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TECHNICAL PAPERS
Presented at the

NATIONAL ASSOCIATION OF BROADCASTERS
NAB

Engineering Conference

April 3-6, 1970

ENGINEERING DEPARTMENT
NATIONAL ASSOCIATION OF BROADCASTERS
WASHINGTON, D. C.

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Opening of the Conference

Vincent T. Wasilewski, President
National Association of Broadcasters

As some of you may know, a Teamster's strike was scheduled to begin last Wednesday, and had it occurred at that time, those equipment exhibits would have been decimated. That would have been a tragedy because this greatest collection of broadcast equipment assembled in one place each year makes a great contribution to the convention.

I know that all of us would have been very disappointed had it been disrupted or diminished, and, fortunately, it is in place, shining, flashing in all of its impressive glory.

Now, I would like to take this moment to make a special award. As I indicated in my speech earlier today, too often broadcasters' good deeds and achievements really go unnoticed and unrewarded. We felt that a group of your fellow broadcasters scattered along the coast of the Gulf of Mexico deserved special recognition from NAB and their fellow broadcasters for actions which went beyond mere duty and were, in fact, heroic.

So, I would like to present an award on your behalf to the Gulf Coast broadcasters, and I would like to ask the gentleman from whom you will be hearing later in this program, Mr. Ray Butterfield, General Manager of Station WLOX, Biloxi, Mississippi, to come forward and join me here and accept this citation.

Ray, will you please join me.

You know, on August 17, Camille, the most devastating hurricane in history, struck the Gulf Coast of the United States. Its fury wrought havoc in the entire area between New Orleans and Mobile with its full slamming death at the Mississippi and Gulf Coast.

Its savage intensity carried ruin and death northward through Jackson, Mississippi and Memphis, Tennessee before veering eastward. Never before had a storm caused such tragedy, and never before had broadcasters performed a greater service.

Broadcasters rose to the occasion. As the waters of the Gulf rose in advance of that storm, and as the storm's direction became more fully known, broadcasters, working in harmony with the Weather Bureau, aired hurricane warnings and predicted the path and the fury of Camille.

There were winds of two hundred miles an hour. Thousands of tornadoes occurred on the fringes of the hurricane eye. Flash tidal waves of thirty feet rolled in, and the area directly hit was totally isolated. Only could citizens know what was happening by transistor radios.

We cannot mention all of the contributions, and I single out these individual efforts only to illustrate the contributions of many.

Broadcasters in the area directly hit between Picayune and Pascagoula, Mississippi stayed on the air up until the tidal waves physically washed away their studios. Their towers buckled, their buildings caved in, and their power blacked out, and during this time, the stations at New Orleans and Mobile continued to funnel information into the stricken area as it was authenticated and released through Civil Defense and disaster sources.

Many, many examples of real heroism occurred. Ten feet of sandbag buffer protected television cameras as they looked into the eye of the storm with waves washing at the feet of the cameramen.

Two engineers jumped from a low hovering helicopter into a lake to swim to a transmitter building.

One broadcaster's car was sliced in half by his own tower as it fell. He remained inside directing the station's last gasp operations, and when the skies finally cleared, broadcasters throughout the area rushed to the aid of the area.

Equipment, personnel, sync generators and turntables, all kinds of paraphernalia were rushed to the area, enabling the stations still able to begin to resume broadcasting.

Most stations, also, converted to full time public service and news operations and assisted greatly in disseminating official information to the stricken families in the area and instructing disaster workers.

Other broadcasters outside of the immediate area at once began collecting transistor radios which were trucked in from throughout the state. RAB and NAB assisted in notifying broadcasters throughout the country of this need, and the response, as I understand it, was overwhelming.

President Nixon singled out broadcasting for special praise. The performance of broadcasting was, indeed, a monumental service in the wake of a monumental disaster, and it was service beyond the call of duty in broadcasting's highest tradition, and I am proud to present this tribute to Gulf Coast broadcasters from other broadcasters throughout their land, and I will read it.

It is a citation of recognition to the broadcasters of the Gulf Coast for their outstanding service at a time of great tragedy to the citizens of their states for their operation of the emergency broadcast system during hurricane Camille at the risk of their lives.

These dedicated broadcasters served the public by sounding the alarm, broadcasting emergency messages, and they helped to bring order out of chaos.

This citation is presented with admiration and respect from the members of the National Association of Broadcasters, and there it is so all of you can see.

MR. RAYMOND BUTTERFIELD: If I can say just one word at this time, I would say that every broadcaster in the United States, in my opinion, would have done exactly what the broadcasters in the Mississippi Gulf Coast did. We realized that our license is to serve the interests and the needs of our community, and I think every broadcaster in the entire United States would have come through, would have performed the service at a time when their people and their community needed their help.

On behalf of the Mississippi Gulf Coast broadcasters, Vince, may I say thank you to the National Association of Broadcasters. We appreciate very much this presentation.

MR. WASILEWSKI: Ray, I am sure that I would share those sentiments that you expressed. I think broadcasters are a unique group of people that not only help their fellow citizens, they help one another. It is a great group to be associated with.

I know our Vice President of Engineering, George Bartlett and your Engineering Conference Committee has planned for you, as they always do, a stimulating and productive time here in Chicago, and I hope that you will all find it rewarding and that you enjoy it as well, and you will be happy you came.

NAB Engineering Advisory Committee Report

Albert H. Chismark
(Chairman, NAB Engineering Advisory Committee)
Director of Engineering, Meredith Corporation

It seems only a few short days ago, that we were assembled in Washington, D.C., to hear the traditional Engineering Advisory Committee report; but, as we all know so well, those few days keep racing past and, before too long, the year has passed. Never-the less, as chairman of the 1970 Engineering Advisory Committee, I am indeed pleased to bring you this status report on the Committee's activities during the past year.

This report will, as usual, be brief — just a review of the highlights of the more important aspects of our work and accomplishments over the past 12 months. First, I would like to express my appreciation for the assistance which has been given me by members of the committee, a group of dedicated engineers working quietly and efficiently behind the scenes, acting as your liaison to the NAB, the industry, the FCC and other governmental agencies. Those serving on the committee this year are: Bob Flanders, station WFBM; Gene Hill, Kaiser Broadcasting Corporation; Bill Honeycutt, station KRLD; Les Learned, Mutual Broadcasting System; Jim Parker, CBS Television Network; Verne Pointer, American Broadcasting Company; Keith Townsdin, station KAYS; Bill Trevarthen, National Broadcasting Company; Ben Wolfe, Post-Newsweek Stations and Bob Leach, U. S. Communications.

The past year has been another very busy period for the Advisory Committee; a year in which many problems were discussed, evaluated, and, in some instances, even resolved. Subjects ranged from microphone to antenna, camera to receiver, seminars to allocations. As you can imagine, we did not find solutions to all the problems, but we certainly gave it a good try.

As past chairmen have reported on numerous occasions we are still wrestling with the problem of VHF-TV remote control. After supplying the Commission with untold reports, and a further multiplex test last November, we are still awaiting an affirmative decision. We had every hope that this proceeding would be finalized prior to convention time and tentatively scheduled a VHF-TV remote control workshop session which had to be scrubbed at the last minute. Nevertheless, we are hopeful that we will have a decision from the Commission shortly.

While on old business, we are still involved in a bitter struggle with the Land Mobile people in the matter of either sharing or the reallocation of TV channels 14-20 with the Land Mobile Services. The Commission held an oral argument in this proceeding in January, at which time the NAB testified against such proposals. During the last month, the Commission devoted much time to this subject on its weekly agenda. In spite of recent developments, the battle is not yet won. Needless to say, the Engineering Advisory Committee continues to follow this matter very closely to assure one and all that any final determination will be based upon sound engineering concepts.

It is refreshing to note that I can report the finalization and termination of a proceeding in the industry's favor for a change. As you know, we have been participating in the Commission's proposal to authorize remote control return metering information to be transmitted on the AM carrier to the remote control point through a system of subaudible tones. We worked long and hard in this proceeding, which incidentally was opposed by the Electronic Industries Association (EIA), on the grounds that potential interference would result to AM reception. After many months of field tests conducted at stations in Dallas, Fort Worth, Santa Barbara, Washington, D.C., and other strategic locations, we once and for all proved that no interference would exist when utilizing subaudible tones for return metering information. Happily, the Commission was convinced and, on December 8th, amended the rules to permit such usage. We think this is an important step forward since it now completely frees the AM facilities from reliance on the common-carrier for interconnecting facilities between the AM studio and transmitter.

A petition which we filed on January 20, 1967, requesting a relaxation of the so-called "two-hour" inspection requirement and the remote logging of phase, still rests on a Commission doorstop. Comments in this proceeding were due April 17, 1969, just about a year ago today.

I think the most important proceeding in which the Engineering Advisory Committee has participated during the last decade is one dealing with the relaxation of operator requirements of aural broadcast stations. I'm sure you are all aware that after struggling with this problem for years, the NAB, last month, filed for such operator relaxation at AM and FM broadcast stations. This was a far-reaching proposal based upon several years of study by a special committee, chaired by Mr. Ben Wolfe, assisted by an excellent cross-section of industry engineers. The petition has requested that the relaxation of the operators requirements be extended across the board to all AM and FM stations. The specific proposals are as follows:

1. Non-directional Stations: Non-directional stations utilizing powers up to and including 50 kw shall employ one first-class radiotelephone license holder either full time, on-call, or on a contractual basis. All other personnel responsible for the routine operation of the transmitting facility shall hold a third-class radiotelephone license with broadcast endorsement.

2. Directional Stations: Directional stations utilizing power up to and including 50 kw shall employ one first-class radiotelephone license holder on a full time basis. All other personnel responsible for the routine operation of the transmitting facility shall hold a third-class radio-telephone license with broadcast endorsement.

3. FM Broadcast Stations: FM broadcast stations utilizing transmitter powers up to and including 50 kw shall employ one first-class radiotelephone license holder either full time, on-call, or on a contractual basis. All other personnel responsible for the routine operation of the transmitting facility shall hold a third-class radiotelephone license with broadcast endorsement.

As of this date, the Commission has not designated this proposal for Rule Making, but I strongly suggest that you follow this action very closely, since its outcome may have far-reaching ramifications.

For years, we have been talking about revising the Commission's Rules and Regulations in one fell swoop. Such a project is easier said than done; but, to get things rolling in this area, we have now embarked upon the revision of Part 74, dealing with auxiliary broadcasting services. These rules, as you know, pertain to radio remote pickup, studio-to-transmitter links, TV STL, remote pickup and intercity relays. It goes without saying that this portion of the Rules is woefully out-of-date and in need of revision. We have had a special group of some 250 station engineers review this portion of the rules and recommend changes. A special meeting of the Engineering Advisory Committee was held April 5 to review a preliminary draft revision of the rules. All going well, we should submit to the Commission, within the next 90 days, a complete suggested revision of the pertinent parts of the Broadcast Auxiliary Service rules as they affect our day-to-day operation. This is the first step in a long-range project to develop meaningful changes on a large scale basis rather than through the time-consuming piecemeal process we have been following in the past.

Another very interesting problem we have been confronted with during the past few months, is the icing of tall towers, not only the antenna, but the tower as well. The hazards involved in falling ice from supporting structures is one which has confronted the industry for many years. Many studies and investigations have been conducted in the past, but to no avail. This problem has now been brought to the attention of the Advisory Committee and, at our last meeting in January, a special subcommittee was appointed to once again investigate the problem looking toward the development, if possible, of ways to minimize the hazards involved. This is not something that will be resolved overnight and, I'm sure, you will be hearing more about it in the coming months.

Again, another highly successful Engineering Management Seminar was held during 1969 at Purdue University with 55 broadcasters participating from all sections of the United States and Canada. Due to the unprecedented demand for such programs, we have scheduled another Engineering Management Seminar to be held at Purdue in December of this year. We strongly recommend that any of you who have not attended one of the past programs, make every effort to attend the 1970 course.

For the first time in the Association's history, the NAB sponsored a Technical Seminar which was structured over a two-day period and held during October, 1969. The program dealt with the design, operation and maintenance of directional antennas and was under the direction of Carl Smith and Associates. The course was so popular that a second such seminar was held during February 1970. The response for this type of technical program has been so gratifying that additional seminars on such subjects as stereophonic broadcasting, UHF-TV, video tape and others will follow.

The revision of the NAB Engineering Handbook is progressing slowly. Although we have fallen considerably behind on our publication schedule, we are still optimistic that this project will be completed during 1970.

Color compatibility has been a subject of discussion for the past year or so. As you all know, we are cooperating with the SMPTE, IEEE, and EIA in this project and progress is being made in solving this very complex problem. You will be hearing more on this subject from Mr. Blair Benson at the television session which will be held in the Great Hall of this Hotel (Hilton).

These are but a few of the more important matters the Committee has dealt with since we last met. They have been reviewed for your information and to remind you that the Engineering Advisory Committee is your committee. It was established not only to advise the staff and the NAB Board of Directors in technical matters, but also to make your thoughts known to the industry and Commission.

If you have a technical problem which may affect the industry as a whole, make it known to your Engineering Advisory Committee. Let us hear from you. It is only through such feedback that we are able to properly and adequately represent you.

Again, on behalf of myself and the other Committee members, I would like to say it has been a privilege to serve as your spokesman on this important Committee. We hope that our past efforts have met with your approval.

Where Do We Go From Here?

Benjamin Wolfe
Post-Newsweek Stations

It is rather easy to discuss the past because, generally, we all know where we have been and most of us know what we accomplished. Discussing the present and future trends in broadcasting is not so easy; for the lense is not always in focus. So one who attempts a paper like this does so at his own peril, and with that disclaimer I will proceed.

Years are usually required to refine any basic invention before widespread introduction is accomplished. Broadcasting, by its very nature, has always been in a hurry. We are already using equipment before the standards of good maintenance are set. For example, many stations employ integrated circuitry and micro-miniaturization but have no test equipment to maintain these boards. We are concerned with automation which uses logic 1 and logic 0, while many of our people have not probed this technology. Future advances in broadcasting are expected to become more and more sophisticated.

Within the next ten years the vacuum tube will disappear from standard broadcast equipment. They have already disappeared from AM studio equipment; they are being replaced by transistors and integrated circuitry in TV studio equipment, and our newest television transmitters use only 10 tubes. By 1980 the high-powered transmitter may have no tubes. New techniques will make use of micro-modular construction and an entire module will be replaced when an outage occurs. All transmitters will be automated and remote controlled.

In AM, the industry can look forward to a uniform standard of cartridge tape recordings for foolproof interchangeability. In TV, automated systems will be used for control of motion picture projectors, slide projectors, video tape, the network and the control of video, as well as studio lighting. For our radio stations there will be a speech synthesizer. This will take the printed word from our news ticker and transform the words instantaneously into real professionally quality speech, and another machine at the radio station would translate the speech symbols back to actual speech which would be aired instantaneously. While this may sound a bit far-fetched, I would remind you that a music synthesizer has already been tried experimentally.

In television our color cameras will be one-tube affairs with much more complex circuitry but easier to align. Video tape will most certainly undergo a revolutionary change and, depending on what progress electronic video recording on film makes, video recording and playback may change completely. All of this will make use of even more complex circuitry and consequently more highly trained technical personnel.

Returning for a moment to Playback Broadcast Electronic Film Video Record, this method, if perfected, could be extremely useful in the playback of commercials. This, of course, depends on the ratio of advertisers' spots on film vs advertisers' spots on tape. I have not heard that the recording portion of the electronic film recorder will be available to individual stations. This, consequently, for the time being, reduces the usefulness of the playback device accordingly.

The technical end of our industry is one of obsolescence, brought about by the creative inventiveness of the motivated technician and engineer. For almost 40 years I have seen ideas and creative thinking change the technology almost every five years. In that brief span, no industry, not even the automobile industry, has forged ahead technically like the electronic industry. While I speak of technical change I would be remiss in not saying that each major technical change causes a business change. Look what the video tape machine did!!

Thus management changes his modus operandi as we change the technology, and in these fast moving days both the manufacturing engineer and the broadcast engineer have indeed a deep responsibility. For instance, in 1939 would any of us have thought tiny transistors would be used to remotely control 50,000-watt (or more) transmitters? Of course not! We would not have even anticipated the transistor. But in those days the technology was slower. Today, technology changes so rapidly that the other day I was stopped by a device called the Magnistor. This can be a magnetically-controlled transistor—self contained—and will pass audio or video, and DC-energized coils can be used to turn it off or on. The inventor claims many other uses in the magnetic sensing field.

Daily, communications engineers are studying the frequency spectrum with an eye towards greater channel capacity. There is considerable talk about satellite transmission to homes in the next ten years or so. Actually, some of the engineers believe that since we now have boosters on hand and some technical problems are being resolved, it is becoming less difficult to get 10 kw or more transmitter power up there to orbit some 22,300 miles above the equator. The thought occurs that with enough power, why not direct satellite-to-home broadcasting. This is, or course, a distinct possibility, but while high-power transmission with only a few channels is universal broadcasting, it may not be economically satisfactory. To satisfy the economics it may be that more channel space is desirable to provide many different video sources. However, it is not so easy to reduce the required video channel width from MHz to kHz and back to MHz for home receiver use.

If this increase in channel space was achieved, it would benefit the entire frequency spectrum and in all probability would be used for satellite transmission as well. Thus, the satellite could transmit many programs simultaneously instead of a few. To receive this sort of a signal would require conversion equipment which would be complex and costly, and thus for many years it would be possible only over <u>a local TV broadcasting station which</u> could air immediately or tape many of the desirable international television shows for delayed broadcasting. This type of transmission would also be possible over CATV systems. The conversion machinery I spoke of would be necessary to transmit to the home a conventional wideband signal converted from a narrow-band channel.

Before the Satellite is put to its ultimate use, the political problems which beset space technology must be digested, but this is not the purpose of my talk. The thought occurs, of course, that TV receiver system specifications could be changed to accommodate narrow-band transmission directly, whether from the local broadcasting station or from a satellite. I do not think that this will happen.

There are millions of television receivers in use today, and it is not really thinkable that millions of people would be asked to discard their monochrome or color VHF-UHF television receivers or to modify at their expense to accommodate any channel space improvement. In fact, the history of the broadcasting industry has been that <u>no changes</u> have been made in receiver specifications for TV once set, and to further substantiate this, most of you remember that the Government specification for color was that it must be received on a black-and-white receiver without discernible degradation.

Now, to technical personnel; what kind are we looking for to handle our communications machinery? When I talk to technicians, supervisors and engineers, I find that the great majority of them are well trained in one area. Our stations use a diversification of equipment which make some much more publicized government installations rather basic compared to our sophisticated use. The technician and engineer of the future must be well-rounded and truly trained in the broadest sense of fundamental electronics. I am convinced that in order to achieve the proper evolution of our expanding technology in a worthwhile sense, better and more communication is required between the manufacturing engineer and the broadcast engineer.

In addition, our management engineers must begin to take a course in digital circuitry, for soon digital circuitry will be commonplace in broadcasting. As a matter of fact, until recently digital circuits have not really had exposure in the broadcasting station; however, modern advances in techniques and processes have resulted in equipment employing digital circuits that are providing not only added functional capability but increased reliability. Digital circuits materially fill the requirements for various types of signaling circuits, frequency monitors, modulation monitors, parameter monitors and control circuits of many descriptions for both radio and television. The broadcast engineer must become familiar with these digital circuits so he can utilize the advantages they offer.

Finally, I look forward to a close collaboration between engineers and management in dealing with the present and future technical problems which beset our industry. In fact, it was this type of collaboration which helped build our industry.

A Look at The John Hancock Broadcasting Facilities

MODERATOR: L. A. Pierce
Chairman
Chicago Broadcasters Antenna Committee

PANELISTS: Charles W. Alton
WSNS-TV

Alexis P. Young
WCFL-TV

William P. Kusack
WFLD-TV

Woodrow R. Crane
WGN-TV

Fred W. Rodey
WMAQ-TV

Orion Arnold
WBBM-TV

MODERATOR PIERCE: Since the NAB was last in Chicago, there has been the addition of five television stations at the top of the Hancock Building, and the sixth one is in the process of construction.

The committee that has been responsible for this construction is called the CBAC, the Chicago Broadcast Antenna Committee. Representatives of the different stations that are involved at the Hancock Center are here with me today and would like to tell you individually about their installations.

I will introduce to you first Mr. Charles Alton, Director of Engineering for WSNS, Channel 44.

MR. ALTON: WSNS is probably the newest station in Chicago. At this moment (April 6) we are approaching twenty-four hours of age; to be exact, twenty-one hours and about seven minutes. WSNS signed on last evening at six o'clock albeit with a slightly disastrous procedure in the first two minutes.

WSNS has a TZP-53-DA antenna operating on top of the east tower, the east stick on the Hancock Building. We are a few feet above WFLD's antenna.

Our transmitter is an Ampex 55 kw; that is, a TA 55 DTD. We have something unique that most transmitters don't have: complete redundancy in the exciter, dual exciters for aural and visual. This is also controllable remotely, a fact that I hadn't mentioned. We are remote control, albeit only from the next room, but we still have it.

Fig. 1 is a view of our Ampex transmitter. In Fig. 2, you see a view of the remote equipment and the colored pipes. This is an idea of the architect. All of the pipes, including the water, plumbing, and the electrical wiring, are color coded for ease of identification for engineers troubleshooting or other maintenance people.

Both of the power supplies are mounted on the rear of the transmitter right next to the windows on a very large tub. This tub is made to distribute the four thousand, some odd pounds of each power supply on the floor of the Hancock Building where we are located.

As you may know, we have an all-news format, and are presently using a temporary studio facility on the top of the Hancock Building.

One advantage of being on the WSNS Engineering Staff is the view from the switcher. Fig. 3 shows the view that the engineer has directly up the Drive north of Chicago.

MODERATOR PIERCE: Next I would like to introduce to you Mr. Alexis Young, Director of Engineering, WCFL-TV, Channel 38.

MR. YOUNG: The Chicago television station owned and operated by the Chicago Federation of Labor and Industrial Union Council is WCFL-TV on Channel 38. Start of operation is planned for early 1971. The transmitter and antenna complex is a product of the RCA Corp. The planned transmitter is a TTU 110A, 110 kw vapor-cooled transmitter. The antenna is a five-bay 15-panel custom designed Vee-Zee directional antenna.

This configuration of transmitter and antenna will permit five megawatt transmission. The antenna, because of its custom design, does not have a particular model number. The pattern of the array was developed through the cooperative efforts of Dr. Frank Kear, of Kear and Kennedy, and the antenna engineering group of RCA.

As shown in Fig. 4, the horizontal pattern of the antenna is a cardioid with a relatively deep indentation to the northeast. The opposing area to the southwest as well as the areas to the south and west are somewhat enhanced, which is desirable and is the general area in which the five megawatt ERP is developed.

In meetings between RCA and Kear and Kennedy, it was determined that the coverage as shown in Fig. 5 could be obtained theoretically. Model tests were then made to determine whether, in fact, the theoretical pattern could be achieved. The RCA antenna design group was commissioned to perform the model tests which proved the validity of the theoretical conclusions.

