is in effect an electric typewriter with a built-in tape punch and tape reader. At the original typing of the log the tape punch will record its typing on the tape in the form of various codes. When this punched tape is placed in the tape reader and the flexowriter operated in the reproduce mode it will type out the log as many times as required at approximately 100 words per minute. Normally the log would be typed completely, then checked for errors requiring correction. The tape prepared from the first typing of the log would be placed in the flexowriter reader and the traffic operator would allow them to retype the log up to a point approaching an error or correction. The operator would then stop the automatic typing, type in the correction, or addition, manually advance the tape reader beyond the correction, and allow it again to continue to type the log until the next correction or addition is approached. In this fashion corrected tape can be prepared quickly which will then automatically wipe out the program log. Once a tape has been corrected the log will be typed automatically and perfectly as many times as required. It can be used for making stencil masters for distributing the log.

We use another feature of the flexowriter to punch out a select tape which will contain only the bracketed information from the log for on the air operation of the automation system. Thus from the typing of the log we prestore all the information for the day's automation switching. Only the important information which has been bracketed on the log is used. All hands at the station have a copy of the complete log showing bracketed and unbracketed information which provides the most perfect read-out of prestored material that can be devised. The same information stored is available for all hands in convenient read-out form by simply reading through a copy of the log rather than having to dial up an address code from a control position.

The paper tape used is an 8 channel tape which is so coded that it is directly translatable into IBM card systems, Remington Rand, National Cash Register, or other data processing systems. We consider this to be a most satisfactory system for handling prestorage of on the air operation. Depending on the station's requirements in certain cases an IBM tab card prestorage may prove more easy to integrate into the sales and accounting departments. In any case, by using the 8 channel tape there is complete intercorrelation between the information on the tape and any card system which may be used.

This method of prestorage has other great advantages. If a change comes through after the final log has been prepared, it is easy to prepare a corrected log page printing out the unchanged information automatically at one hundred words a minute and then entering the correction as fast as it can be typed. By cutting the tape in this fashion and running off a new corrected log page from the tape cut, there is positive proof of all stored information on the correction tape which is available to all hands at the station in the form of this corrected log. The correction tape would go to master control for operation there as described later.

Summary -- Automation of TV station operations is going to be essential for stations to keep competitive and to produce the efficiency required to maintain proper earnings from gross revenues. The Chief Engineer is going to be the key man in automation planning due to the fact that the end result of the automation is his on air operation in the technical department. This automation of the on air operation will be found to act as the catalyst which will affect work flow--department to department throughout the organization. When properly organized the information handling and scheduling in the Sales, Program, Traffic, Technical and Accounting Departments will be integrated to provide over-all efficiencies far exceeding those which may be immediately expected in the technical area. Consider the automation system units as (a) the active storage display located in the technical department which can be operated manually, or by simple control room tape punch and reader and (b) separately the large capacity prestorage facility. Plan that any unit installed should allow for gradual growth and change of systems in the station's other departments. It is essential, therefore, that the on air automation system have the capability of being integrated with all data processing systems, which over the next decade will be the order of the day for all businesses of any size.

AUTOMATION PROGRAM LOG

True Time	Description	DURATION (Sec.)	VIDEO	AUDIO
--	Live Show	96	LA	0
6:57:50	Live Show - Commercial Film	30	P2	0
6:58:20	" " Live Close	30	LA	0
6:58:50	" " Closing Credit Slide #1	05	S1	3
6:58:55	" " " " " #2	03	S1	3
6:58:58	" " " " " #3	01	S1	3
6:58:59	" " " " " #4	01	S1	3
6:59:00	" " " " " #5	01	S1	3
6:59:01	" " " " " #6	02	S1	3
6:59:03	" " " " " #7	05	S1	1
6:59:08	" " " " " #8	02	S1	1
6:59:10	" " Closing Film	18	P2	1
6:59:28	" " Promo Slide	96	S2	1
6:59:30	Station Break - 1st Commercial Film	14	P1	0
6:59:44	" " " " Slide #1	04	S2	1
6:59:48	" " " " " #2	04	S2	1
6:59:52	" " 2nd " Tape	20	V1	0
7:00:12	" " Identification Slide	05	S1	1
7:00:17	Feature Film Show - Intro Film	05	P2	0
7:00:22	" " " " Slide #1	05	S2	4
7:00:27	" " " " " #2	05	S2	7
7:00:32	" " " " " #3	03	S2	7
7:00:35	Feature Film	(96)	P1	P

LA	Studio A	
P1	Film Projector	#1
P2	" "	#2
S1	Slide "	#1
S2	" "	#2
V1	Videotape	#1

In audio column, "0" designates audio follows video. In duration column, (96) is code to stop timer and await manual, film cue, or true time start.

Errata and Letters to the Editor

Re: Vol. BC-6, September 1960, Number 3, page 41 of IRE Transactions on Broadcasting

Dear Sirs,

You were so kind as to include our article

Stereophonic Broadcasting
Using Pulse-Amplitude Modulation
by H. F. Mayer and F. Bath

in the IRE-Transactions. Thanks for making our article accessible to the readers in the USA who are interested in the subject. The reprints sent to us are also very welcome.

Incidentally, we would like to draw your attention to a few printing errors. The Greek letter τ_o is missing on page 42 at the left, line 7; page 46 at the right, lines 19, 20 (twice), line 22 (twice). The letter τ is furthermore missing on page 42 at the left, line 14, and the letter Δ on page 44 at the left, lines 21 and 23.

Siemens & Halske, A. G. (Dr.) Bath
Munchen, Germany

To the Editor:

During the recent PGB Symposium in Washington, I mentioned briefly the article on Stereophonic Broadcasting which appeared in the September PGB Transactions (BC-6, No.3).

In my opinion, certain expressions could be modified to conform with the original meaning. Referring to Figure 5, the word "Geräuschspektrum" should be changed to "Noise spectrum" and the expression "signal/sound" should read "signal/noise". "Spannung" is actually "voltage".

The term "UHF transmitter" is probably derived from the expression "UKW", meaning ultra short waves, a designation used for frequencies above 100 mc; more descriptive would be the word "FM transmitter". Otherwise, the article reads quite well.

I am in favor of including articles from abroad and perhaps we should try to solicit original articles for the transactions rather than reprints.

Serge Bergen

Kear and Kennedy
Washington, D. C.