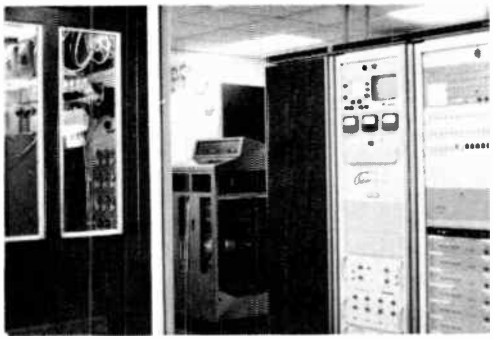
Fig. 1

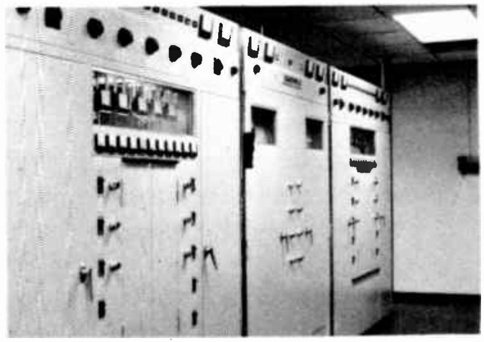
Fig. 2


Fig. 3

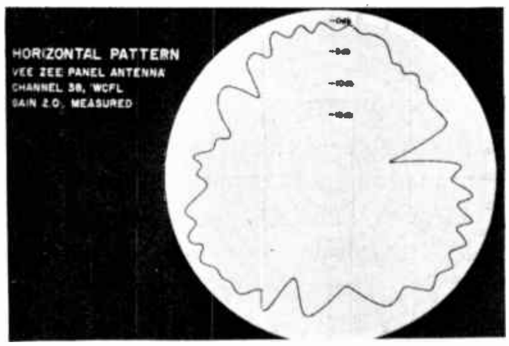

Fig. 4

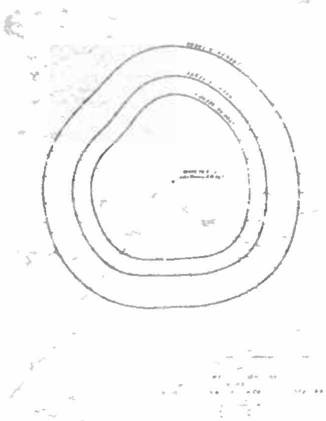
Fig. 5

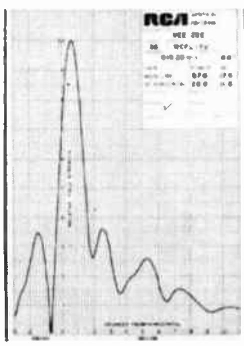

Fig. 6

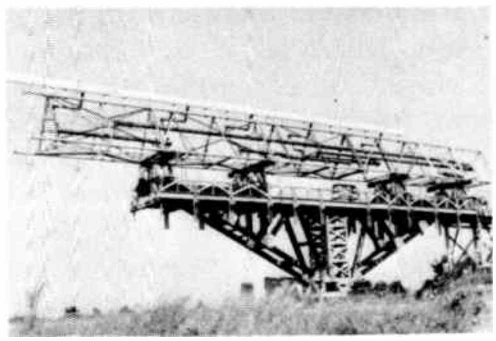
Fig. 7


Fig. 8


Fig. 9

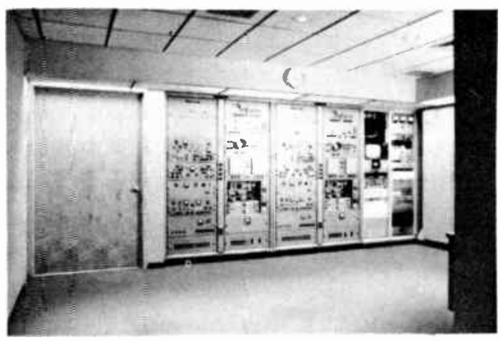
Fig. 10

Vertical pattern measurements were made of a single face of the antenna with results as shown in Fig. 6. The antenna has been developed with 0.625 degree electrical beam tilt. The necessary null fill has been accomplished by appropriate power division within the antenna feed system complex.

For the vertical pattern measurement, a single face of the antenna was mounted on a full-sized tower with the associated transmission line and structural members also assembled within the tower structure. (See Fig. 7.)

The individual panels of the antenna have a power-handling capacity of 25 kw which provides ample protection. The feed system to the individual bay is 6-1/8 inch transmission line, and the feed system within the bay to the individual panel is 3-1/8 inch transmission line. Universal transmission line has been used throughout this installation. A 6-1/8 inch line is used in the main run to the antenna and a combination of 6-1/8 and 8-3/16 inch line will be used in the transmitter room. The antenna is split, with the top bays, 1 and 2, forming the top half, and bays 3, 4, and 5 forming the bottom half of the array. This configuration provides a built-in emergency antenna.

The WCFL-TV antenna is the bottom array in Fig. 8. Using this type of antenna has provided us with the projected optimum coverage in view of the mechanical limitations imposed by a tower of this configuration. The tower in this installation is nine feet on a face. The aperture of the antenna is 67.3 feet, and the directional gain is 57.6.

The antenna is mounted on the West mast of the Hancock Building (Fig. 9) at a height above average terrain of 1250 feet. It is presently anticipated that the transmitter will be shipped in late May and that installation will be completed in August.

As mentioned, air operations are expected to begin early in 1971, and you are certainly welcome to visit the big, empty den I have on the ninety-seventh floor.

MODERATOR PIERCE: Next, I would like to introduce Mr. William P. Kusack, Vice President of Engineering, WFLD-TV, Channel 32.

MR. KUSACK: Well, first of all, I would like to make the comment that we actually moved the transmitter when it was on the air. It was a complete parallel installation, and the transmitter was moved from the nineteenth floor of the Marina Tower location to the ninety-seventh floor of the Hancock Building without losing one second of air time. So, here we go, and I will try to just hit some of the highlights of the installation. That is about all the time we have.

Fig. 10 shows the entrance to the transmitter and shows the two exciters side by side. There is a standby system so that if one goes off, the other goes on.

Fig. 11 is the installation in the transmitter room itself. There are two amplifiers. At the present time, two twenty-five kilowatt amplifiers are paralleled. Not only the video, but also the audio is paralleled. In other words, we have two audio and two video amplifiers.

One thing we do that is really different is that we actually diplex before we power-combine. The reason we do that is to get a certain amount of redundancy in the system. We can afford to lose one diplexer since we have two.

Our power system handles 580 KVA. It is a unitized system, built away from the construction site and put into place. We use the IMAC Flexetron water-cooled external cavity configuration, with all the necessary flow meters and thermometers. Fig. 12 is the back of the cooling system. We are also in the plumbing business. You can see here that the top two cover one particular amplifier. Below, the other amplifier. Recently, we have pumps run in parallel, and the idea is in case of a pump failure or something we can't repair quickly, we can substitute another pump if necessary. There is a three and five-eighths filter in the system. We designed our system, first of all, to handle 110 kilowatts, and we are at the moment operating at half power. Our ERP is two and one-half megawatts.

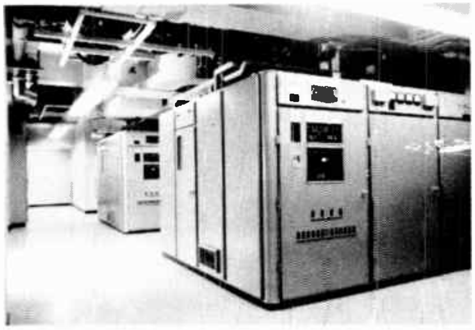

Fig. 11

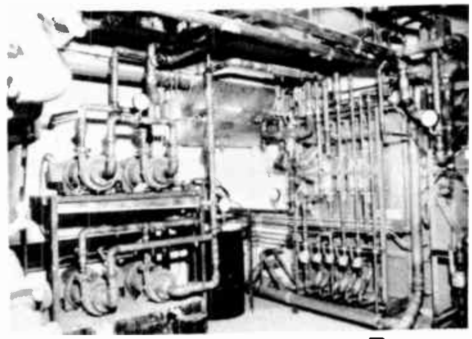

Fig. 12

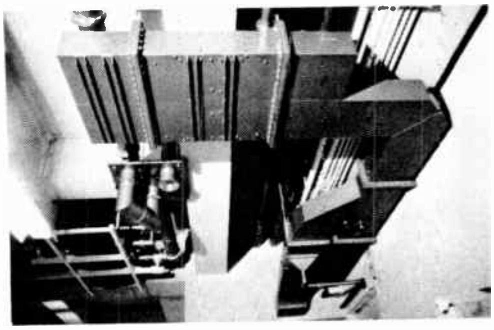

Fig. 13

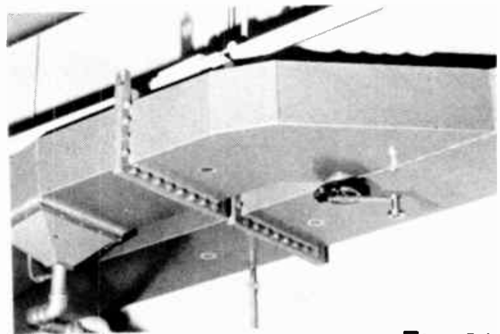

Fig. 14

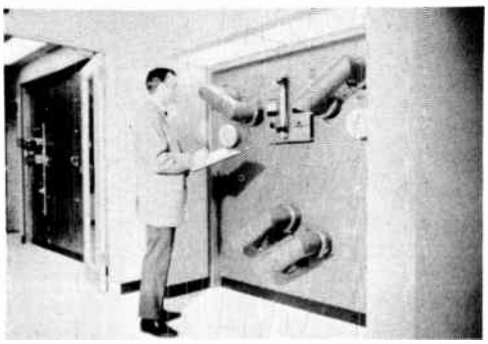

Fig. 15

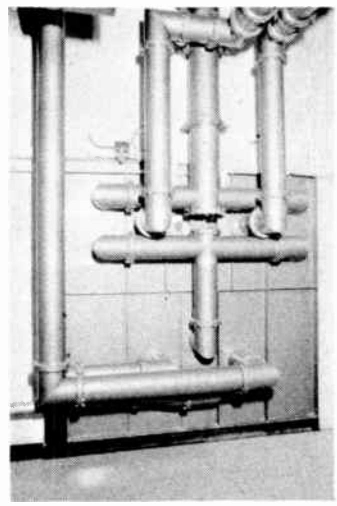

Fig. 16

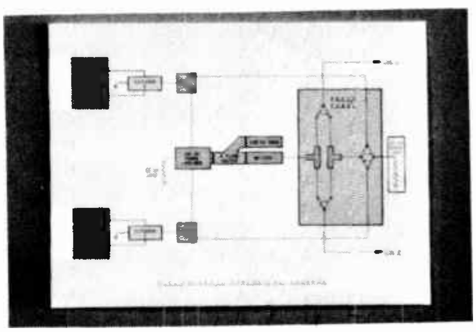

Fig. 17

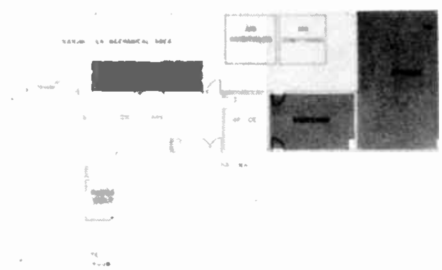

Fig. 18

Our RF system was designed by Microwave Communications. Fig. 13 shows the waveguide power combiner. This is something new. Waveguide power combiners are of four terminal hybrid configuration. The power divider is the big square thing in the foreground. We feed out of the power combiner into a waveguide section, and then into something new, which is shown more clearly in Fig. 14. We tried to limit ourselves to six and one-eighth inch line for patching. Anything larger, such as eight inch or nine inch, is just too heavy for one man to handle. So, we have limited our particular size to six and one-eighth.

In order to get around this particular problem, we had them actually build us an H plane waveguide switch, and in our opinion this is new in our business. All you have to do is throw the lever. It works like a damper and feeds into a tapered water load which is the unit to the left which has the water outlet on the bottom. It will handle well over a hundred kilowatts.

Fig. 15 is the patch panel, six and one-eighth inch. This allows us to feed the T, which, in turn, feeds our RCA directional polygon antenna. The antenna is split, and we have two-line feed for redundancy. We can lose half of the antenna or one of the transmission lines, and continue operation by certain patches in the system.

The back of the patch is shown in Fig. 16. Up at the top is the eight and three-eighths inch T splitter, and, then, we feed two coax lines from one into it and split. Directly below is another T splitter which allows us to feed one into it and split.

Fig. 17 is a block diagram or pictorial schematic of the RF system. We come out of the two amplifiers into a diplexer, then into the switching to allow us to bypass the power combiner and feed directly into the T that feeds the antenna. On the other hand, we can feed the two into the hybrid power combiner, then into the waveguide section. With the H plane switch, we can bypass into the tapered water load, or feed out of the waveguide directly through the eight and three-eighths inch coax transmission section into the T, and then to the antenna.

MODERATOR PIERCE: Now to Woodrow R. Crane, Chief Engineer of WGN and WGN-TV, Channel 9.

MR. CRANE: The WGN Continental Broadcasting Company's Broadcast Center was completed in 1961 on a twenty-one acre site which is located approximately seven miles northwest of the Chicago Loop.

In planning our new facility at the Hancock Building, we were faced with a dilemna. We learned that our selected transmitter supplier had a superior product which was not scheduled for marketing until approximately ten months after our air date of October 1, 1969. In order to take advantage of the latest technology, we chose to use an interim RCA TT 12/12/EH transmitter until the TT30 FH becomes available, hopefully, later this year.

Our main antenna is an RCA omni-directional zee panel type with a gain of six, producing an ERP of 110 kilowatts in the horizontal plane. Located on the opposing mass is our emergency antenna which is also a panel, butterfly type, with a directional pattern yielding a gain of 2.23 and a resulting ERP of 48.5 kilowatts in the maximum lobe.

We have approximately five thousand square feet of space on the ninety-third floor (See Fig. 18). Our exposures are both to the north and to the west, selected to allow optimum STL and microwave utilization. The two parallel operated transmitters are as indicated in black on the drawing. Immediately to the left of the existing transmitters is a removable wall of some fourteen feet of space which is reserved for the new transmitter. On the right we have a storage area and video tape screening room for clients and agencies.

To the north of the screening room, we have located the mechanical area containing both the transmitter air handling and space conditioning equipment. Built-in re-

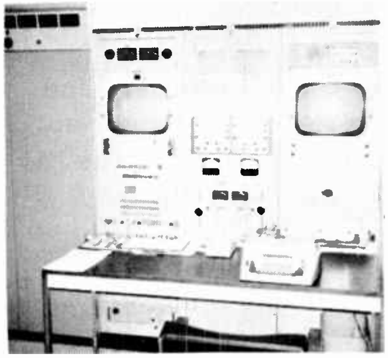

Fig. 19

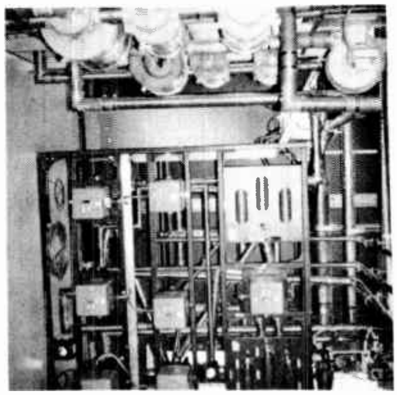

Fig. 20

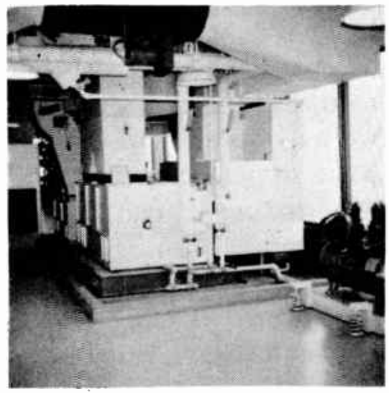

Fig. 21

Fig. 22

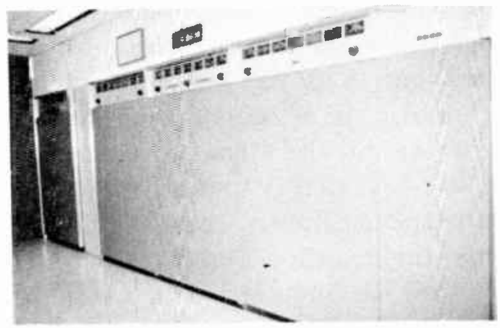

Fig. 23

Fig. 24

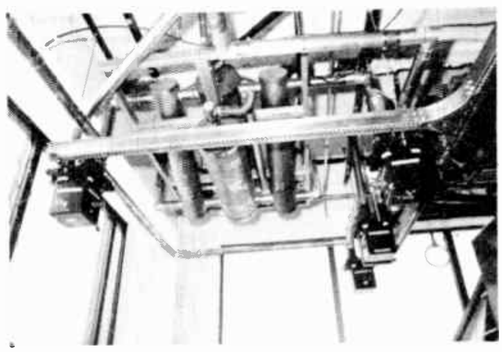

Fig. 25

Fig. 26

Fig. 27

dundancy allows the transmitter to obtain air from either system, if so required. An office is adjacent to the operating area with both the washroom and kitchennette located nearby. A corridor door provides private access to telephone terminal room, or entry can be made from within our quarters.

Adjacent to the terminal room, we have installed a color video tape recorder, and we will have a film island in the near future. Should it be necessary, we could continue to program from the transmitter location. Our power vault and switch gear has two sources of two hundred kilowatt incoming power, with automatic changeover facilities.

Fig. 19 shows the parallel transmitters on each side with the three monitoring and operational racks. These racks contain separate black-and-white and color monitors for each transmitter as well as test equipment generators, such as stair-step, multiburst sine squared, window, color-bar and sync. These racks are, in effect, our operating console-vertical style.

Both the combining network and filter plexers, shown in Fig. 20, have been floor mounted for ease of installation and availability of components. We have installed coaxial changeover relays so we can operate either transmitter 1 or 2 separately or combined into our regular or emergency antennas.

We have two microwave dishes hanging from the ceiling. One is on the north wall and one is on the west wall. These two dishes connect to independent microwave receivers, with automatic signal selection occurring when the inevitable window washer knocks out the signal by passing in front of one or the other.

We have thirty tons of space conditioning and two thousand CFM of air handling for the transmitter. For ease of service, as much equipment as possible is mounted on the floor. (See Fig. 21.)

With the acquisition of a Moseley Automatic Data Printer, ADP-120, we have an excellent beginning of a remote control system (See Fig. 22.) We record our transmitter parameters every ten minutes, saving fifteen minutes per hour formerly required for manual reading. In the event that we are out of tolerance, we have an audible alarm plus a red readout on the log.

With our new location, WGN Television is delivering a much higher quality picture to a greater majority of homes in the Chicagoland area. In fact, we like the additional height so much that if it were legal and practical we would even move to a satellite.

MODERATOR PIERCE: And, next, from Mr. Fred W. Rodey, Station Engineer for WMAQ-TV, Channel 5.

MR. RODEY: As shown in Fig. 23, WMAQ has a BTF/5E FM stereo transmitter made by RCA and also the RCA TT30 FL-1 television transmitter. This transmitter is identical to the TT 30 FL, except that each fifteen kilowatt unit is designed to operate with two discrete output power levels, the higher power level being twice the lower, in both the visual and aural portions.

The operating output power levels in each fifteen kilowatt unit installed by WMAQ-TV are 10.8 and 5.4 kilowatts visual and 2.36 and 1.18 kilowatts aural. The design of the TT30-FL1 permits operation with authorized power outputs of 10.8 kw visual and 2.36 kw aural, and, consequently, full effective power, using either fifteen kilowatt unit alone or both operating through combiners.

Each transmitter has a separate power supply located directly behind its respective unit. The transmitter and the power supply cabinets are air-cooled with an external air supply system.

The transmitter cooling system consists of two separate motors and blowers with automatic changeover features in the event that the operating unit should fail. Outside air is taken in, filtered, and passed through a precipitron, before it reaches the blowers proper. We have provision for adding room air to the air intake to temper the air somewhat in very cold weather before it is fed to the transmitters.

Four Dialectic Products RF coax switches are located directly behind the transmitter to allow the power combiners to be bypassed, feeding either transmitter directly to the sideband filter and then to the diplexer (in the case of the visual side) with the aural output fed directly to the notch diplexer. (See Fig. 24.)

If either transmitter should fail while operating in the normal parallel mode, the remaining transmitter continues to feed power to the antenna system through the combiners, but the combiner power outputs are reduced to one-fourth the normal values at this time. Provision is made with these switches to bypass the combiners and divert the outputs of the inoperative transmitter to dummy loads, and the operating transmitter to the antenna system. The transmitter output power is one-half of the normal value in this mode of operation. Control is provided so that the output power of the operating transmitter can then be raised to double its normal value to restore the station to full operating power.

The notch diplexer and four more coax switches are located behind the power supply cabinets. (See Fig. 25.) The output of the diplexer is fed to a power T which splits the power fifty-fifty and feeds it to the upper and lower sections of the antenna. The switches enable us to bypass the diplexer and feed the visual power to the lower antenna section and the aural to the upper section. The combined aural and visual power can be fed to either the upper or the lower sections of the antenna, so we are completely covered with great flexibility in the event of any failure to any section of the antenna.

The operating console shown in Fig., 26 allows direct view of the transmitters and the frequency monitoring equipment. All audio and video monitoring is done at this location for WMAQ-TV and FM and the AM station which is remotely controlled from the Hancock Building.

RCA has provided an intercom between all of the stations in the building and each transmitting tower for antenna maintenance work. There is indirect metering of the antenna beacon and sidelights which appears on the console. Provision has been made for microwave and radiophone facilities to be operated from the control room area. This console was designed by WMAQ and built by Emcor Metal Products of Chicago.

The station is supplied AC power by two separate Commonwealth Edison transformers and fed to an Asco automatic transfer switch which will transfer power feeds in case of a drop or complete loss of station power. We also have space and provision for a 225 KVA turbine generator on the ninety-eighth floor of the Hancock Building for a second source of auxiliary power. All transmitters and the input equipment are fed from regulated transformers.

MODERATOR PIERCE: Next is Mr. Orion Arnold, Associate Director of RF engineering for CBS Television Network Engineering and Development. Mr. Arnold speaks for WBBM-TV, Channel 2.

MR. ARNOLD: WBBM-TV, CBS owned and operated, put in a transmitter plant that was aimed at the major objective of remote control capability, and for this we put in a redundancy of capacity in the air systems, we put in dual program channels, and we put in three transmitters.

The three transmitters are arranged for operation by two in parallel, and if one should fail, the other transmitter can be switched into operation without any off-air time. There is a moment when you are operating at quarter-power until you get the other transmitter on.

The third transmitter is always put into a dummy load so that it is available for maintenance, and being an old transmitter operator, I kind of look forward to being able to work on a transmitter during some sort of normal hours. I think you know what I mean.


Fig. 28


Fig. 29

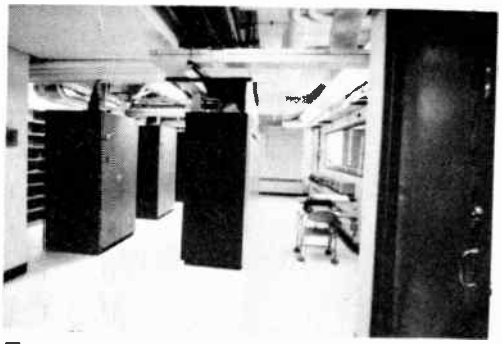
Fig. 30


Fig. 31

The audio and video program channels, as I say, are dual channels. We have signal loss detectors at the inputs and the outputs of the channels that automatically will switch to the other channel if there is a failure.

I would also like to mention the test system. We have a very complete and extensive signal test system, also RF switching to get RF sources into the demodulator or what you might be using. We feel that not only does this help the operators now, but in a time when remote control is used, you can route and check the plant operation thoroughly with a minimum of time.

We also put in a quite complete status and alarm system that could also be remote controlled at some time, and, last, we also included a parameter sampling system that is operated from the console and with a minimum of interfacing we could extend this to a remote control path.

As you walk in the front door, to your left would be our storage rack with the file in the center of the toom. Fig. 27 shows our main operating room. To the left are storage cabinets. In the center of the room we have a nice table layout for blueprints and such. At the far end of the room is the control console. Through the window you can see the three transmitters lined up there. This window is specially designed to provide some 30 db of sound isolation. Down the other side of the room is our rack equipment. We have eleven racks. Nine have some equipment in them, one is empty, and one is used for telephone company equipment.

Looking from the console back the other way (Fig. 28), on the left is the workshop area. In the center is the office of the engineer in charge and on the right is the kitchen area and personnel lockers.

Fig. 29 is a lefthand view of the console. This console was custom-made by CBS. Across the front of the console are short, standard-sized, equipment racks. Just to give you a quick rundown, briefly, on the left is a set of VU meters. That is the audio monitor position. Next are the two picture monitors. The left-hand one is switchable to about thirty sources, and is called our test monitor. The other one carries programming. It has a limited input.

Directly below these is the video routing system, below that is the video test system, and then the transmitter control. All transmitter controls are mounted there.

We interfaced it so that it is all 24-volt momentary-contact control. Further on down is the status alarm system. We have a digital clock between the two picture monitors. Fig. 30 shows the transmitter room with the line of three transmitters in the center, and the three power supplies behind them (to the left). At the front of the transmitters, under the window is an RF patch panel.

As I mentioned, we have a rather extensive test system. We have probes in the transmitters at various power level stations. All of the probes from all of the RF feeds come through this panel, and, then, onto the racks, so if you are out there working on the transmitters, you can get at any of these probes with your test equipment.

The combining system for the three transmitters is shown in Fig. 31. On the left, the one and five-eighths inch panel is the aural system. At the bottom, there are six

Fig. 32

transfer switches which are required to transfer the three transmitters into any parallel combination.

The next frame over is visual. It is a carbon copy of the aural except that it is a three and one-eighths line. The last frame is the antenna combining or patching system.

You will notice that there are manual patch panels which can be used in the event of the failure of a transfer switch. We can also patch around the whole combining system if necessary.

Fig. 32 is a view of the Hancock Building, obviously. Our antenna consists of two two-bay antennas on the right-hand tower as you view it. We have split our antenna so that we feed the aural to the bottom bays and the visual to the upper bays. We can combine it downstairs with a pushbutton switch and feed a single transmitter into four bays and still maintain our ERP.

On the left at the top of the 100 foot tower which supports the antenna structure is our emergency antenna which consists of a single bay bat wing spaced around the ten foot diameter tower.

MODERATOR PIERCE: On behalf of CBAC, I thank you for your interest in our installations. We thank you.

Planning for Emergency Broadcasting

Ray Butterfield
WLOX, Biloxi, Mississippi

If I had but one thing to say when it comes to preparing for emergency broadcasting, it would be "have a lot of good broadcasting friends in adjacent areas that are willing to pitch in and be helpful." I mention a few of them here today such as, WWL-TV in New Orleans who moved in with equipment across bridges that had been almost totally destroyed—equipment that got us back in operation at our studio location off the Coast; WLBT in Jackson who arrived with cameras at our transmitter site where we started broadcasting some thirty miles north of the Coast; WHSY in Hattiesburg who supplied turntables, cartridge tape machines, and a host of other equipment.

Our studios and television station was totally destroyed. Our radio station was totally wiped out. The only thing we had left as far as the radio station was concerned was our tower; and, how it remained standing, we will never know, since it is mounted out over the Gulf of Mexico.

The ingenuity of our engineers and our group of dedicated broadcasters is the only thing that really pulled us through. They were able to string copper wire, insulated on either end, and feed it with a home-made transmitter with a little amplifier. Quite frankly, when we first went back on the air with radio, we had a little three dollar plastic microphone like you find in a recorder. We had no turntables. There was nothing to work with but that.

We had to start back immediately in that manner delivering messages of encouragement and, in fact, direct messages such as "this family is all right"; "here is where you go for emergency supplies"; "this is a shelter that has been set up." I know our voice was rather weak at the time. We talked to everyone—every one of the men who went on this talkathon because, and again I repeat, we had no records, no music, no turntables. For eight days and eight nights our radio programming consisted of delivering messages and factual information.

To prepare for an emergency, the people on your staff should be familiar with such matters as how to dispose of human waste, what foods would be consumable, and what you should do with water. The tainted water which results from one of these disasters is really something that could have caused a mass problem in our community. We delivered messages on how long to boil the water, what water was available, where to get it, and where medical supplies and medical services were available.

We had to have factual information before we could relay this to the public, and thank goodness for the Citizen Band operators. I would like to compliment the Citizen Band operators and call on you, if you have a Citizen Band group in your community, to get them to work with you in your disaster planning efforts. They are able to relay the information to a central point because of the mobility of the CBs where you can contact them in automobiles in various areas.

Another group to work with, and one we would suggest, would be your Ham operators. They also were able to move in with us and get information in and out of the area.

Maybe I failed to point out the fact that a total communications blackout resulted in the Gulf Coast area when Hurricane Camille struck. You couldn't get telephone calls in or out, and I am sure many of our news people found this out when they tried to get through.

The first information from the Gulf Coast area came from a relay system of Highway Patrol transmitters. They stationed cars every twenty miles from the Gulf Coast area northward and relayed from one unit to the next until they could get the information out to the public on what had actually happened in the area.

The storm either totally destroyed or made uninhabitable more than sixty-three thousand homes. Now, if you can just imagine sixty-three thousand homes in which there are approximately four people to a home, you can see the number of people along that Mississippi Gulf Coast area that were directly affected as a result of Hurricane Camille.

After this information channel became operative, we began to get aid from the American Red Cross. The radio broadcasters began to bring equipment in so that we could get back into operation. Television stations arrived with equipment so we could get back on the air. Generators that we had planned on using before, of course, were of no value because the salt water made them inoperable.

I guess the best thing I have to say is you will have to have—and I am sure all of you do have—a completely, totally dedicated group of broadcasters within your organization. When the chips are down, they will come through.

The engineers were ingenious in putting together things that we swore wouldn't work, and I am sure they broke every rule as far as the Federal Communications Commission is concerned, but the need to serve that community had to come foremost. You must get words of encouragement to the public. You must deliver information on where medical supplies and food are available and where various items for their protection are.

I have some recommendations that I would like to make to you as broadcasters, and, in fact, to all of us in this room. We should have some energgency preparation for communications available to be flown in to cover such disasters. Now, each of us in this room can sit here and say, "It is never going to happen to us—it is going to happen to the other guy;" but one morning, whether you live along the Mississippi River or the Ohio River, it may just happen to you.

Look at the Alaskan earthquake. Who would have thought that would occur. We along the Mississippi Gulf Coast—Louisiana, Texas, Florida, all the Gulf Coast—realize, of course, that we are subject to storms. We prepared our emergency plans; but, when every radio station in the immediate area is rendered inoperable and a total communications blackout exists, you are faced with tremendous problems.

South Central Bell, for example, had to fly in trucks, men, and equipment to start untangling the spaghetti of wires. Power plants were unable to turn on the generators until all the power lines that were down throughout the whole area were considered safe.

So, your responsibility to serve the community is not only before a disaster, but following a disaster.

The recommendation that I would like to pass on would be a simple one, and I think that we can pattern this after the use of communications equipment in Viet Nam. The radio communications there, as many of you know, are airborne as far as the transmitters are concerned—both radio and television. Television, of course, would be the least important to serve the immediate disaster area. Transistor radios, and, of course, automobile battery powered receivers make radio readily accessible to get the message across, and most everyone would have, within walking distance, a radio that they would be able to listen to for proper guidance. I don't know whether the federal government could provide and equip one of these surplus airplanes or whether we as broadcasters should take the responsibility of requesting one, or whether the Red Cross should handle it, or where it really should start, but my recommendation would be that we have one available to be flown into an area that is hit as ours was. It should be an airplane that could trail the antenna behind it, feed it with transmitters mounted aboard on the frequencies, of course, where the crystals could be changed. Your transmitters would be tuned to the local frequencies to relay from ground to air, and then to the public, via our regular commercial band, the information they really need to know.

I say that possibly—and I notice there are several equipment manufacturers in the room—if we as broadcasters would call upon them to furnish an airplane, if we could get it from the federal government to have ready for the Coast Guard, Navy or Air Force to fly in at a given time, this would provide one of the greatest services to the American public that broadcasting could possibly provide.

I think each of us in our individual communities should make plans in advance for total coverage in the case of a disaster. I think that we should work with stations in our neighboring areas to be prepared so that if something should happen in either area we could move in immediately with equipment to try and help them out. As far as the airplane concept is concerned, I think the minute that commercial broadcaster facilities have been restored, transmissions from the plane should cease and local broadcasting should be resumed.

In our area martial law was declared and the Commanding General spoke into our little three dollar plastic microphone. I can imagine how at a civil defense headquarters or one of the police departments with a walkie-talkie type unit, he could have communicated from ground to air or from his command headquarters and back out to the public, giving them the information they so direly needed. I think it is something that we should really consider. I repeat again that today each of us may say, "It will never happen to us," but I can assure you that none of us are immune to a tornado, flood, or any major disaster hitting our immediate area.

Airborne communications systems would be the answer. I would like to make the recommendation that the National Association of Broadcasters or the American Red Cross consider having an airplane equipped and prepared to move into any given area on a moment's notice where our people and our communities can really be served.

I would like to take this opportunity to say that the neighboring stations in the neighboring states did a tremendous job, but they, of course, did not have direct contact with the immediate community for many, many hours and in some cases for several days.

To try to describe this disaster is almost impossible. I have pictures in the briefcase, but you don't want to see destroyed equipment, or destroyed homes. I think we have to look forward and develop plans to prevent a total blackout of communications in any future disasters. I think the National Association of Broadcasters, our American Red Cross, and our federal government, possibly combining together, could provide this service and take the fright away from a lot of people.

Imagine you are at the station with your family miles away and no way to get to them. You don't know how they have come through the storm—not only you, but your employees are faced with the same uncertainties. You don't know whether your next door neighbors' home has been destroyed or whether they are alive. You know you have done a job to the best of your ability right up to the last minute you can broadcast both on radio and television. You hope that everyone has heeded the warnings, and you have sent them the shelters; but if you can imagine a storm so bad that the shelters themselves were destroyed, you know what it can really mean to a community and how it can send them into a state of shock.

I think we on the Mississippi Gulf Coast will be forever grateful to you broadcasters who came to our aid, not only directly but through your appeals for food, clothing, and money.

We hope that we never have to come and help any of you because we hope a disaster will never occur in your area; but, believe me, plan now as if it will. Plan to work with your Citizen Band group in your area. Plan now to work with your Ham operators so you will have the inflow and the outflow of true, accurate information. Plan now to break the rules as was so necessary in our part to deliver direct messages. There was no way that people five miles apart could communicate with one another. Some families didn't know whether other members of the family were dead. We broke probably one of the greatest traditions. One of the greatest rules we have ever held is that we didn't want anyone to ever know of a death in their family as a direct broadcast over our facilities. This was one time that we broke that rule. As we would receive confirmed deaths—and it was a real God's blessing that there were only one hundred forty-one—we would give those names on the air and preface it each time with, "Normally we would not do this as we know it will hurt some people but we feel the relief to the thousands of others, knowing that their family is okay, will make it worthwhile." So, we gave the names.

We needed help. You came through. You may need help in your areas, and I call upon you to make some serious plans in your community in case a real disaster should happen to you.

I also wish to publicly state that our Federal Communications Commission people, when we could finally get through, were the greatest people in the world. When we told them of what had happened, their answer to us was, "It is not an emergency—it is a disaster. Do what has to be done to serve the public," and that we did.

I think I should also thank the equipment manufacturers and especially RCA for flying a transmitter to us with generator and everything that we needed to finally get back in operation, even sending one of their engineers to help install it. I would also like to compliment those men on the hours they spent and did not turn into the company once they saw what had really happened to the community.

It wasn't only our station. It was every station in the community and everyone did their best. I know each of you would do your best, but I think in a disaster we need help. If each of us could contribute one little piece of equipment, or the manufacturers could, and we could get an airplane ready to fly anyplace in this country at any time to provide that little voice of hope for good information and not for false information, we would provide a greater service as far as broadcasters than anything else that we could ever do.

I really call upon you not to think, "It can't happen to me;" because it can, and I am sure by this time next year, to some of you, it probably will have happened already.

So, make your plans, have some emergency setup prepared to go, and if we have learned anything and can help, call on us. We will try to give you any information that we possibly can.

Thank you very much, and I hope that none of you ever have to face what happened along the Mississippi Gulf Coast on August 17 this past year.

Color Monitor Matching

Moderator: Charles Abel
KFMB-TV
San Diego, Calif.

Panelists: Gideon Fiat
American Broadcasting Company
New York, N. Y.

J. G. Jones
Conrac Corporation
Covina, Calif.

Daan Zwick
Eastman Kodak Company
Rochester, N. Y.

Edward P. Bertero
National Broadcasting Company
New York, N. Y.

Bill Pegler
Television Equipment Associates
Bayville, N. Y.

MODERATOR ABEL: Back in the early days when color television first was born, there had to be some kind of reference set for what was called white in those days. It was termed Illuminant C.

Through the years in working with the color television and the monitors and the various phosphors that go into the tubes, it was discovered that the complexities of white should be mixed to a different amount, and it is commonly referred to now as D65 illuminants instead of C. Here to discuss the changes, and what we can expect, and what the state of the art is at the moment is a panel that has been selected as experts in this field.

Our panelists are Mr. Daan Zwick, Senior Research Associate of Eastman Kodak; Mr. Edward Bertero, Senior Project Engineer, NBC; Mr. Grayson Jones, Technical Director, Conrac Corp., Covina, California; Mr. Bill Pegler, Director for Television Equipment Associates, and Mr. Gideon Fiat, Assistant Director of Film, ABC News. These gentlemen will discuss what has occurred in the way of trying to establish reference and matching of color monitors. I am sure I don't have to go into any dissertation on what that amounts to. Everyone here connected with television has had their chance at it. We will start the discussion by having a short talk from each of our panel members, and we begin with Mr. Daan Zwick.

MR. ZWICK: Someone asked me a question when I came in. Why should someone from Kodak be concerned with this problem? Kodak, of course, sells film, and we are very concerned that film should look well over television systems, and when we were considering what are the necessary things to be done to make films look well over television, we found, for example, that it was necessary to examine each part of the total system, not only the film input which gets a lot of criticism, the television film, but, also, what is really the indicator of the station output, the color television monitor.

One of the areas in which I have been working is on this committee which Blair Benson is going to report on tomorrow (April 7). I feel a responsibility for trying to improve the variability of the film input. In this connection, we have been endeavoring quite strongly to get the film industry to establish standard conditions under which they view films.

The standardizing proposal is that films will be reviewed at a higher color temperature for 16mm than had been done in the past. The D6500 condition has been sort of accepted in this country and Canada and to some degree in Europe. The question arises, "What other pieces of standardization areas are there?", and, of course, the monitor is quite an obvious part. Many stations use the monitor as the last check. It is obvious if the monitor is very blue, somebody is going to say, "That picture looks too blue," but they merely turn a few knobs to make the picture look correct.

Similarly, if there are different monitors which are set up differently, one person may be controlling one source of signal on the basis of another monitor and, as you switch back and forth from one program source to another, you get a decided color shift.

We at Kodak have felt quite concerned that there should be a method for the station to set up his color monitor to the recommended D6500 color temperature and to the brightness level of the A20 foot lambert on an open white level. The instrumentation for this is certainly approaching and we will probably hear more about that. I did, however, want to explain why a film manufacturer is interested in seeing that the television monitor has a standard color and brightness.

It does affect, of course, the signal. It also has a relationship to how the film is viewed, an optical projection relative to how it will appear on the station monitor.

MR. BERTERO: I would like to change the scope of our discussion slightly. The title is "Color Monitor Matching." All I want to add is, "color monitor matching to what?" Some reference of standard is what I am implying at this point.

In the early days of color television, when the number of studios in use was small, the number of hours on the air was small, and the number of home receivers was also small, it was possible to exercise some control. That is, as a broadcaster, we had simple devices to visually compare the adjustment of a monitor to these devices, and the people at home had their sets serviced, of course, to the proper color temperature. However, it didn't take long before we found out that the customers did not like Illuminant C as a color balance for a home receiver.

You might well ask why. Well, the answer is rather obvious when you consider in those days there was not much color transmitted on the air. The man who purchased a color set had to look at not only color, but black and white, and Illuminant C on a black-and-white transmission does not look like a black-and-white picture. Since the customer is always right, the servicemen raised the color temperature of the receiver to simulate a black-and-white receiver.

Obviously, we were confronted with a condition of broadcasters trying to stay at Illuminant C, and customers converting the color temperature.

This persisted for quite some time. If anything, it got worse and worse as time went on. As more and more people got into the color broadcasting business and more sets were sold, any conversation I had with receiver people was always to the extent that, "Look, you take care of broadcasting. You put out an NTSC signal and leave us alone. We will take care of our problems. We have customers to satisfy."

To further compound the problem, right after the color explosion, we went through a cycle where we had phosphor changes. Now, theoretically, when you change the phosphor or kinescope, you must also change the color of the camera. Fortunately, my receiver friend said, "Look, again. Stay with NTSC. Let us change our demodulation circuits and receivers. Let us make pleasing pictures. You just keep the signals coming the way FCC requires."

This was all well and good, since color was really exploding. In fact, so much so that enough people got interested in the color temperature problem and color monitor adjusting problem that the Society of Motion Picture and Television Engineers developed a recommended practice concerning the color balance of monitors. I am saying color monitors now. This applies just to broadcasters—color monitors shall be Illuminant D.

Broadcasters having agreed that we will have a given color temperature, the next thing, obviously, was instrumentation. The instrumentation has broken down into two kinds, since there are differences in phosphors. You can make all phosphors geared to the same color temperature, but they will not give you the same color picture. So it was obvious that someone had to come up with two kinds of instrumentation, one to establish Illuminant D, the second to repeat these results day after day.

Fortunately, there are instruments available, and there are more instruments being developed, both along these same lines. The point I want to make is that not one of us singularly can establish this standard. It takes the efforts of all of us. I think the time is soon approaching that most everybody will have one of the instruments available.

That being the case, we will be able to take the position that no matter who comes to us with a piece of color film or tape, we can play it back on any of the networks or any of the stations with some degree of assurance that the results are consistent. I think that day is approaching very soon.

MR. PEGLER: My background and experience in this area has been from a marketing point of view, in marketing the color-band sync equipment which has been available for about three to four years. We have sold this equipment to nearly a hundred TV stations or networks in this country and abroad. The general reaction has been favorable on pretty much all levels.

We have now settled into a position where we are offering two types of equipment. The first device is a color comparator. The color comparator is a visual comparator and permits the technician under semi-laboratory conditions to balance a particular phosphor type to a color temperature of D5400. It is necessary to operate the comparator in a reasonably darkened room. It would be very difficult for a technician to have to balance over, say, two or three monitors at one spell. If he had to do more than that, his eye would probably give out. Ambient effects such as room lights, color surrounding the area, affects his judgment.

In any event, the first piece of equipment essential for this type of work is the color comparator, and they are available from reasonable prices, under a hundred dollars, to prices in excess of a thousand dollars.

Once the color monitor has been set to the D6500 color temperature, a piece of equipment is, then, required for the repetitive setting of this monitor on a day-by-day basis; and to achieve this requires some type of an instrument with a memory. There are at least three different types of instruments available today with these color memories. These can be calibrated for a particular phosphor, a type, or for a particular monitor, have a memory assigned to each monitor if you so like, and the technician using this instrument could balance the monitor in very short time, maybe a minute and one-half, maybe, two minutes.

MR. JONES: I might say right off the bat that everybody has been wondering if anything concrete is being done, if there is some help on the way in the form of standardization. It has already been mentioned that the SMPTE has recognized Illuminant D6500, and I think we can, in all probability, figure it will become the final standard. Even though the system was originally designed around Illuminant C, Illuminant D is very close, and it turns out that it is almost possible to make a standard for Illuminant C anyway.

Now about the TIA committee. TIA is defining the standard monitor in terms of SMPTE and the TV Committee is working on the problem. There is a Subcommittee on the West Coast specifically devoted to monitor matching which is charged with producing a recommended practice and tutorial paper to explain specific methods for repeating the exact adjustments. Such standardization is the first step in getting things going.

Now, in order to match monitors or get correct rendition, there are really three things you have to do. First, the electrical signal has to be correct. You must have the matrix operating according to the NTSC standards, delivering the correct signal to the three guns. This used to be a big problem, but I think it is practically solved and not much left of that as long as the equipment can be ordered.

The second thing is really the subject that we are concerned with today—that the picture tube, to give the correct rendition, must have the phosphors with the primary lights in a place where the NTCS specified, and that hasn't happened. The third thing is room conditions, and everybody knows the surrounding light should be controlled.

Some of us have an opinion that it ought to be somewhere in the neighborhood of Illuminant D, but this is just an opinion. There are correctional tests being made. Everybody has seen the condition where the man with the red shirt standing in front of the monitor just changes the whole thing.

Fig. 1 is a CIE color chart, and all of the Xs up there are phosphors which have been used in monitors. Some of them don't show. I think probably the most significant thing I get out of this is that the distances are all over the map, which explains why you have so much trouble trying to match two monitors at different times.

Another interesting thing to note is that one of the green phosphors is almost on top of the NTCS green primary. That is the old zinc silicate that was used in the metal cone 21-inch tube.

When you look where the modern phosphors are, you think you are going backward, but there are a lot of reasons for the phosphor beside the primary light.

So, the picture tube manufacturer usually makes a choice based on how good a formula that can be built and mostly how much light you can get out of them.

In Fig. 2, most of the Xs are gone. Actually, those Xs in Fig. 1 are of historical interest because they were used a long time ago, and with 8600 hours a year in broadcast monitors running most of the time, they are mostly all gone.

The two phosphors shown in Fig. 2, the ones with the vertical and horizontal axis on the crosses, are the ones that are probably most widely used now during the last two years. That is the good phosphor. It is good for manufacturing; stable, reproduceable. It is used more or less pretty close to those coordinates in a lot of home receivers, and it looked two years ago like, maybe, that was it, and the problems were all over; that all of the picture tubes would have the phosphor in that general area, and all that would be necessary would be to select them to close tolerances for monitor matching, but it didn't work out that way.

The chemists are always trying to produce things and make new developments; so, we now have shown by the crosses in Fig. 3 (the Xs) what is currently a very good phosphor for home receivers. It is brighter than the other one. This one happens to be the RCA 23VALP22. We used to call it a 25-inch tube, but you can't do that anymore. That phosphor is real fine for the industry except for broadcasters, so here we are again where we have two kinds of phosphors to worry about.

However, the situation is not nearly as bad as it used to be. The new phosphor, the highest brightness phosphor, is pretty close to the other one. It is close enough so that if the monitors are not side by side, people will think they are matched.

For example, an audience and monitor control room phosphor would look very much alike.

MR. FIAT: I just would like to say that there is a need for the standardization of setup and color reproduction of the color monitors in the TV industry today if we are to televise a uniform quality of pictures from the various locations and among the various TV networks and stations.

With this in mind ABC has undertaken a study program to determine what steps can be instituted to achieve this goal and to actually implement the results.

The first question is what is white, and what white should be standardized on. At present we have accepted Illuminant D6500. Time does not permit me to present a complete technical paper, but if anybody is interested, call me or write, and I will give you the paper I presented to the Electric Optical System Design Conference, titled "An Approach for Standardization of TV Color Monitor Calibration."

We have tried and tested all types of color instruments, including visual colorimetry, tristimulus colorimetry and spectral radiometers. We have come to the conclusion that the initial setup of color monitors should be done with a visual comparator, then we calibrate a tristimulus type meter on the correctly balanced monitor, then, we just repeat day to day the same value on the meter in conjunction with a specific monitor.

I want to stress that each monitor requires an individual calibration, and the values recorded in the tristimulus type meter should be available for future use. We just write on each monitor these values and with what meter they were recorded. As I said earlier, time does not permit a detailed presentation, so I'll be happy to answer questions.

MODERATOR ABEL: A good many chief engineers are not, at the present time, using any type of reference meter to establish white. I am sure there must be some pitfalls, something to watch out for, as we decide on some type of instrument to utilize when matching color monitors. What do we look for? What do we look out for?

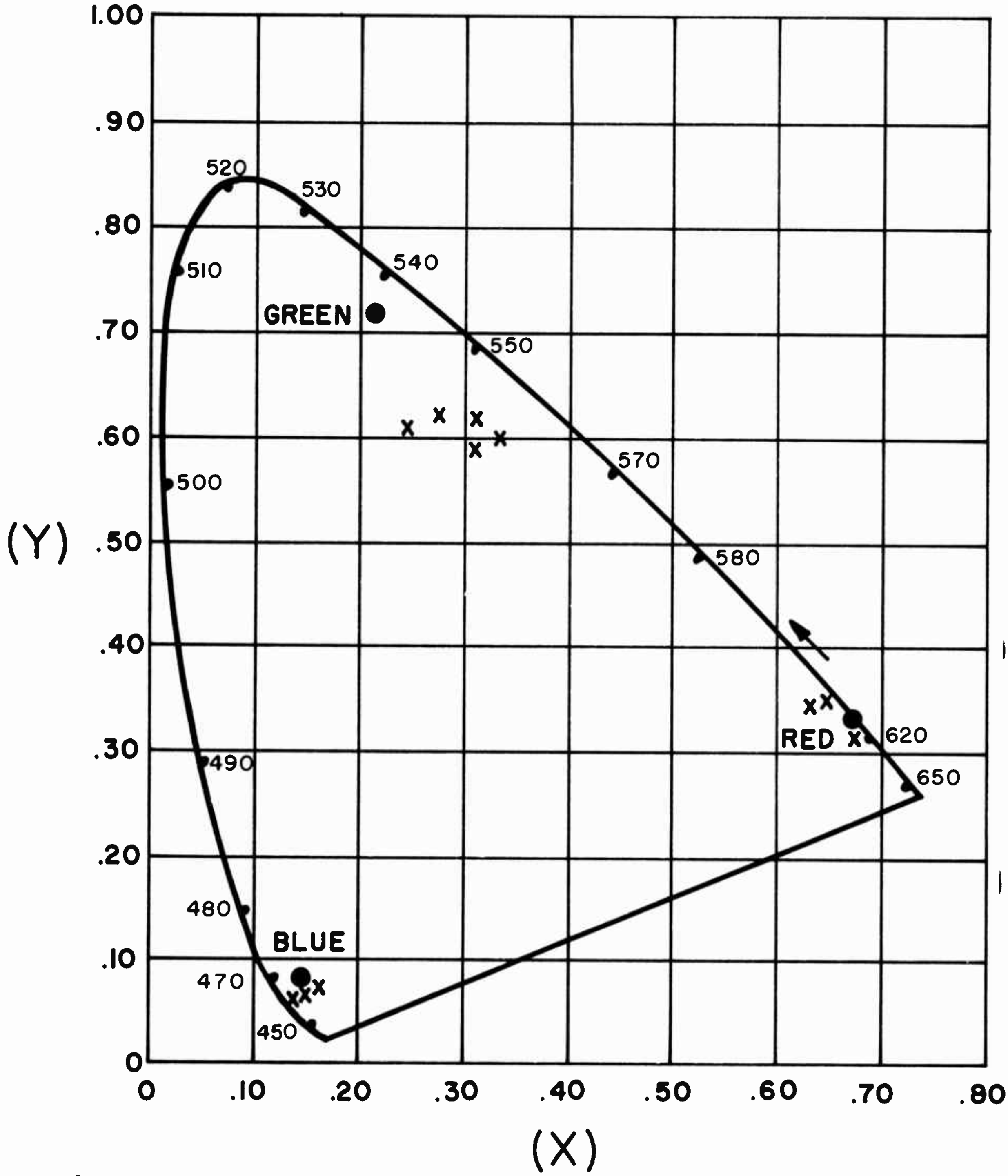
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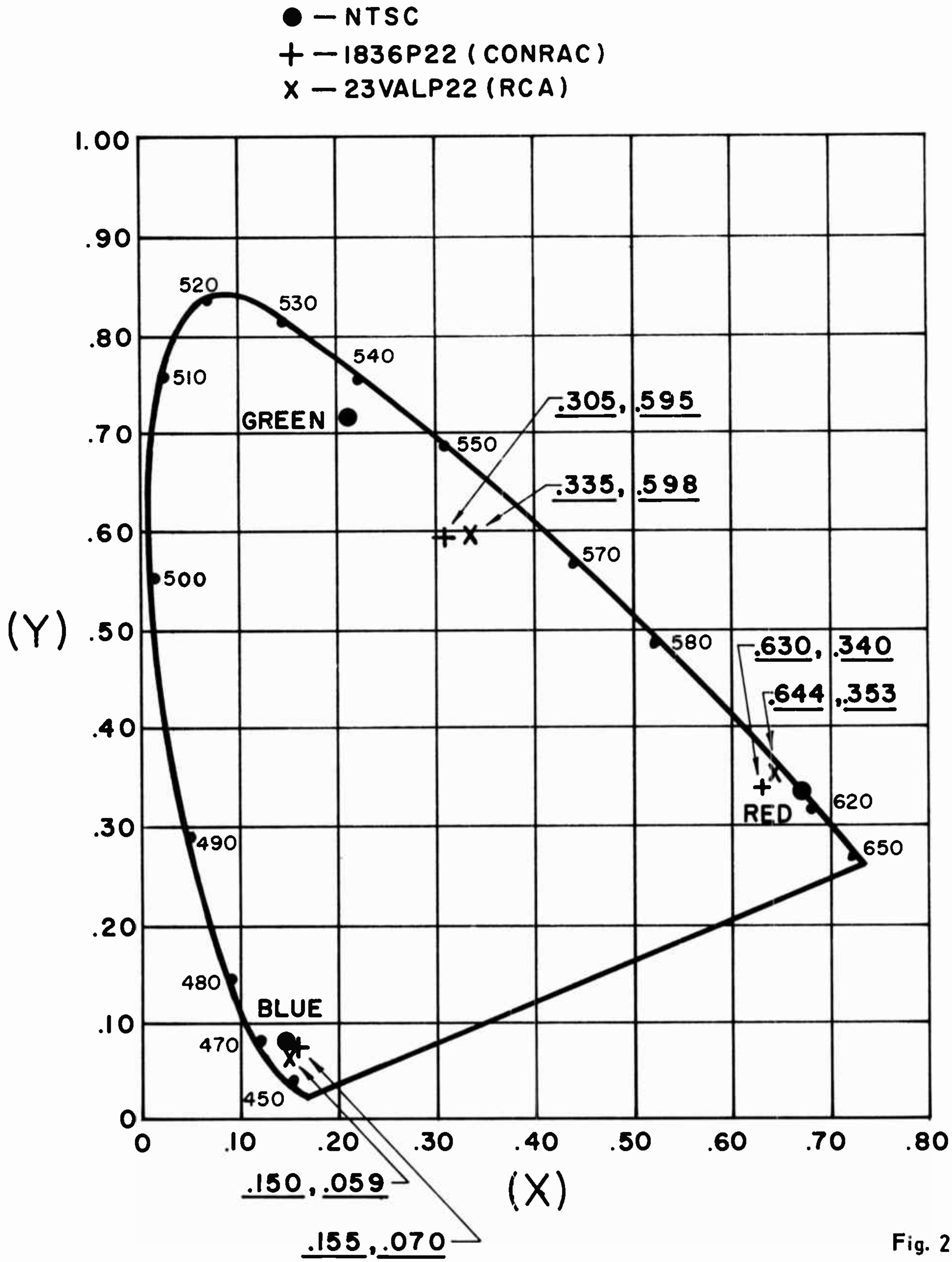
Fig. 1


● — NTSC
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X — 23VALP22 (RCA)
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GREEN
550
570
500
580
620
650
490
480
470
450
BLUE
RED
.305, .595
.335, .598
.630, .340
.644, .353
.150, .059
.155, .070

Fig. 2

CRT PHOSPHORS		RED		GREEN		BLUE	
		X	Y	X	Y	X	Y
NTSC		.670	.330	.210	.710	.140	.080
CONRAC	1836P22	.630	.340	.305	.595	.155	.070
RCA	23VALP22	.644	.353	.335	.598	.150	.059
OLD HITACHI		.647	.353	.250	.611	.145	.054
HITACHI "R-E"		.676	.324	.287	.627	.145	.054
HITACHI "HI LITE"		.671	.329	.305	.618	.145	.054

Fig. 3

MR. ZWICK: I could start by saying that I think it is easier to do this job than we may have implied. It is not a difficult job.

First, you have to decide what tolerances you want. How close do you have to match a monitor to D6500 and how precise does this reference have to be?

From my visits to television stations and my limited experience in seeing what the situation is, it is bad enough so that almost anything is going to be an improvement. It won't take too sophisticated a piece of equipment to get monitors closer to D6500 than they now are. Most of them are pretty high in color temperature because they have been used to match black and white. They have been adjacent to black-and-white monitors which are higher than color.

I think the only real pitfall is that you have some severe visual abnormality such as color blindness which would negate the use of the instrument. That is the one thing you want to make sure of, that the person does not have a severe color blindness problem.

MODERATOR ABEL: When the monitor is set with this standard, or to D6500, what is the effect of the monochrome or the white that they are normally seeing?

MR. BERTERO: My experience has been that it takes a little bit of educating the operating personnel to get used to it. A D6500 is quite pinkish looking compared to the 9000 you normally have on a black-and-white receiver and monitor.

What happens on a color transmission, people will be inclined to like it. It is a rather warm-looking picture, but we have a monotone transmission, and they are going to say, "That is terrible. That is a black-and-white picture. We can't stand that."

That is part of the educational process you have to institute with your client. It is not easy. I think that it is more difficult to overcome than getting D6500 on the monitor.

MR. FIAT: We find the major problems which we have is when we have two color monitors side by side and both do not match, and no matter how much time we spend; there are some small differences.

At present in all of our critical major shows, we have one color monitor. By using only one monitor we eliminate many problems:

FROM THE FLOOR: You said when you first started, to get the standardization, all of us are going to have to work together. Now, you are discussing color monitors and transmission. What about the final end result of that picture? The home TV viewer? How are you going to get standardization here? How are you going to prevent him from taking that tint dial and screwing up everything you just did?

MR. FIAT: I think the initial thing is that all of us in broadcasting should generate the same quality picture.

FROM THE FLOOR: In other words, if you have a lousy picture it will be the same type of lousy?

MR. FIAT: Not necessarily lousy. Right now for each program they have to change their set. This is the beginning. If they do not have any reference at all, what can we expect.

MR. ZWICK: I would like to make a personal complaint. I took one of these monitor comparators home and set up my own receiver this way, and my wife and children who aren't color experts said, "Gee, what made the set better for color reception?" It was a much more pleasing picture than the way the serviceman had set up my set.

Now, I think you can extrapolate and say maybe instrumentation like this should be available to servicemen or whoever else is responsible for the initial setup of the set. If it is this way to start with the home receiver, the home customer may be less apt to change it, but certainly it makes a difference whether the set has been installed in the daytime or evening, finding what reference the operator used, but that is a problem, and I think Gideon's comment that we have to control the piece that we have the good control over is right, and that is the studio monitor, and this would tend, at least, to make the person at home do less knob twisting than he now does.

MR. PEGLER: We have had some experience selling equipment to the color receiver manufacturers who are now beginning to look for equipment from us in their live testing area and on the production line to set the gray-scale balance as it comes down the production line.

MODERATOR ABEL: My personal feeling on the subject is that I am sure those of you who are chief engineers and have had to deal with service business feel that it certainly would be helpful and almost essential that some type of instrument be developed at a cost, or available at a cost, so that television servicemen could use it.

I don't know how many of you have had the same experience I have. You see a badly misadjusted television set, and you ask the owner why it looks quite like it does; they say, "Well, I just paid eight hundred fifty or nine hundred dollars for this receiver. The dealer came in. He set it up, and before he left, he told me not to touch anything." With that parting word servicemen keep people from enjoying color television to the fullest.

I am sure that many of you have experienced the same thing. Therefore, if a low-cost instrument can be developed that the television serviceman will use to set up home receivers, I think we will go a long step in helping correct the reception problem.

MR. ZWICK: I would like to add that I have been charged by the Ad Hoc Committee for Color Television Study of the Joint Committee for Inter-Society Coordination to try to set up an experiment to demonstrate what quality improvement or quality differences there are when pictures are viewed at D6500 relative to 9,000 or 12,000 and some of the other conditions which do exist on home receivers.

This experiment is not done yet, but it is one step that is being made to try to provide some factual evidence to the manufacturers, whoever might be interested, as to where the best place is to set up a color receiver.

This may provide some useful information on the subject. Another bit of information on that subject, a year or so ago at the Annual Meeting of the Society of Motion Picture and Television Engineers, Ken Liss presented a paper in which he showed the results of going around in his neighborhood with a measuring instrument; he measured color, related color temperatures up to over 20,000 degrees Kelvin in sets as they were being used in his neighbor's home. This really demonstrated that part of it was a serious problem, but I think right here we should be concerned with the variation that exists in broadcast centers and how to get them to D6500.

MR. FIAT: I would like to mention experiments we have made in the studio in New York in which we have recorded information about four or five days on one of the soap operas. We monitored the video operator at D6500, and we continued another four or five days with the same video operator with monitors that were set to1,900or as high as we could.

Then, we played back the video tape to a conference that we had, where we had a lot of our engineers and technicians and the regular reserve RCA servicemen we employ, and I played the tapes at random and asked the people what program was recorded with what type of monitor, and they were unable to identify any of them.

What I want to bring up here is that when you talk about a difference between Illuminant D and 9300, it is a very small difference.

FROM THE FLOOR: Is it an actual fact that a monitor set to D6500 is pinkish, and, if so, how do you convince other people that a black-and-white picture on a properly set monitor does tend to be pinkish.

MR. FIAT: Pink is only with respect to the surrounding. It depends where you have the monitor.

MR. JONES: May I suggest turning off the black-and-white monitor.

MR. FIAT: Actually, I have seen European stations which have set all of their black-and-white monitors with a sort of a varnish on the filter to bring the black-and-white and color out—the black-and-white,the same as the color monitor, and they have done even more. On all of their windows between the control room and the studio, they have, again, filters that the operator sees the studio from on top; it looks like Illuminant D.

FROM THE FLOOR: You mean a pinkish filter.

MR. FIAT: It is not pinkish, it is white. We are talking about Illuminant D. By daylight it is considered white. Compared to the surroundings, it looks pinkish because you have monitors that are cyan, they are green and blue, not white, but we have learned to accept it as a black-and-white monitor.

MR. ZWICK: I think the eye adapts to the brightest white in the viewing area as being white, and usually the black-and-white monitor is the brightest white in your scene when you are at a control panel.

D6500 is actually a perfectly acceptable white. I think if you look out the windows in the back of the room, that is pretty close to D6500 now. It is a white, but if you have something that is greener and/or blue-greener white in the view, that would look pink relative to it. It is all relative, and the question is if you turn off your black-and-white monitors, or if you put a filter over your black-and-white monitors as some people do, then, you do not have this adaptation, and your D6500 you will be accepted as the white.

FROM THE FLOOR: Perhaps what we need is to be sure what we are measuring is D6500. How do you establish that standard so that our measuring devices can be set on D6500?

MR. ZWICK: This is the problem in the construction of the measuring devices and is part of the cost of the measuring devices. There are at least four of them that I know of, one of them (possibly two) use fluorescent light sources as references with proper filtration. The others use tungsten lamps with controlled voltage and a special filter that has been calculated and measured with other radiomatic conditions.

So, you have to, then, have confidence in your reference which you are matching to. Then, from then on, it is just as simple—a simple optical device where you can compare in the same field the white window signal or something on the television monitor with a reference side from this source, and I think most of the time when I put one of these up against a station monitor, the station monitor has been quite green, as Gideon remarked, or blue-green compared to what this D6500 is, and you start cranking down the blue and green gains.

FROM THE FLOOR: We wish you would visit us when you return to Rochester. We are from Rochester, and we would like to discuss this with you.

MR. ZWICK: I should remark that our company has a program in which our technical representatives have been visiting the various television stations across the country, and one of the pieces of equipment they bring with them is a monitor comparator so when you view the film output, you have some monitors set correctly, and the interest in this device has been quite high, and most people feel pleased after the monitor has been set this way.

I think, it might be useful at this point to ask—I know the Canadian Broadcasting Corporation and the Canadian Telecasting Practices Committee took the lead in this thing several years ago, actually proposing that such tools were necessary. There was a paper several years ago on such an instrument. I wonder if there is anyone in the audience from the Canadian group who has had experience with monitor comparators; what the status is there.

MODERATOR ABEL: Do we have any representative of the Canadian group in the audience?

MR. FIAT: We don't. We are using the equipment that we designed by Dr. Machevsky at Central Dynamics originally. They don't make them anymore. We got good results except they were cumbersome and difficult to use, but we were able to match monitors very closely and were able to transfer those values to the customer's parameters as I mentioned earlier.

FROM THE FLOOR: I wonder if there is a filter available which will refer black-and-white monitors to D6500 so it will be adapted to staying that color.

MR. FIAT: Yes there is, and it is actually designed by the BBC. If you will write me, I have this information in my books.

MR. BERTERO: I understand the BBC has used a varnish, and painted the face of the tube with it. I haven't learned the formula, but if you use a cyanamide 54, I believe it is called (a pale rose), put that over your black-and-white monitor, and the black-and-white monitor must be of a high color temperature; something over 9,000 degrees or more that would give you a fair approximation of what Illuminant C is. You have to play with it.

MR. ZWICK: Are the black-and-white monitors standardized so it would apply?

MR. FIAT: No, they are not.

MR. JONES: Well, actually, it is very difficult to get a black-and-white monitor that is D6500. If you can firm them up with filters and get a lot closer quite easily, then, it is very worthwhile, but a black-and-white monitor as a set up standard for Illuminant D is bad. It is a miserable problem because the phosphors don't fall; nothing comes out even. The phosphors that are close all have something wrong with them. Either they burn easily or are not uniform. So, it is not at all a simple matter to make black-and-white monitors Illuminant D. Most monitors, at least ours, are close to the 9,300 of the black-and-white. Home receiver tubes sometimes are higher than that, 13,000.

MR. FIAT: I would like to bring up one point, that we are using continuously a term "color temperature." There might be people that are not familiar. This term is really used very loosely and can generally explain what white is, but they do not have color temperature at all, any of the monitors, and, actually, if you would use terminology of color values, even if it is white, you would be in much better shape. You would not have this confusion. You won't find people trying to measure, with color temperature meters, the white of the monitors as steep as they are in some places.

MR. ZWICK: I think that is an important point to emphasize that most color temperature meters—especially the two-color temperature meters, and even some of the three—are designed to measure continuous light sources like studio lights, and if you try to measure a phosphor display with the sharp peak distribution they have, you can be in quite serious error. You are not measuring color temperature as those instruments are designed. I think that is the reason for visual comparison with this rather than depending on that type of instrumentation.

FROM THE FLOOR: Mr. Chairman, as a Canadian, I have some further background on that. They certainly recommend all that has been said by the panel in regard to the monitor color temperature. They have gone one step further and recommended the practice of viewing which involves providing light surrounding on the monitor wall of D6500 at between three and five foot lamperage greatness so that the eye is based with an anchor of the proper color of light.

MODERATOR ABEL: Thank you very much, Panel, for appearing. We are appreciative of all of the comments.

Compatible Installation, Optimum Termination & Equalization & Debugging of Modern Stereo Phonographic Pickups

John J. Bubbers
Vice President
Field Engineering
STANTON MAGNETICS INCORPORATED
Plainview, New York

This paper has been written as the result of many inquiries which have been received, many of them showing that the use of modern phonograph pickups was not fully understood. It was considered important to present solutions to the most frequently posed questions since the broadcaster is confronted with many problems other than phonograph equipment.

The disc playback turntable is for most broadcasters one of the mainstays in his equipment lineup, yet there is much that could be done to bring this area up to date for many stations. Historically, the broadcaster has used magnetic phonograph cartridges. This paper considers the questions related to the magnetic phonograph cartridge.

HISTORICAL BACKGROUND

In keeping with the input circuitry of audio equipment, early pickups were low impedance, in the order of 150 to 600 ohms. The very low impedance moving-coil devices of the universal vertical-lateral type had transformers mounted in the arm to raise the impedance from 1/2 ohm to something usable, such as 150 or 600 ohms.

Concurrent with this era, from the earliest days to even the present time, equalizers were passive networks which were combinations of classical filter design and corner networks, all of which were somehow put together to achieve "playback equalization." Precisely what the recording curve used was a carefully guarded secret in the pioneer days so that, at best, most equipment manufacturers were hard put to design anything better than a good approximation of what was recorded in the disc. In addition, no two companies recorded with like equalization.

Not until standardization in the late 1930s was an attempt made to unify the problems of the great differences between recording curves. The NAB was one of the first to standardize with the transcription playback standard of 1942. Early playback equalizers were also faced with the problem of shellac surface noise. The equalizer switch, for those of you not exposed to these turntables, had such markings as "flat," "worn," "old," and later the NAB position.

All of this added up to a period up to 1942, during which no definitive lines were drawn for the record companies on standard equalization; concurrently, equipment manufacturers were hobbled, and ultimately the broadcaster was limited by the lack of what he could do in the way of supplying quality disc reproduction.

TYPES OF EQUALIZATION

The development of the early equalization was rather a cut-and-try method as indicated, but until the post-World War II era the designs were a combination of corner networks and "pi" or "T" sections for low-pass as in the case of 3500 Hz cut-off filters for scratch elimination. The impedance level was most frequently set at 150 or 600 ohms and the output was fed into a mike input with appropriate level equalizing pads or into an intermediate gain input designed for playback level (See Fig. 1.)

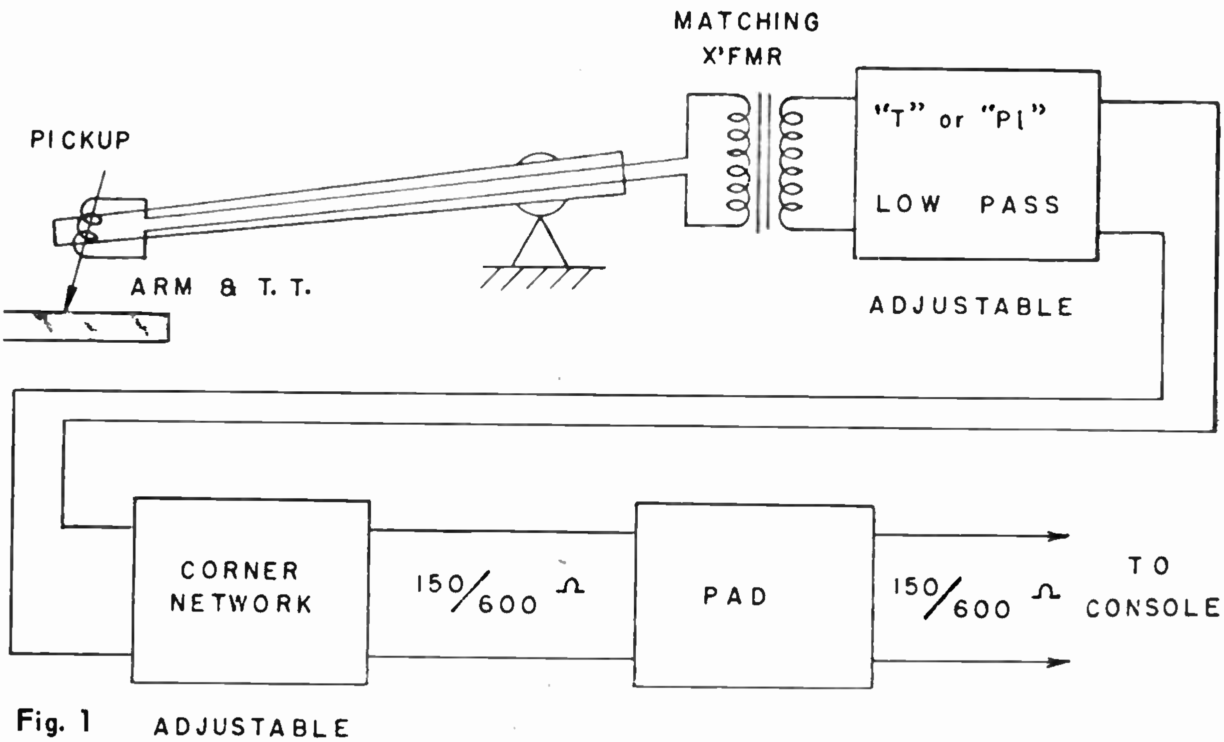

MATCHING
X'FMR
PICKUP
"T" or "PI"
LOW PASS
ARM & T. T.
ADJUSTABLE
CORNER
NETWORK
150/600 Ω
PAD
150/600 Ω
TO
CONSOLE
ADJUSTABLE

Fig. 1

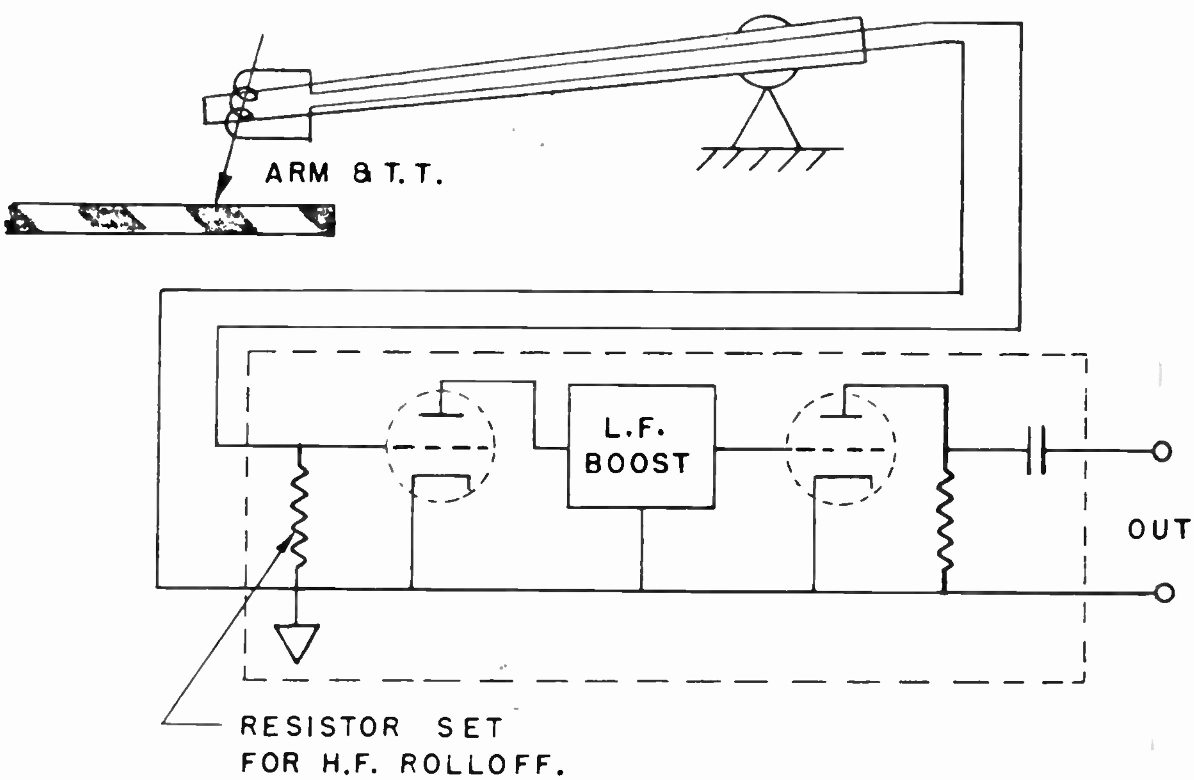

ARM & T. T.
L.F.
BOOST
OUT
RESISTOR SET
FOR H.F. ROLLOFF.

Fig. 2

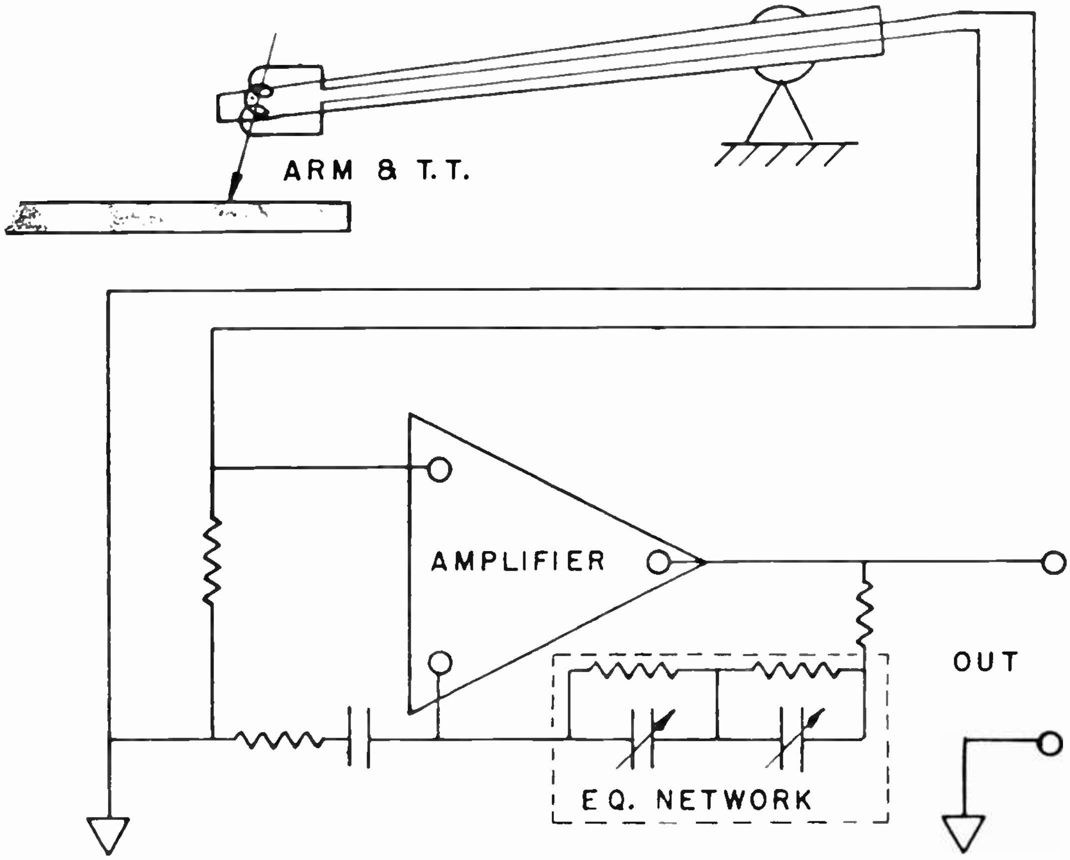

ARM & T.T.
AMPLIFIER
OUT
EQ. NETWORK

Fig. 3

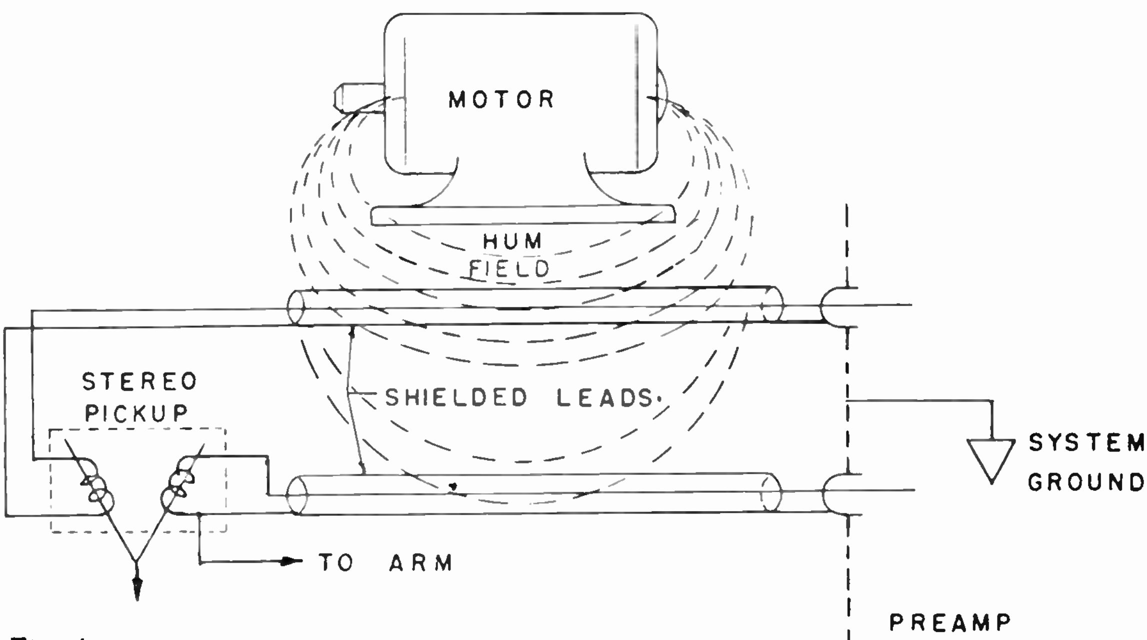

MOTOR
HUM
FIELD
STEREO
PICKUP
SHIELDED LEADS
SYSTEM
GROUND
TO ARM
PREAMP

Fig. 4

The advent of inexpensive magnetic pickups at the end of the War made available excellent quality pickups for the home user in the newly emerging era of the LP and the embryonic hi-fi industry. In order to make these pickups usable with the equipment in the home, an equalized preamp was made available which had its equalization limited to resistance and capacitance. There were no inductors since they were expensive and the cost to the home consumer would have been accordingly increased. Since adequate standards had been agreed upon, some of the guessing had been taken out of the equalizer design. High-frequency roll off was provided by loading the cartridge so that the inductance and the loading resistor gave a corner frequency of something about 2000 Hz and the low-frequency lift was provided by a resistance-capacitance network. Additionally, the preamplifier increased the output to about 0.5 volt which was adequate to be used in the auxiliary inputs of the old reliable "parlour radio." This design offered relatively high performance; however, the broadcaster who tried it soon found its major problems: tube noise and lack of adequate reliability. (See Fig. 2.)

Subsequent preamp designs went into the area of feedback to get rid of some of the noise problems of tubes and to stabilize the preamp with tube aging. It was then one simple step to include the equalization in the feedback loop of the amplifier so that the input was now loaded to terminate the cartridge. The standardized load was 47K. It is significant that the phonograph pickup now had a standard impedance into which it was to "look." The agreed upon termination value was 47K with a shunt capacitance of 275 pf. From the 1939 era to 1955, the tracking weight required went from 2 ounces, or 56 grams, to 5 grams, and the upper frequency response of the pickup from 4 or 5 kHz to 20 kHz or better. These devices were available at nearly every corner parts house. Stylus replacement varied in the new pickups but most of them had some sort of user stylus replacement feature, although not all offered this feature. (See Fig. 3.)

ADVANTAGES AND DISADVANTAGES

The early pickups offered a ruggedness that was in keeping with a tracking force requirement of 2 ounces. An armature would occasionally be shifted off center but, in most cases, it could be field repaired by a deft technician. The output was relatively high and the equalizers, being passive, added little to the noise except in those cases where inductors were set too close to hum fields. The performance was poor but really not any worse than most of the discs available at the time.

The active equalized preamp offered far better control over the response of the reproduction chain: however, it suffered the fault of adding tube noise. Transistors have eliminated the reliability problem and have provided a low-noise and accurately equalized system. Some of the equalizers even provide a trim control for trimming the high-frequency roll off.

From a pickup manufacturer's point of view, there are several points which, perhaps, need emphasis. Without the basic point of view of the transducer designer, it is our observation that less than the optimum result will be obtained.

It cannot be too strongly emphasized that modern high impedance cartridges are usually designed to be terminated in 4K with a maximum shunt capacitance of 275 pf. To use the cartridge inductance and low-resistance load to achieve roll off is no longer in keeping with the uniformity of performance of which the rest of the system is capable, nor is it in keeping with the basic design concepts especially in the area of stereophonic reproduction. With a properly designed system, the tolerances of the NAB standard for disc reproduction are easily achieved terms of response. It therefore, is important that the equipment and system designer use the concept of 47K loading and appropriate equalizer/preamp design if the optimum is to be achieved. (See Fig. 4.)

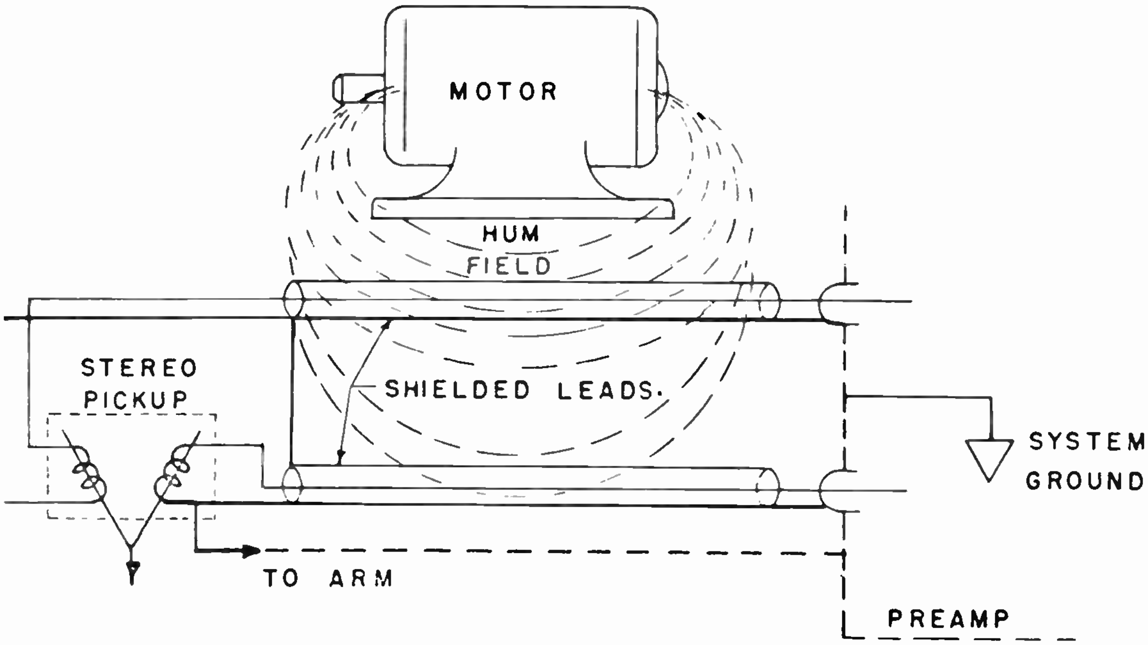

MOTOR
HUM
FIELD
STEREO
PICKUP
SHIELDED LEADS.
SYSTEM
GROUND
TO ARM
PREAMP

Fig. 5

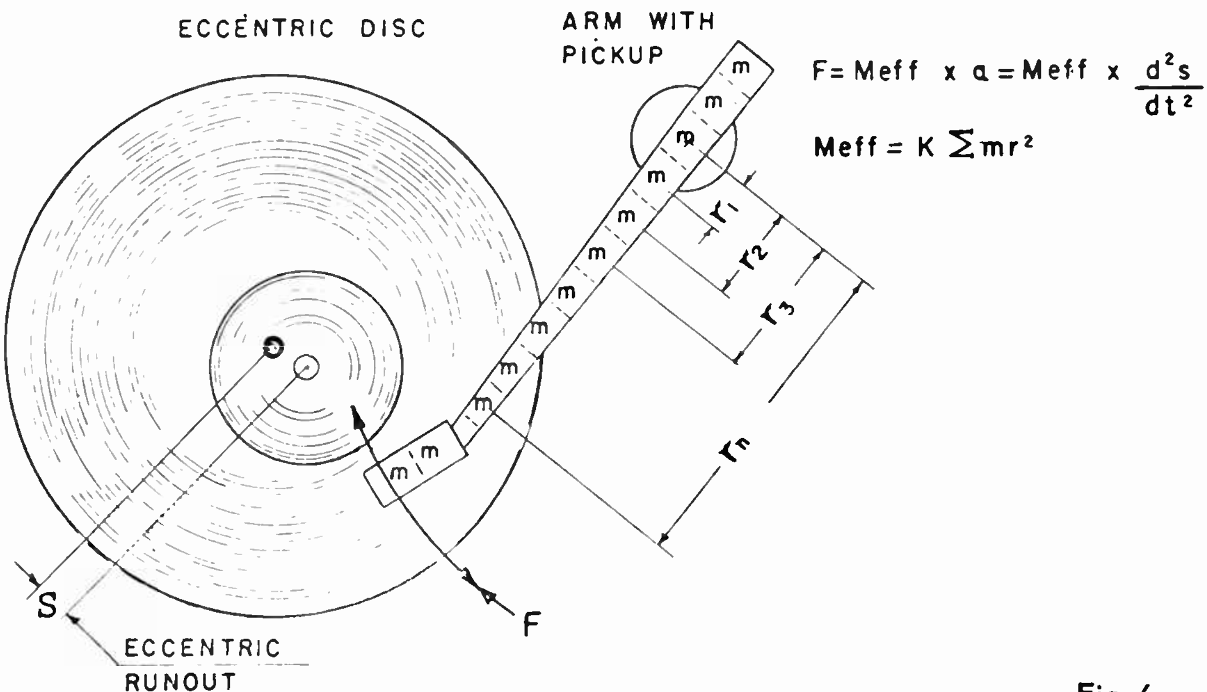

ECCENTRIC DISC
ARM WITH
PICKUP
F= Meff x a = Meff x $\frac{d^2s}{dt^2}$
Meff = K $\sum mr^2$
S
F
ECCENTRIC
RUNOUT

Fig. 6

STEREO PROBLEMS

The age of stereo has brought with it a new set of problems. The primary problem is one of ground loops. The use of two relatively low-signal level circuits from the pickup to the preamp, if not installed with the usual precautions of good grounding, will lead to ground loops and hum. This is not a difficult problem to overcome if the usual practice of a single-ground tie point is observed; the leads should be dressed to avoid any strong fields from motors or transformers. The grounding of the arm should be accomplished with a single positive lead to the head; the ground that relies upon continuity through the pickup arm bearings will inevitably have a problem since grease is generally a good insulator and the arm will tend to be intermittently grounded. (See Fig. 5)

Electrically, the method for tuning up a stereo system for broadcast use is well outlined in the 1963 NAB Standard. The requirements for frequency response are easily met with most modern systems and, for those who find they cannot meet the requirements, the solution will frequently be found in a new reproducer chain. The broadcaster who is less than meeting the standards runs the risk that the listener at home can frequently achieve better reproduction from his home disc reproducing system. If he once discovers this, I think that the tendency is to listen to good records than to the poor off-the-air broadcasts. The home units are frequently truly outstanding and at relatively modest investments so that the broadcaster is technically competing against the home unit. No longer is "broadcast quality" an undisputable hallmark.

PHONOGRAPH ARMS

No critique of playback systems would be complete without mention of the arm in which the pickup is housed. Low-tracking forces for the pickup have put new requirements on the arm. Since part of the force at which the arm is set is needed to keep the arm-pickup combination in the groove, the force required for things other than the pickup should ideally be minimized.

In the case of heavy arms compared to light arms, relatively additional force is required to move the arm either as the arm either as the groove proceeds to the center or to move the arm to and fro as in the case of an eccentric disc. In either event, massive arms are not desirable with modern low-tracking force pickups. (See Fig. 6.)

Although the diagram indicates the force from the acceleration of the arm in the horizontal plane, measurements indicate the vertical force resulting from the vertical acceleration attributable to warped discs as being a greater problem than the eccentric disc. The lack of flatness of the disc surface is a fact of life and, as disc users, we simply have to minimize this problem.

In the same vein, the use of 16" arms leads to effectively increasing the dynamic mass which the stylus must move. A longer arm for the same unit weight will result in a higher effective dynamic mass; hence, again, this should be avoided where possible. The 12" arm is far more desirable for reasons of lower effective mass. Where this is not feasible, the user should not attempt to use low-tracking force pickups since this will frequently be less than an ideally mated setup.

Much has been done in the area of viscous-damped arms and it must be recognized that the viscous-damping force must be overcome by the force available at the stylus tip. Again, the low-tracking force styli cannot be utilized since this combination will result in insufficient force to override the viscous damping. For high-performance, low-tracking force pickups, the viscous-damped arm is generally not suitable; on the other hand, the viscous-damped arm with a stylus at 6 to 8 grams might be a usuable combination in the studio dealing in the "Top 40" kind of format. (See Fig. 7.)

In the stereophonic installation, frequently side thrust from viscous damping or a

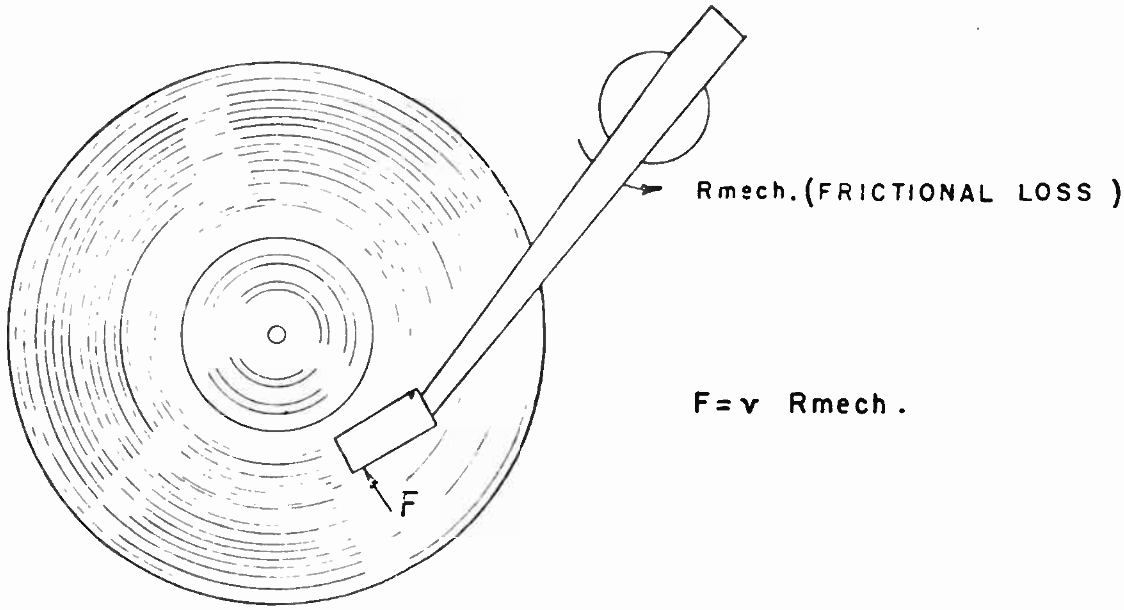

Rmech. (FRICTIONAL LOSS)
F = v Rmech .
F

Fig. 7

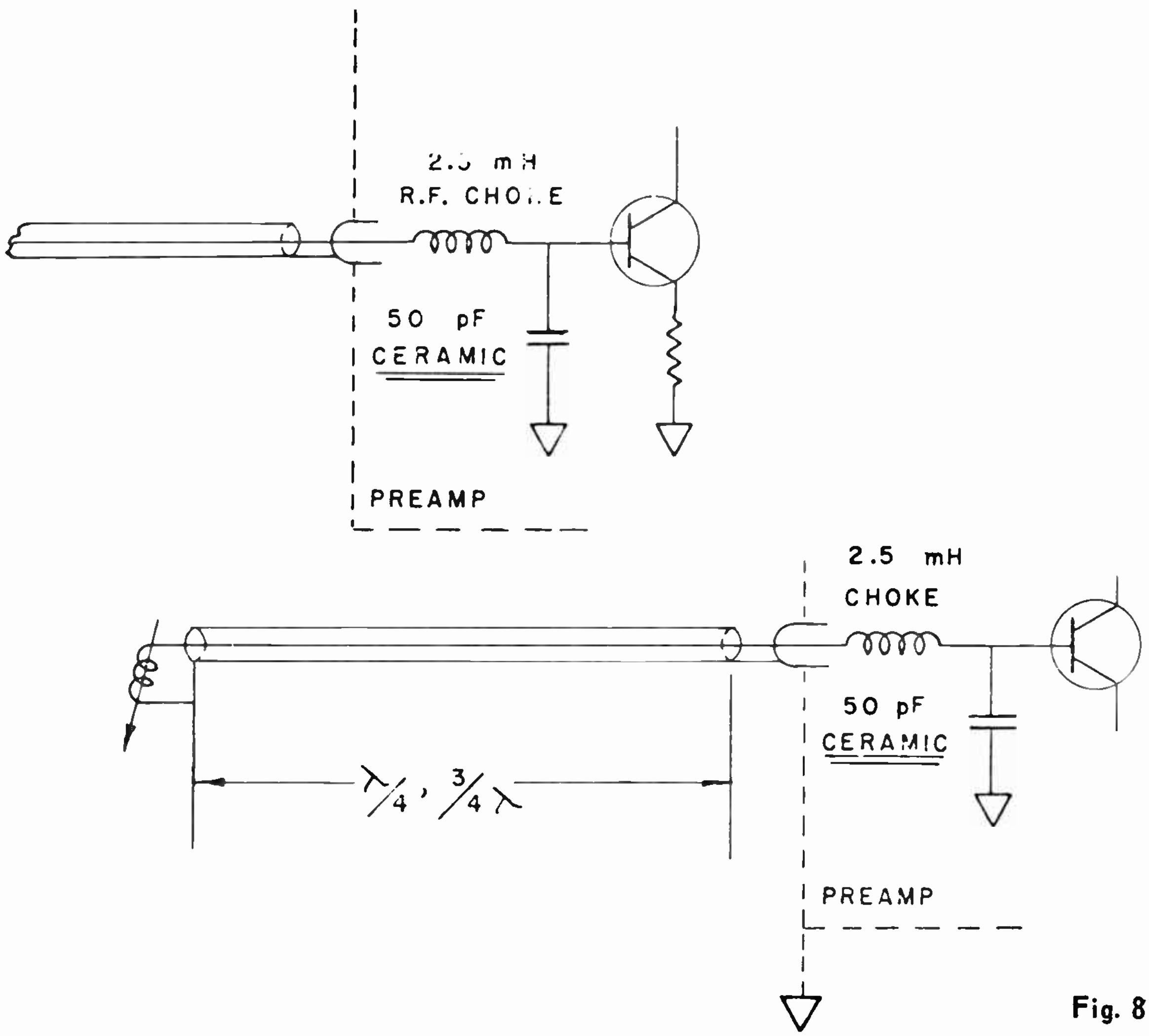

50 pF
CERAMIC
PREAMP
2.5 mH
CHOKE
50 pF
CERAMIC
λ/4 , 3/4 λ
PREAMP

Fig. 8

high effective arm mass will give rise to the separation degeneration or distortion resulting from loss of groove wall contact.

In summary, the arm should be considered as contributing to the reliability and performance of a playback channel, stereophonic or monophonic. The best pickup chain can be reduced to poor quality by an arm not adapted to the job at hand. Broadly stated, the less force required to drive the arm the better.

RF PICKUP & INTERFERENCE PROBLEMS

RF problems in phonograph pickup systems generally divide into two classes: the pickup of RF voltage and subsequent rectification in the preamp input stage and the direct rectification of the induced RF.

The rectifying characteristics of an oxided pin and clip are fairly well known; however, there are still many complaints from users which are easily cleaned up by the use of either mechanical brightening or chemical cleaning of the offending interface. The most desirable method of cleaning is, of course, to solder all junctions, although this is not recommended in the case of the connections to the cartridge. The broadcaster with a permanent installation may find the soldering of the remaining connections the best permanent solution to further maintenance. The elimination of an oxided joint in high potential RF fields is highly desirable.

Less easy is the elimination of AM RF interference from the preamp. Here, the RF induced in the lead is of sufficient amplitude to be rectified, generally, at the input device. The transistor with its nonlinear characteristics and sharp clipping when the input bias is exceeded is somewhat more critical than the vacuum tube was. Generally, a small ceramic capacitor in parallel to the input fitting on the preamp chassis will correct the situation. If this does not clean up the problem, the addition of a small resistor in the order of 1 to 5K in series with the input lead prior to the bypass should further attenuate the unwanted input signal. In the extreme case, the resistor can be replaced by an RF choke. (See Fig. 8.)

Occasionally, there are complaints of FM getting into the preamp. This means that the FM has somehow been converted to an AM signal and the leads from cartridge to preamp are suspect since they can form a quarter-wave section; if one is lucky, the FM-to-AM conversion takes place across this high Q section and the signal at the input of the preamp is now AM. The solution is as above, although more effective is the changing of the lead length to insure that no quarter-wave lengths appear. In this kind of FM interference, the lead length is the main culprit since the resonant characteristic of the lead length acts as an FM-to-AM converter.

As in the case of induced hum, the use of good and adequate grounds cannot be overemphasized. Anyone who has had to struggle with low-level audio in RF fields is aware that no one solution is good for all situations; however, the practice of heavy station ground systems to reduce potential buildup is still the basis for at least a uniform ground. Beyond this, the individual situations must be worked out.

LIFE EXPECTANCY

In the area of phonograph stylus wear much has been published in the way of data—some scientific, some folklore and some advertising. The mechanisms of wear are no different from those of any classical system of abrasion. The factors are the coefficients of friction, the normal force available at the interfaces, and the hardness of the materials. These are the primary parameters.

It is commonly believed that since diamond is the "hardest material known to man" that it is uniformly hard and will not be worn by a softer material. Neither idea is true. The fact is there are certain diamonds which will wear better than others and the softer materials will abrade the diamond tip at a lesser rate than a harder material (compare vinyl discs to shellac).

As a practical problem, the storage of discs is best done to exclude dust and dirt which will increase the wear of both disc and stylus tip. Most modern discs are made of vinyl and cause a minimum of wear.

The tracking force on the stylus will increase the normal force; hence, the wear. While this statement sounds as if the tracking force should be reduced to an absolute minimum, the trade-off in reliable performance must be considered. Bearing friction and viscous damping will additionally add to the wear of the stylus tip. All of this then leads to an obvious question.

How long will the diamond stylus tip last? As in grounding, there is no pat answer. With a sufficient amount of abuse, a stylus can be destroyed in a few hours and, yet, with a sufficient amount of care, will last 500 to 1,000 hours. The best insurance is, of course, to keep a log or return the stylus for inspection to the manufacturer; most manufacturers maintain a free factory service. The cost of a replacement is far less than the potential cost of ruined discs.

One added word of caution: The care of modern styli does NOT include cleaning the assembly with any of the commercially available fluids. These cleaners and modern styli are NOT compatible, and their use will lead to partially if not complete disintegration of the armature assembly. The best care is still a clean environment and, if there is a buildup on the stylus, it can be carefully removed with a gentle swabbing with a dry "Q Tip."

FINAL PERFORMANCE EXPECTATIONS

With a modern playback system, the frequency response will be well within the requirements of the NAB Disc Playback Standard of 1963. The channel separation will most likely be beyond the measuring capability of the average user. With discs recorded at standard levels, the distortion contribution of the playback system will be negligible. Hum and noise should be below -50 db referenced to 5 cm/sec.; lateral at 1 kHz. As a matter of fact, it is not infrequent that the tape noise from the master tape is discernible on the finished disc.

Periodic maintenance and replacement of the stylus will give long trouble-free reproduction of the discs available in the radio station and at a cost lower than that of earlier times with better than ever quality.

CONCLUSION

The necessity for a good disc playback setup is a pragmatic problem for the broadcaster. In earlier days the quality of home equipment was limited and the broadcaster had a virtual monopoly on good-quality playback systems. The growth of the hi-fi industry and general affluence have improved home equipment to where much of it performs at a level equal to a good broadcast setup. The receivers and speaker systems available in the home will ofttimes show up broadcast system limitations. The broadcaster today is literally competing with the home playback system for the attention of the listener.

The modernization and maintenance of the disc playback system is relatively inexpensive, while the rewards in listener acceptance cannot be overemphasized. Conversely, the well-equipped listener with his state-of-the-art receivers and loudspeaker systems can become an appreciative recipient of quality phonograph disc reproduction.

Digital Integrated Circuits Are Easy

Danny Coulthurst
Vice-President for Engineering
INTERNATIONAL GOOD MUSIC, INC.

This paper deals with the ease of learning and maintaining digital electronics using integrated circuits. It takes the technician who has had no experience with digital electronics other than a switch or relay and attempts to coax him into experimenting with the basics of ICs, including bipolar gates, MSI, and MOS ICs as memories. These are things he will have to know in maintaining some of the newer equipment now coming on the market.

The new decade is upon us. So is the expanded use of ICs. The 1960s were the years that saw the perfecting of the IC and saw the prices drop where they could be used in other than military projects. ICs are now being used in the smallest portable radio and in the largest computers. They have been used for a number of years in broadcast equipment and recently have been used so extensively that the technician who services this gear must realize that, just as the transistor, the IC is here to stay. Most of us have worked on equipment that has an IC or two and have just sort of ignored it in hopes that it would go away or at least not create any problems. We are not used to looking at schematics that look more like block diagrams and ignore the fact that these little devices called ICs are filled with all sorts of electronic components, and we don't know what they do. Somehow, we have to tell ourselves that we don't really care what is in the IC, rather is it doing the job it is supposed to do or does it need replacing?

In the last few years, we at IGM have been using ICs in our automation equipment. Until now these have been digital ICs. We find that many technicians are afraid of them, just as IGM was when we first got started. I'm sure that you will find, as we did, that they are easy to work with. I'd like to talk about some specific types of ICs. ICs that are getting quite popular with IGM and other segments of the electronics industry. First, we should be sure that everyone knows what an IC is. Most of the current ICs are monolithic devices. The dictionary says that monolithic means, "consisting of one stone." So a monolithic integrated circuit is one where all the circuits are formed on one silicon chip. As a general rule, it can be stated while it has taken years to bring the IC industry up to its present position, for the man in the field ICs are easy!

Easy to maintain

Easy on the pocketbook

Easy to learn

Easy to design

And reliable, too.

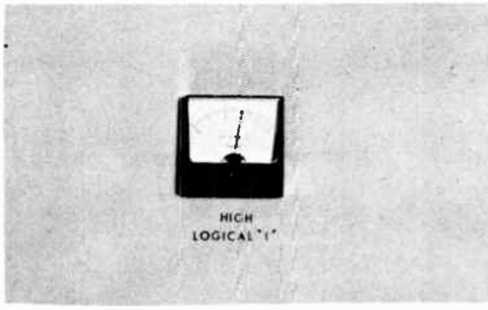


Fig. 1

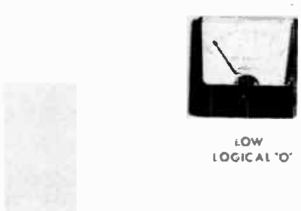


Fig. 2

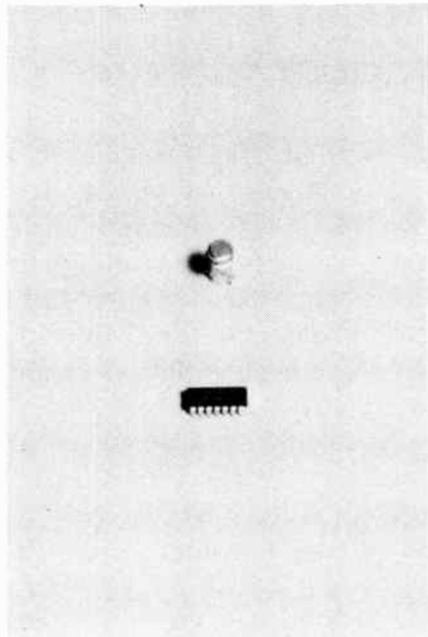


Fig. 3

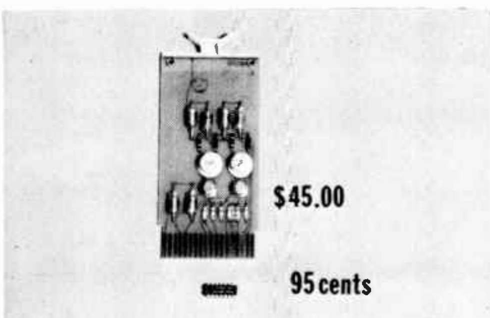


Fig. 4

Fig. 5

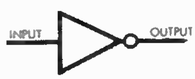


Fig. 6

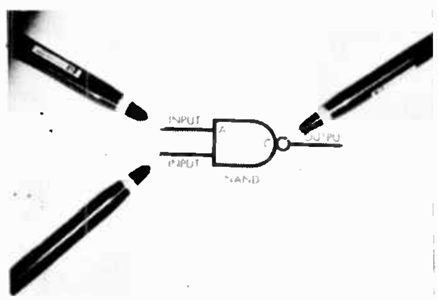


Fig. 7

NAND

A	B	=	C
0	0	=	1
0	1	=	1
1	0	=	1
1	1	=	0

Fig. 8

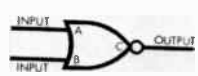


Fig. 9

Let's take a look at it one at a time.

Easy to maintain:

The experts behind the scenes at IC manufacturers, such as National Semiconductor, Fairchild, or Texas Instrument, are designing unbelievable reliability into each package. This means that very little maintenance is necessary when ICs are used extensively. We have built and installed systems where the IC count went up to five or six thousand, with only a few failures, and these occurred just after installation. If there are problems, they are easy to locate with the simplest of voltmeters or one of the new logic probes that are about the size of a fountain pen. I say this because the majority of ICs are gates, where highs and lows on the inputs in various combinations produce highs or lows on the outputs. In the static condition the voltmeter will maybe read three volts if there is a high (Fig. 1) and very little (under a volt) if there is a low (Fig. 2).

If the IC is bad, unsolder it, or unplug it, and throw it away. Generally, they are so cheap that you hardly worry about warranty (Fig. 3). Of course, there are ICs more complicated than gates.....like various types of counters, which are nothing more than one or more flip-flops, designed by experts in their field and reduced down into a little silver or black package or can. Some of the newest devices are MOS ICs. (The manufacturers can't even agree on what those letters stand for. Metal oxide semiconductor or metal oxide silicon.) The dynamic shift registers that we use for memories need a scope to check their operation, but if they are built on plug-in cards and there is suspected trouble, substitute a spare card and return the defective one to the manufacturer for repair.

Easy on the Pocketbook:

Equipment being built today with ICs could not have been sold two or three years ago because of the expense of designing with discrete components, such as resistors, capacitors, relays, or transistors. Let's make a couple of comparisons.

Five years ago I bought a flip-flop on a circuit card. It cost about $45. Today, we buy two flip-flops in one IC for $1.90 or 95 cents for each one (Fig. 4). Our older equipment uses relay logic. Good relays cost up to $3 in quantity. (See Fig. 5.) We now buy quad-two input gates for 70 cents or about 18 cents per gate. In other words, fairly complex equipment can now be built for a small fraction of what it would cost using relays or other discrete components.

Easy to Learn:

It isn't any harder to circuit trace ICs than relay logic. Remember, it's like a switch, either on or off. There is no in between. Sure it takes awhile to design complex circuitry, but after someone has it working, any technician who can operate a voltmeter and a soldering iron can trace down most problems quite simply. Let's look at some logic.

This is about the simplest form of logic. It's called an inverter (Fig. 6). If there is a low on the input, there will be a high on the output; and conversely, if there is a high on the input, there will be a low on the output. The little "O" shows the inversion. Now let's look at practically the same device with another input added. This is a NAND gate. This gate takes a high on both inputs to produce a low on the output. If there is a high on only one input or none of the inputs, the output remains high. Fig. 8 is a truth table for a NAND gate. A and B are inputs, while C is an output.

If A and B are low, C is high. If A is low and B is high, C is high. If A is high and B is low, then C is high. If A and B are both high, C will be low. The only condition where C is low is when both A and B are high.

Fig. 9 is a NOR gate. Notice that the symbol is somewhat different for a NOR gate than a NAND gate. Both have two or more inputs and a single inverted output, but the body of the symbol is shaped somewhat differently. If either or both of the inputs are high, then the output will be low. If you think of it as, "If input one or input two is high, the output will be low." Remember, the "OR" in an "OR" or "NOR" gate and the "AND" in an "AND" or "NAND" gate.

Fig. 10 is a truth table for a two-input NOR gate. Again, A and B are inputs, while C is the output. If A and B are low, then C will be high. If A is low and B is high, then C will be low. If A is high and B is low, then C will be low. If A and B are both high, then C will be low. In a NOR gate if either or both of the inputs are high, then the output will be low.

When he first looks at a logic diagram, many technicians sort of freeze up.....like the radio repair man who has been repairing AC/DCs and gets his first color set.... but this is where the similarity ends. One of the leading manufacturers of ICs puts the guidelines for one series on a single small page. Most people can grasp the basic rules in a few minutes.

Just a short time ago, if a logic design engineer wanted a flip-flop, he had to spend a lot of time making one work, then laying it out for the drafting department to make into a circuit card. Today, he just lists a number for the IC he has chosen, the drafting department sticks a little tab on their drafting paper (Fig. 12), and that circuit is complete. Most companies (including IGM) get hooked on a certain style case and a particular series which makes that selection easier. Also, manufacturers of these devices have gotten together and made many series compatible. Just as 12SQ7 tubes of all manufacturers are interchangeable, so are certain series of ICs. This helps servicing in the field as well as making manufacturers very competitive, passing the savings on to the customer.

Let's now talk about some of the terminology used in ICs. There are three basic types of bipolar logic, RTL, DTL, and TTL. RTL means that basically there are resistors and transistors in the makeup of the IC logic. "R" for resistors, "T" for transistors, and "L" for logic, hence, RTL. DTL is diode transistor logic, while TTL is transistor, transistor, logic. TTL is the newest family of bipolar logic and has many advantages over the other types.

#1. It is the fastest of the three families. As digital electronics becomes more sophisticated, it becomes desirable to get more speed out of the logic devices so that large, complicated data is not slowed down in the computing process. Computer manufacturers are constantly trying to get higher speeds and are now picking TTL logic.

#2. TTL is fast becoming the cheapest. Now that the manufacturers of these devices have much of their R and D costs recovered from these devices, the prices are really nosediving. Just a few months back we were paying $1.40 for TTL gates. Now in reasonable quantity they are down to 70 cents. (It's rumored that the cost in parts of an IC is just a few pennies.)

#3. As I previously mentioned, there is direct interchangeability between different manufacturers' devices with the same number. For instance, IGM uses the SN7400 series of TTL ICs. We are able to buy this number from various manufacturers.

#4. TTL is less susceptible to unwanted noise. Noise, whether from a transmitter in the form of RF, the AC line, static electricity, or other man-made forms, can falsely trigger logic circuits. Using manufacturers' recommended procedures, TTL has good noise immunity compared to other families of logic.

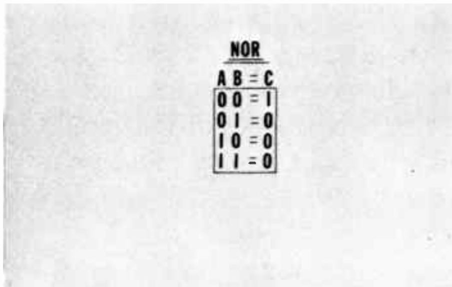


Fig. 10

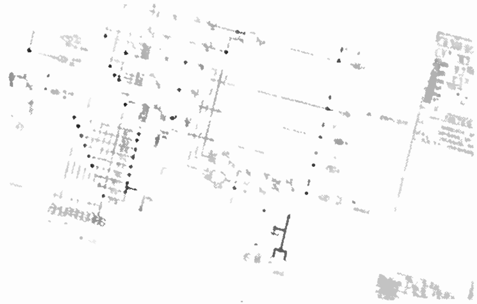


Fig. 11

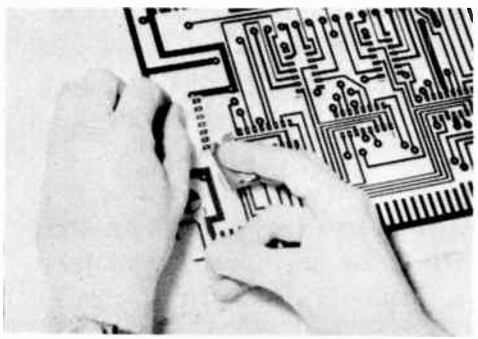


Fig. 12

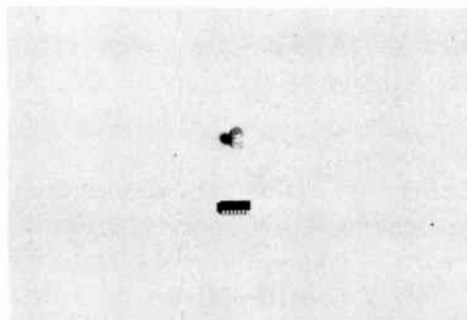


Fig. 13

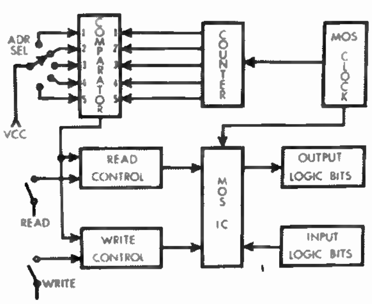


Fig. 14

Fig. 15

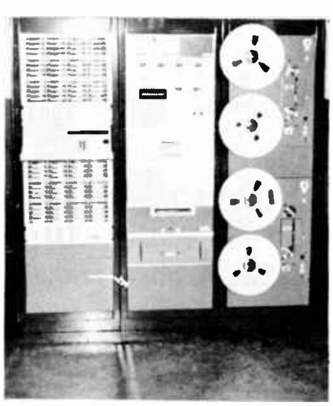


Fig. 16

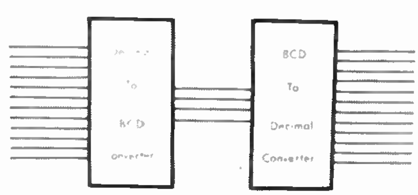
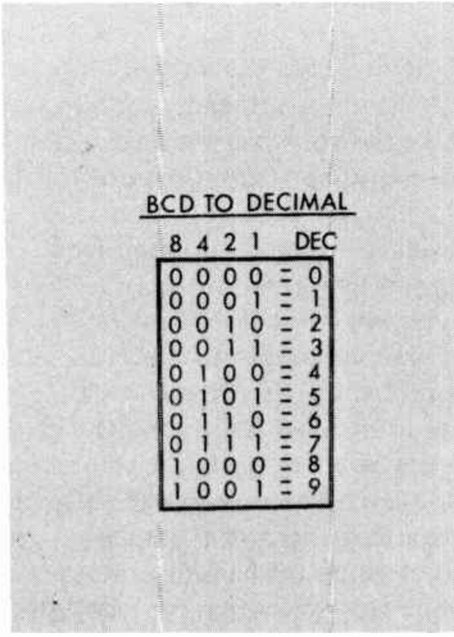


Fig. 17



BCD TO DECIMAL

8	4	2	1		DEC
0	0	0	0	=	0
0	0	0	1	=	1
0	0	1	0	=	2
0	0	1	1	=	3
0	1	0	0	=	4
0	1	0	1	=	5
0	1	1	0	=	6
0	1	1	1	=	7
1	0	0	0	=	8
1	0	0	1	=	9

Fig. 18

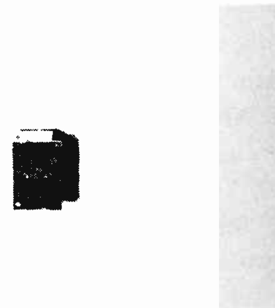


Fig. 19

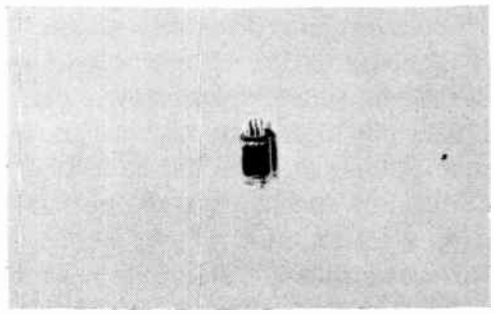


Fig. 20

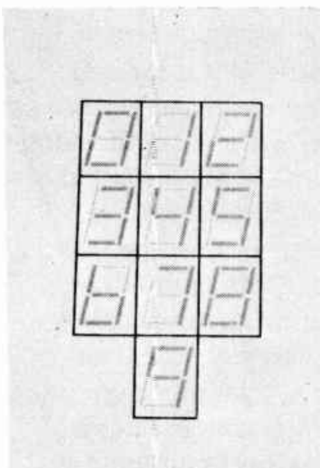


Fig. 21

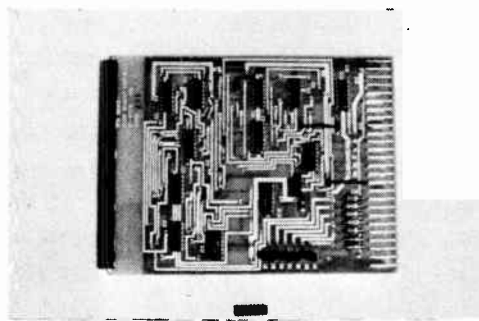


Fig. 22

#5. There are more multifunction arrays with TTL than with the other two families and more are being manufactured every day. This helps the designer, who now doesn't have to worry about putting together a whole lot of gates or other devices to make up a function or functions. These multifunction devices cost more than gates but far less than would have been spent in making up individual devices to make up the circuit. TTL is the newest family, and manufacturers are spending more time and effort in their development of this product. This gives the design people more efficient use of their time. Many of these devices are classified as MSI, meaning medium scale integration.

So far, we have been talking about ICs used in gating plus flip-flops as counters. Flip-flops can also be used as memory devices. If it has flipped to one side, it might produce a high (sometimes referred to as a one) and when it flops to the other side, it could produce a low (sometimes referred to as a zero). This then could memorize and store information fed into it. One or more flip-flops are designed into a single IC and are handy for small memories but get expensive if the memory gets large. (Fig. 13 is a picture of a dual in-line and a T05 can.) This is because each flip-flop costs in the neighborhood of 95 cents per bit of memory, and compared to other memory devices, takes up quite a bit of space. The definition of bit is a binary digit. One or more bits used together in a common function may be called a word.

Recent innovations in memories include the MOS. Each device can store from 50 to 200 bits, while manufacturers of such devices such as National Semiconductor are planning to stuff many more bits of memory into each can in the very near future. These cans are all interchangeable, which means that you can jump from a memory of say 50 to 200 by just changing the IC. The great part is that the cost per bit in quantity is around a dime, and coming down fast. It is expected that these memories will be down around one cent per bit in the near future. When using the dynamic MOS shift registers for memories, some precautions and added circuitry are necessary. First, it should be understood that there is only one input and one output to the MOS memory. Inside the can the bits are lined up serially... in a row. If you pulse the device at say 100,000 times a second and there are 50 bits in a MOS IC, each bit of information will reach the input and the output 2,000 times each second. If we attach a 50-step counter (probably an MSI TTL counter) to the line that is pulsing the MOS that will count to 50, we can tell when each bit reaches the output of the MOS.

To this let's add a comparator (Fig. 14). A comparator, just as its name implies, takes two different logic sources and produces a signal when the two compare. Let's also add a selector switch to set up a location, usually called an address. This selector switch feeds one input to the comparator, while the counter feeds the other input. If we now set the switches at say 25, when the counter gets to 25, the comparator will send out a pulse. This pulse can be used to see what is in step 25 or to insert new information in that address. We don't have to wait long for the MOS to step around either. The longest period would be one 2000th of a second or 500 microseconds after we set up the switches. We can use the MOS memory for many purposes.

The IGM Instacart is a good example (Fig. 15). We are able to store commands for the next 200 events. We can select any of 48 trays in up to 7 Instacarts or up to 336 locations in 200 addresses. These instructions are entered into the memory via a keyboard and are stored in MOS memory until erased when new instructions are entered into the memory. To return to some previous terminology, this particular unit has 200 addresses. Each address has 12 bits to memorize the programming data. Thus, this device uses a 2400-bit memory (200 x 12) or we can say that it is a 200-address memory, using 12 bit words. It is necessary with MOS dynamic memory that the pulsing or stepping, but usually called clocking, never stop or the memory will be lost. To be sure that the memory is not lost due to power failures, a battery or batteries are placed across the power supply. Now, if the power goes off up to a quarter hour, the batteries will keep the clock operating so that the memory is not lost.

Since IGM first started designs using the dynamic MOS, a static MOS memory has become available. The difference here is that you do not have to continually clock the device to keep its memory. There are a number of disadvantages, however. Because it takes more area on the chip to make a static memory rather than a dynamic one, fewer bits are possible in the same size can. Just as in the dynamic memory, current must be supplied to hold the memory, and more of it. It is still necessary to clock the device to read information in or out of it, and last but not least, the cost per bit is about 50 per cent higher for the static memory.

I'd like to talk a little about various codes used in digital logic. The main purpose of a code is to conserve parts and wiring. For instance, suppose we want to light 10 lamps in the decimal system. We also want to memorize which lamps have been lit. This means that we need 10 memory devices, plus 10 sets of all of the electronic components to make this circuit operate.

One of the most popular codes is the binary coded decimal system, usually referred to as BCD (Fig. 17). In this system, only 4 memories and other devices are necessary to produce 10 digits. In other words, only 40 per cent of the components are necessary to produce the same results. In a standard 8-4-2-1 BCD code, a 1 is A 1, a 2 is A 2, while 3 is 1 and 2. A 4 is A 4, a 5 is A 1 and 4, and so on. One or more combinations of the 4 BCD digits gives you 10 different functions. It used to be quite complicated to convert from decimal to BCD and from BCD back to decimal. Now, an IC does it for you. For instance, an SN7442 TTL IC directly converts BCD to decimal. Four wires on the input control 10 different functions on the output. This doesn't sound too important, but remember that you only need 40 per cent of the components when using BCD rather than decimal. The larger the system, the more significant this is. I have only talked about one code...the 8-4-2-1 BCD. This is probably the most popular of codes and most MSI for code conversion is designed with this in mind. Switches, too, are designed with BCD directly out, using 8-4-2-1. The numbers refer to the weight of each digit. The first digit is 8, the second is 4, the third is 2, and the fourth is 1.

Fig. 18 is a conversion table of decimal to 8-4-2-1 binary coded decimal. The one means that the line is high, while a "0" means that the line is low. It can be seen that this code can perform 16 different functions from the four digits, (0000 to 1111) however, the combinations past nine would not be used in direct conversion to decimal.

The operator must have some sort of readout (Fig. 19) so he can see what is in the logic. The simplest is a lamp on each of the logic lines, but remember we are trying to read this in BCD. This would be hard to read as we don't normally think..... light one is out, light two, three, and four are on....that's seven. There are much better ways to read out this information. Two such displays are quite popular, the nixie tube and the seven-segment display. IGM has been using the seven-segment display and it seems to be a good choice. New seven-segment displays have recently been designed at lower cost, such as the RCA DR2000 series (Fig. 20). This readout sells for about $3 in quantity and looks like a 9-pin tube. The seven segments are viewed from the side. The readout is bright and has an expected life of 100,000 hours, which is over eleven years of continuous burning. From the diagram (Fig. 2.) it can be seen how the numbers 0 through 9 can be displayed with 7 bars of light. In a seven-segment display, the numbers are bright and bold with nothing in front of each bar to shadow the light on any digits.

At first it would seem difficult to convert the four digits in a BCD code to the seven bars of light, and up to a short time ago, it took a whole printed circuit card. Now one IC does it for us (Fig. 22). You feed BCD in, and out comes the necessary drive to operate a seven-segment display. In addition, the IC has a test position to check that all segments are working. In addition, there is zero blanking. This feature allows the design engineer to blank our zero's where they are insignificant. In other words, instead of having a number like 009, with zero blanking, all that would be shown would be the 9. This is all done with TTL, MSI, ICs. Remember what that all stands for? Transistor, transistor, logic; medium scale integration; integrated circuits.

Let's once more go over the things we have talked about. The thing I'd like you to remember is that digital ICs are very easy to learn and work with. We can forget all about resonant circuits, bias, equalization, and all the other multitude of problems that you are used to working with. It is a little difficult at first to let the design engineer worry about what goes on inside the ICs and just forget it. We aren't used to operating that way generally. However, if a tube or transistor failed, very few of us ever took one apart to try to repair it. We must think of ICs the same way. Even if we could get it apart, we couldn't do anything about it. So, forget about being really concerned with what's inside an IC. The information is available if you're the curious type, but in servicing it really isn't necessary. Think of schematics more as block diagrams than of schematics. Maybe then you won't have to worry about what's inside. It's a new way of thinking but really easier in the long run. If you aren't getting the proper high or low where it should be, I'd first look at connectors, power supplies, solder connections, etc., before changing the IC. The problem is probably elsewhere. ICs are here to stay and they are getting more reliable and less expensive every day.

Static Electricity On AM Towers

By
Robert A. Jones

The subject of this paper may sound overly simple and it may be something about which you may think you already are completely familiar. This may be true, but I've found it helpful to review from time to time, those subjects which we think we know all about. There may have been some new ideas or concepts developed and I trust my talk will teach you something new or at least review your past knowledge on this subject.

The beginning point for any talk is to first define or describe the subject. Let's see if we can define what static is, or can do, with respect to AM towers. Static electricity on an AM tower is the effect caused by a gradual build up of negatively-charged particles on guy wires and towers. These particles can be created in several ways, the most obvious being that caused by lightning strokes in the close vicinity. Another common way is by rain or snow. Many times heavy static can be caused by an approaching storm, even before the rain or snow reaches the tower. In cases like this the charged particles are carried on the wind, in front of the storm.

The Greeks were the first to discover that when they rubbed amber (the fossilized resin from an extinct pine tree) they could cause hair to stand on end and bits of cloth to be attracted. The Greek word for amber was elektron. That name has stuck with us and, with a slight change in spelling, is the word we use today to represent a negative charge of electricity.

Certainly you all remember Ben Franklin's famous kite-and-wet-string experiment. His experiment proved the electrical nature of lightning. Another such experimenter was not so lucky. George Richman of Sweden was electrocuted attempting a similar test.

Fig. 1 shows a typical thunderstorm map. The isobars represent the average number of "thunderstorm days" to be expected in various parts of the country in a typical year. As you will notice, the State of Florida has the highest average.

Fig. 2 represents the three major causes of static accumulation on AM towers. These are lightning, rain or snow, and wind-laden particles. These negative charges will collect and build up on towers and guy wires (Fig. 3). Those charges that build up on the tower itself, normally will bleed off to ground through RF chokes or the tower-lighting choke neutral wires. These negative particles that accumulate on the guy wires cannot bleed off to ground, since the Johnney-ball insulators block them. As you all know these charges build up until bang! They jump across the insulators. What normally happens, if you've ever stood outside and watched, is that all insulators appear to flash simultaneously. Actually, they don't. Somewhere one insulator breaks down first. The radiation from this first arc, traveling with the speed of light, trips the others which explains why they all appear to flash simultaneously. It should be pointed out that the guy wires at the guy anchor points should be grounded securely. This will lessen the danger of fracturing the insulators.

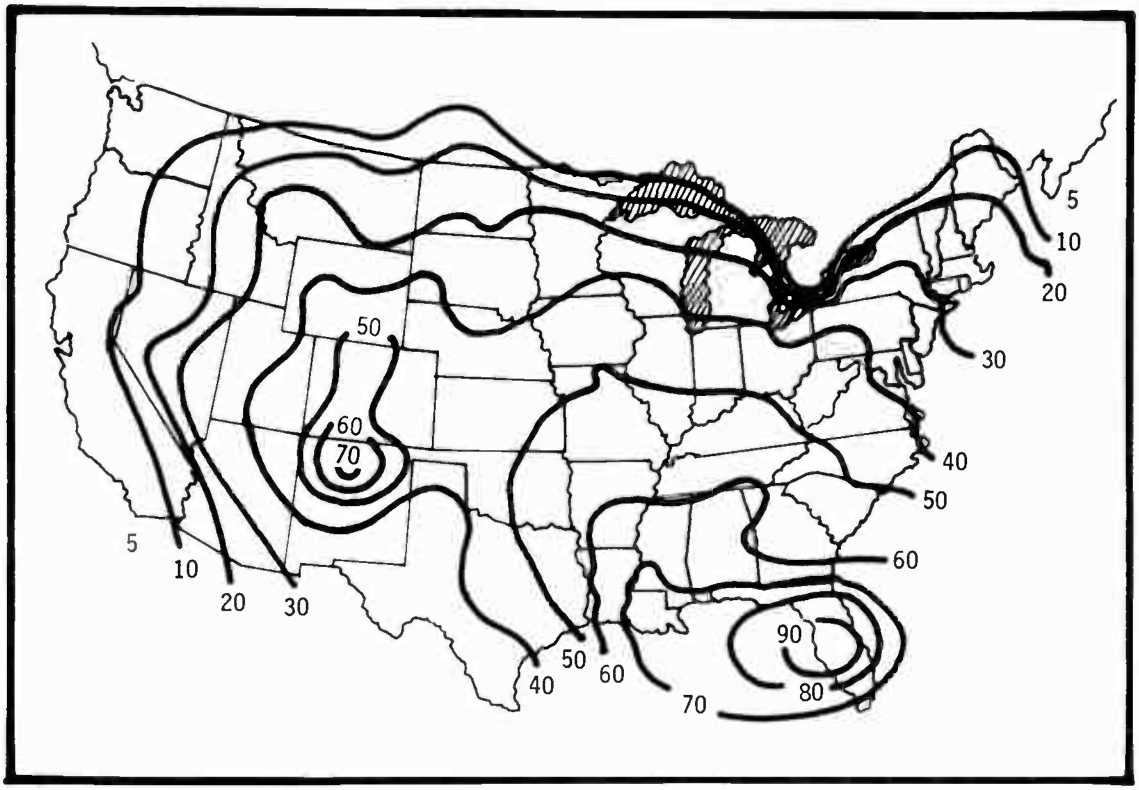

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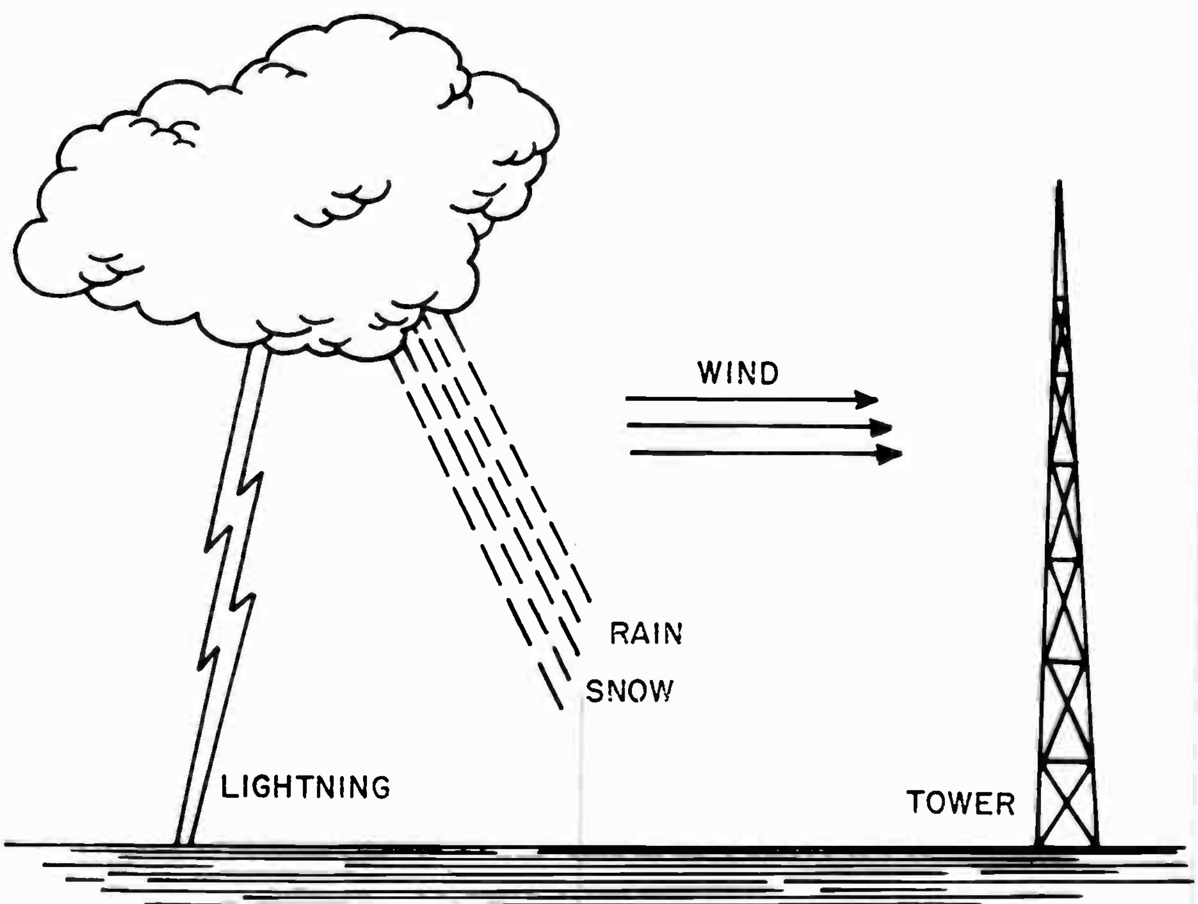
Fig. 1


WIND
RAIN
SNOW
LIGHTNING
TOWER
Fig. 2

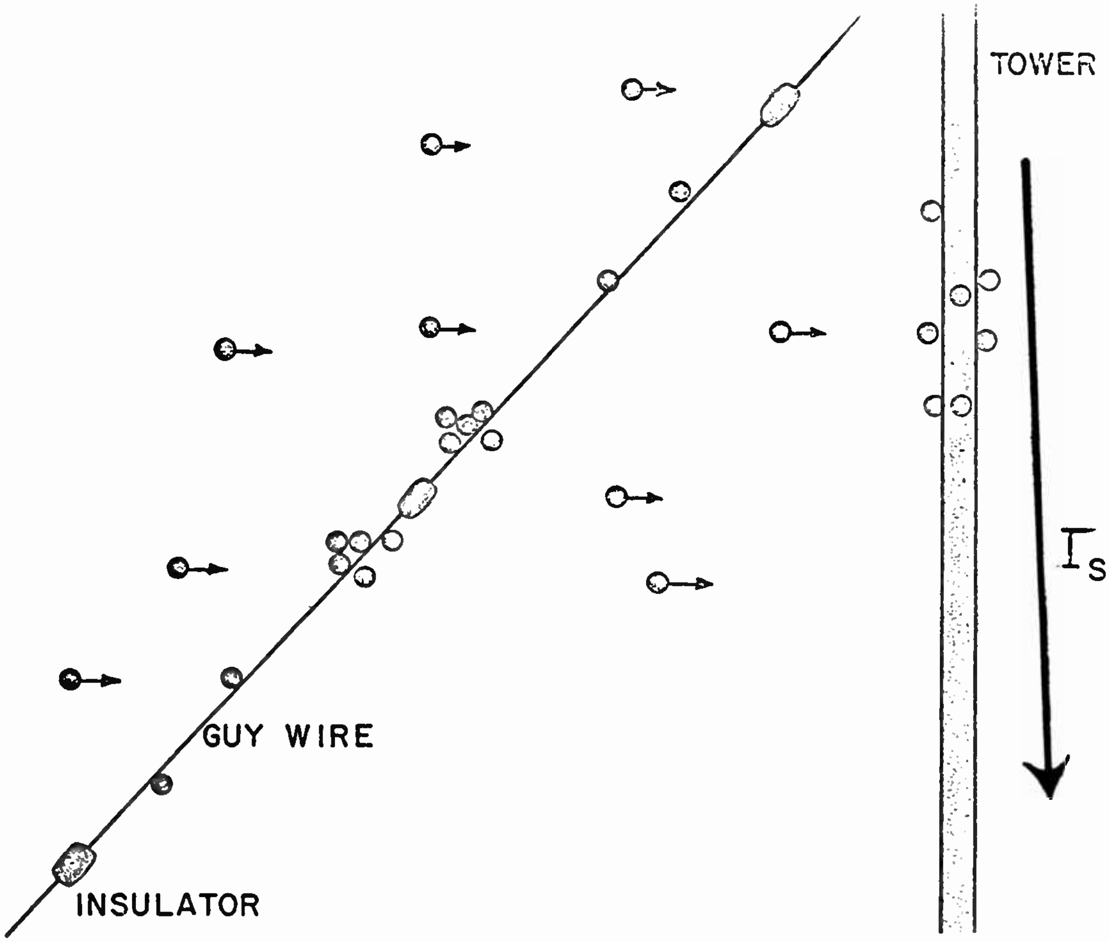


Fig. 3

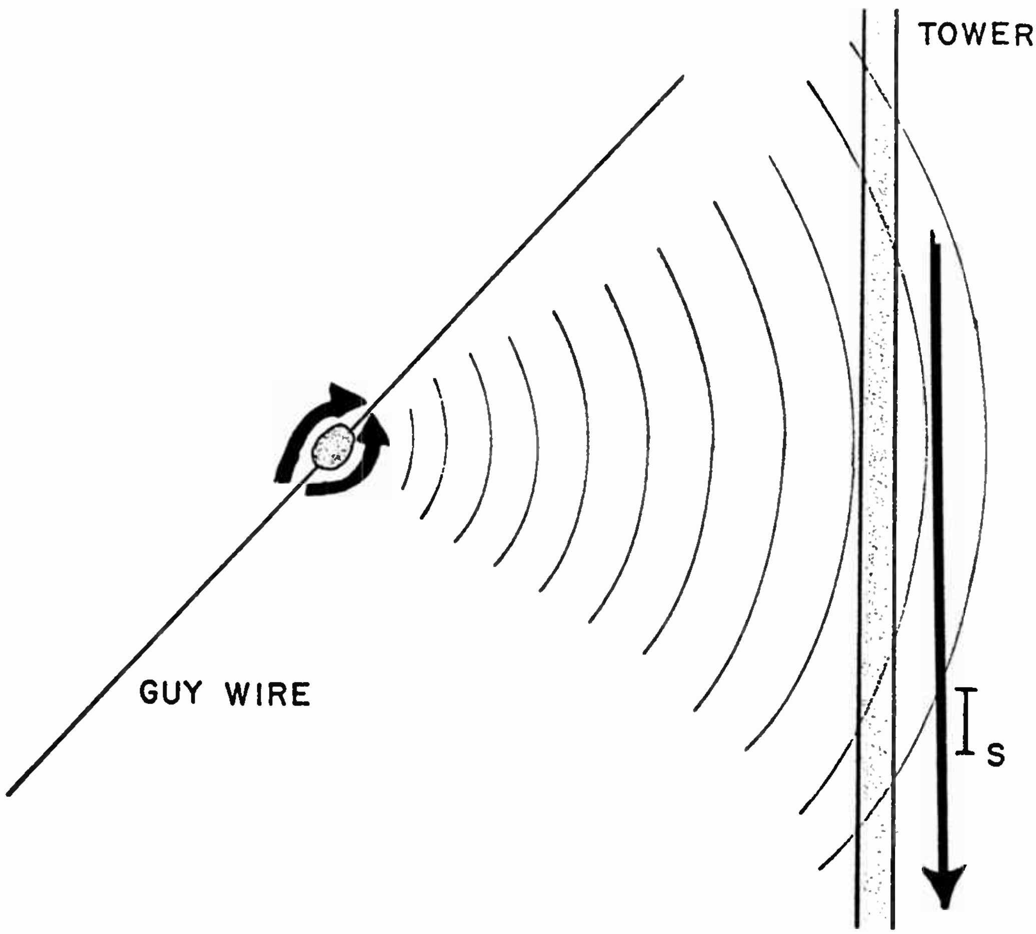


Fig. 4

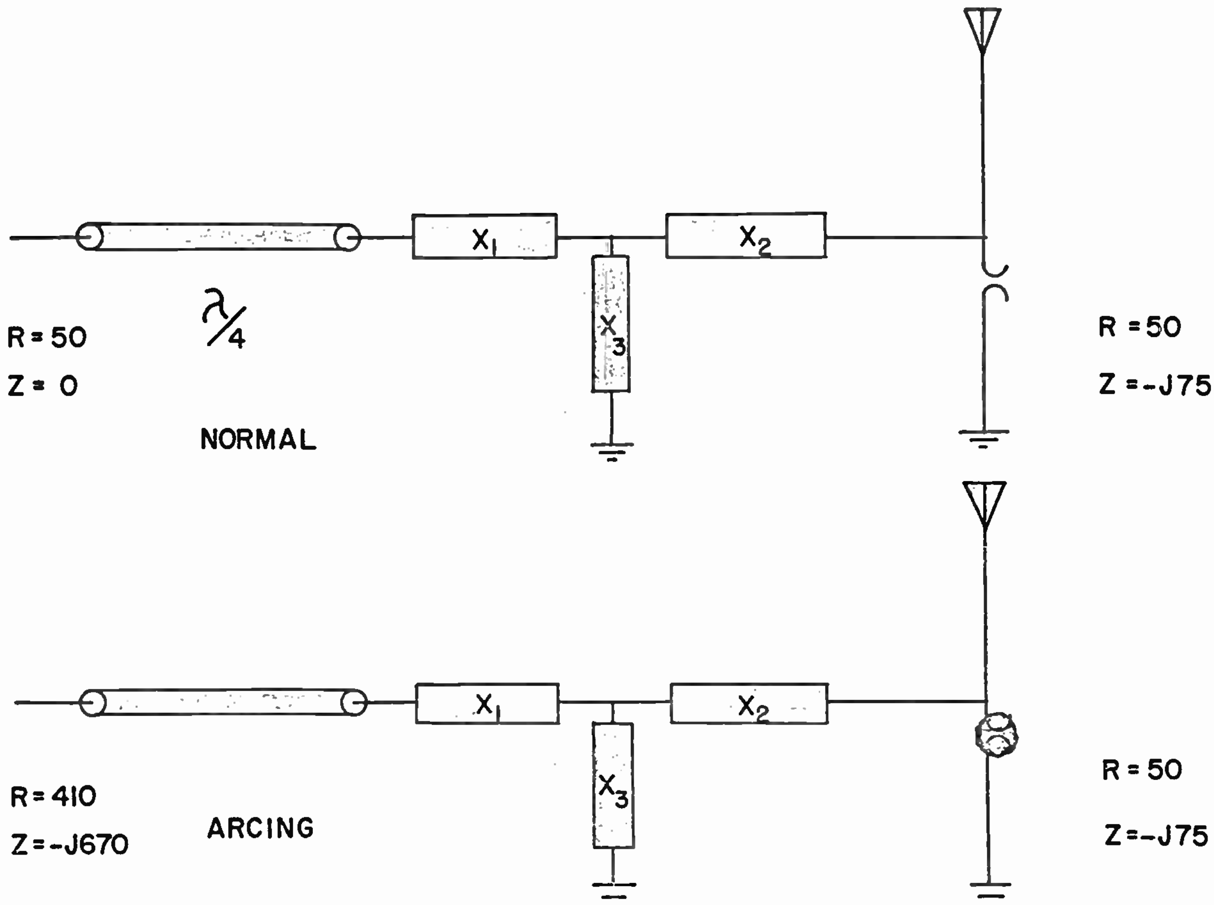

X1
X2
X3
λ/4
R = 50
Z = 0
NORMAL
R = 50
Z = -J75
X1
X2
X3
R = 410
Z = -J670
ARCING
R = 50
Z = -J75

Fig. 5

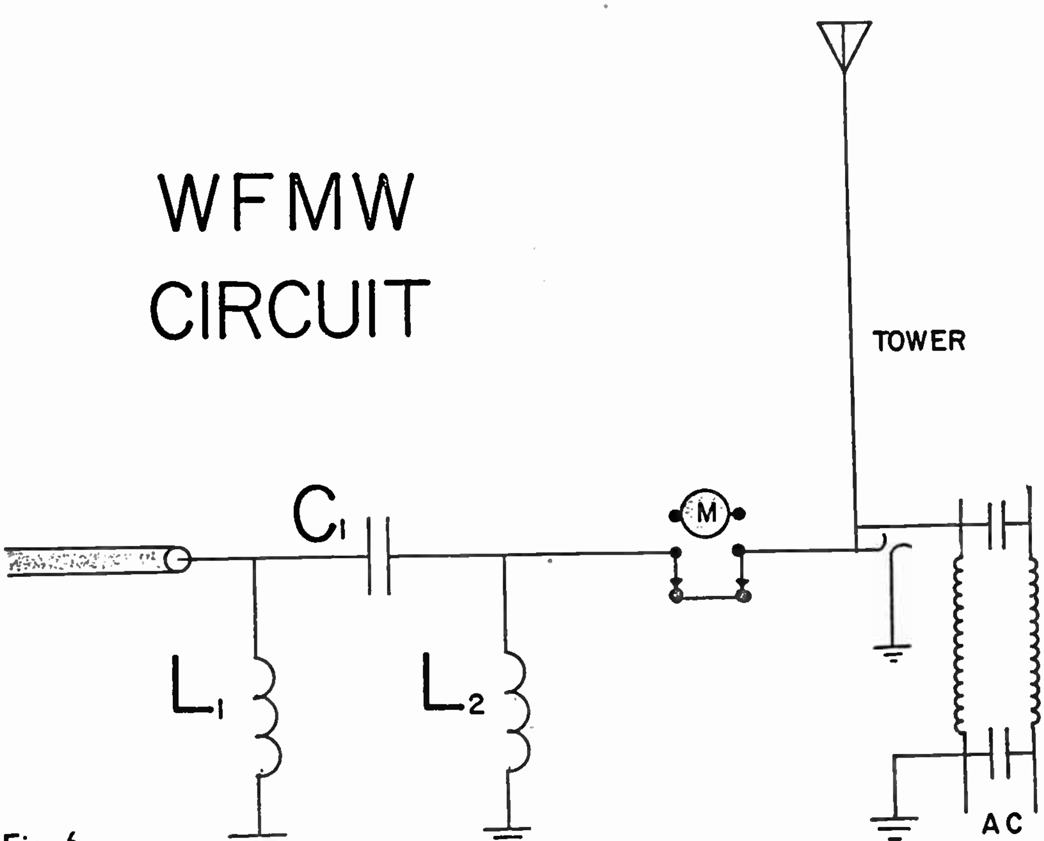

WFMW
CIRCUIT
TOWER
C1
M
L1
L2
AC

Fig. 6

This brings us to the real problem, or I should say to the problem which causes the most trouble to broadcasts. The arcs on the guy wires induce static electricity into the tower (Fig. 4), which flowing at an extremely high rate of speed, finds too much inductance in the normal RFC or lightning choke. The result is that this sudden surge of current jumps the lightning gap at the base of the tower. If the power of the broadcast transmitter is 5 KW or higher, the transmitter may actually sustain the arc. Once the air across the lightning gap has ionized, its resistance falls to a mere fraction of the resistance of dry air. Because the resistance is now very low, the power of the AM transmitter maintains it. Most stations have installed protective devices, which effectively break this arc by momentarily shutting off the transmitter. In the case of lower power transmitters the transmitter goes off the air to recycle, and does not sustain the arc at the tower base.

Let me explain how this last fact occurs. Assume a typical tower of say 50 ohms plus j75 ohms, with a tee-matching network, and with a one-quarter wavelength transmission line. With the values shown in this example (Fig. 5), the transmitter will see a good load of 50 ohms. When the static discharges across the spark gap, we have in effect a short circuit in place of where we normally saw 50 plus j75. Calculating this through the network we find the transmitter seeing 410 - j670 ohms instead of 50. The instantaneous change in load at the transmitter causes the plate current to shift, which causes the plate overload to trip, With lower power transmitters, the recycling circuits normally turn the rig back on within a second or two.

Some engineers believe that the use of a shunt-fed tower can eliminate this problem. While it's true there is no base insulator or spark gap at the tower base; it must be recognized that high static charges can be induced in the slant wire. These can cause flashover in the series capacitor or spark gaps at the base of the slant wire. I concur that the problem may be less with a shunt-fed tower, but it is not eliminated. As a side point, I assume all station operators are familiar with how to set lightning protective gaps. If not, much is written on this subject.

The real problem caused by these flashovers is not necessarily one of damage to equipment, but one of interruption to station programming. These pops and arcs on the air are a nuisance to the listener. It is not infrequent to sustain as many as five to ten arcs a minute under high static conditions. If your competitor's station is not popping you may lose listeners. And as we all know, when people turn away from your station, the guys in the front office get unhappy.

Is there a solution to this problem of carrier interruptions and listener fatique? Yes, there is. Is this a new concept or solution? No, it is not. Actually, this is not a new idea I dreamed up, nor do I pretend to take credit for any secret solutions. In fact, most consultants have known about these circuits and, had you asked your station's consultant, he probably would have solved your problem in a similar method. If the average station operator is guilty of anything, it is of assuming static interruptions were a fact of life and ignoring them.

Let me cite two cases where my firm was employed to correct static problems. First is the case of WFMW, in Madisonville, Kentucky. WFMW's antenna system is shown in Fig. 6. The natural (or self) resistance of their tower is 62 plus j2 ohms. I call this case an example of a tower with a low-base resistance. The pi-tuning network was calculated to match this antenna value to a 50-ohm transmission line. I'll not bore you with the math required to compute the values necessary. In the case of WFMW, whose frequency is 730 kHz, I found L1 and L2 to require 16 uh coils and C1 to be a 0.0035-mfd capacitor. The idea of using a pi-network in place of the customary tee-network, is to produce a very low-resistance, low-inductance, path to ground. You can appreciate the purpose of passing these sudden static currents to ground requires a coil with few microhenries. It is many times faster than one with high inductance like an RF choke Fig. 7. The effect we create here is to pro-

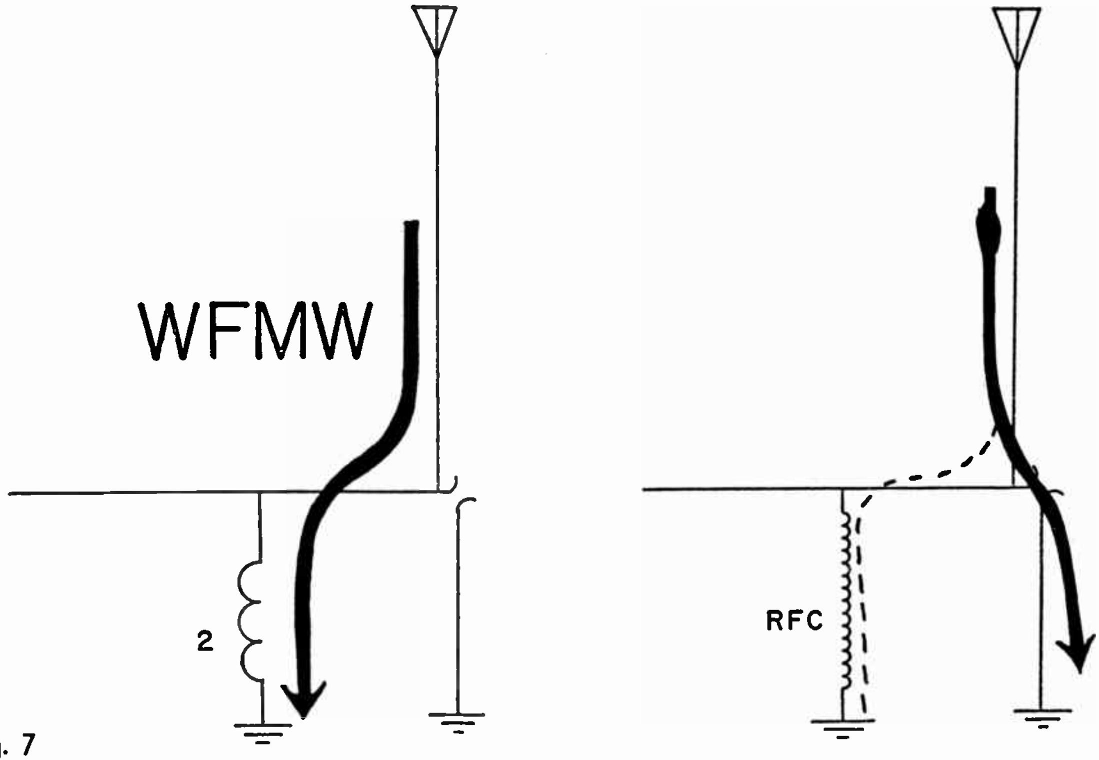


Fig. 7

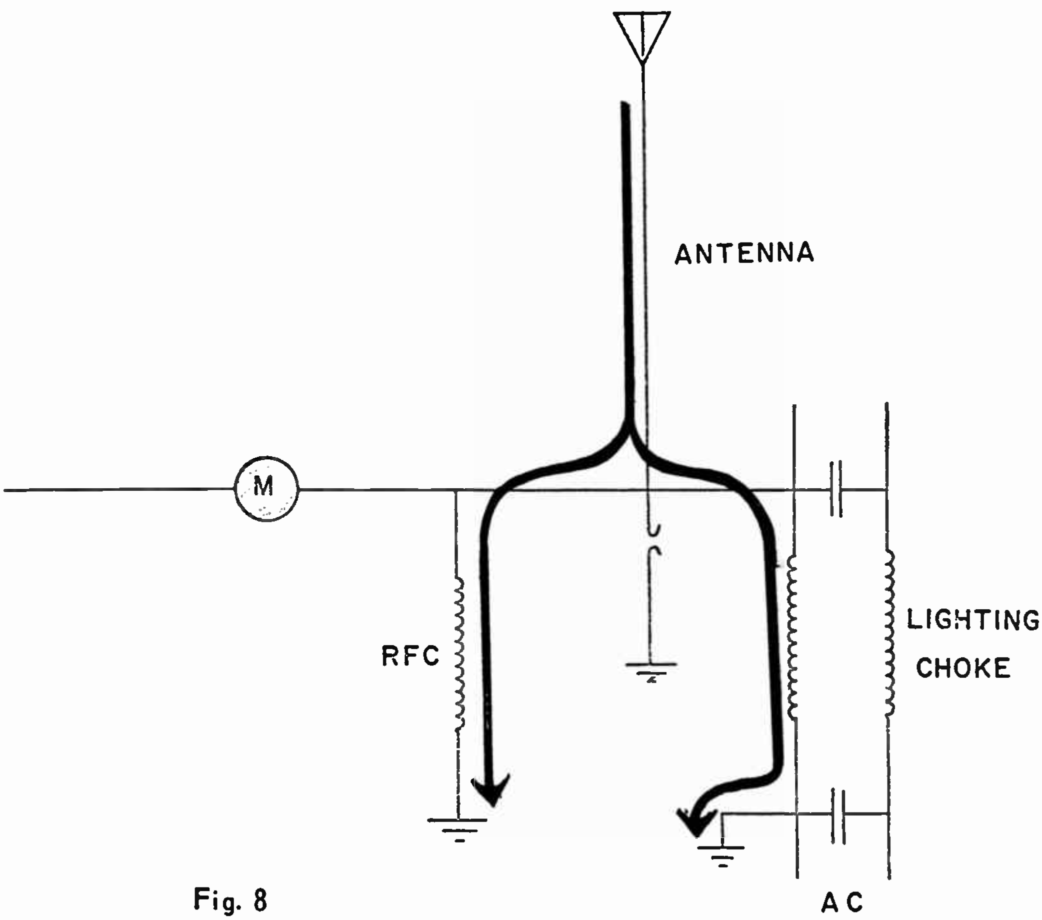


Fig. 8

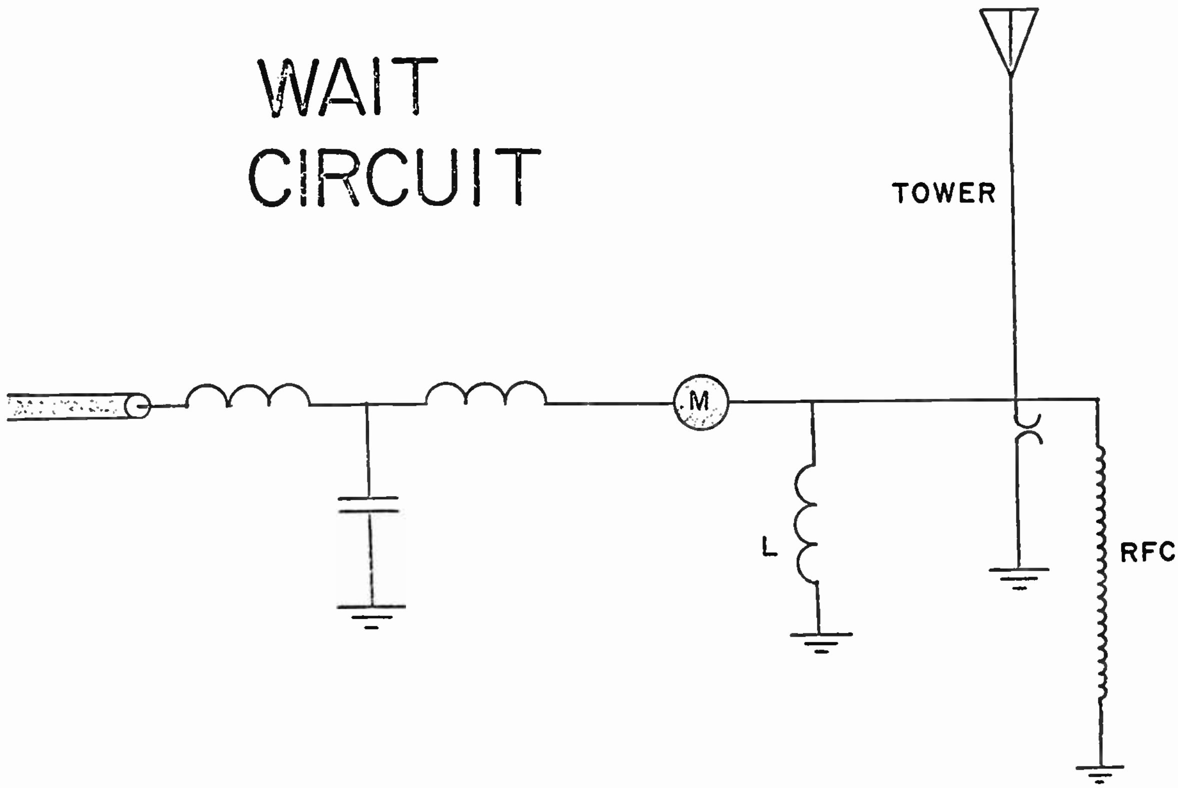


Fig. 9

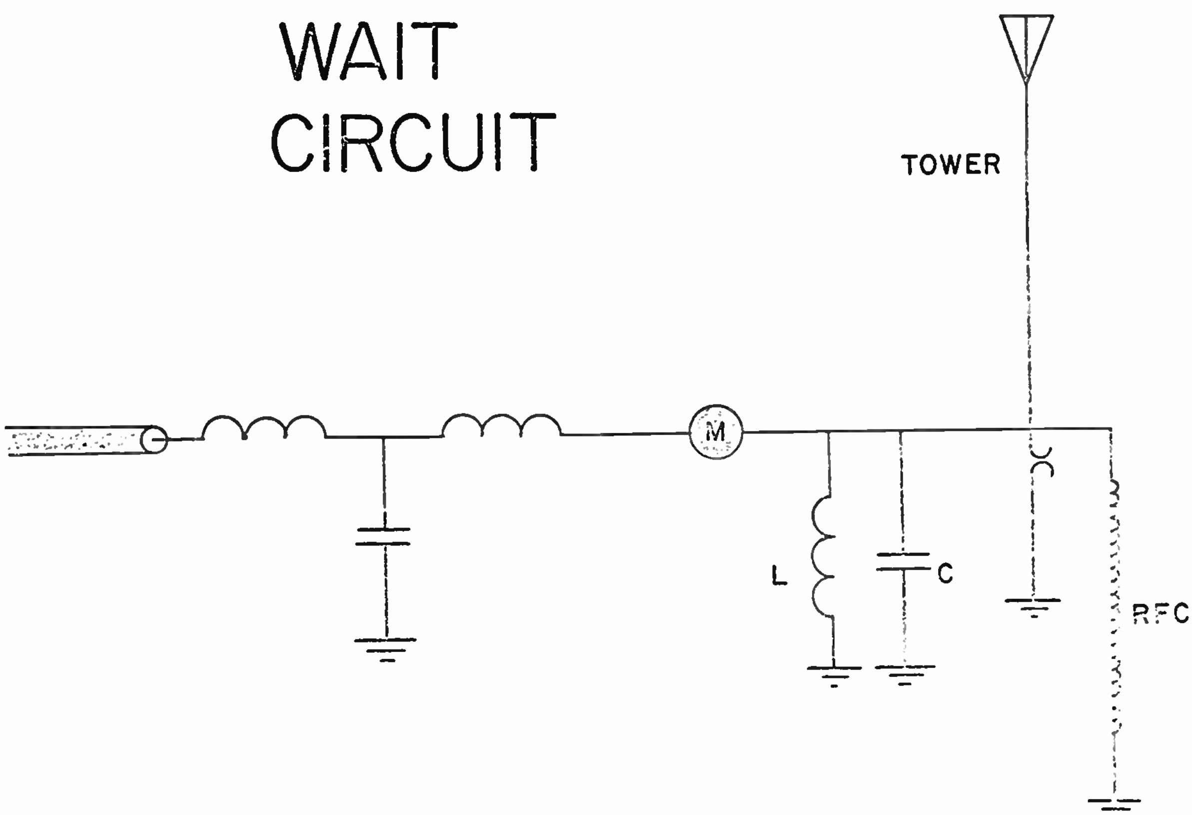


Fig. 10

vide a quicker path to ground. Fig. 8 shows the path followed by the static discharge current. With this type circuit the lightning gap will almost never be jumped on static discharges. Hence no more shifts in load by the transmitter, and no more carrier interruptions to upset the front office.

The second case involves WAIT, Chicago, Illinois. In this solution I worked with Walter Kean to solve a very difficult static situation. WAIT's tower has a self resistance of 440 plus j560 ohms. This represents what I would call a very high-resistance tower. The solution employed for WFMW might have worked, but since we would have had to use a coil of two to three times the inductance, it was agreed to install instead a special static circuit directly across the tower base (Fig. 9). This way we could choose a coil having very low inductance (L). In the case of WAIT we chose 10 uh. At 820 kHz this gives a reactance of 51.5 ohms. With a base voltage of about 1600v for 5 kw, this yields a shunt current of about 32 amps.

As any good engineer knows, you just can't go and hang a shunt coil, having 51.5 ohms, across a tower having 440 plus j560 and expect things to stay put. Fig. 10 shows how the addition of a parallel capacitor compensates for the effect of the inductor. Some people may call this a tank circuit, but it really isn't. It is a circuit capable of eliminating, or if you prefer, cancelling, the effect of the inductor at 820 kHz; but not without the advantage of a fast static path to ground. In the case of WAIT, the capacitive branch has a value of 4000 mfd. We selected vacuum capacitors, since they are the only ones having current ratings capable of passing 32 amps. Please keep in mind the shunt currents in the C branch will be similar in magnitude to those in the L branch, or about 32 amps.

The installation of this circuit is made with the aid of an RF Bridge. After measuring the self tower resistance, add the C and L branches, and adjust one or the other until the new tower resistance returns to the previous value. In our case it was easiest to adjust the L branch. This circuit worked very well and eliminated all the static interruptions the station had been experiencing.

One final area you must keep in mind. This is the need for good heavy ground connections between these static protecting devices and an earth ground. You just can't run a #10 copper wire from the tuning network and expect the circuit to work. You must construct a very, very low-resistance path from the tower to ground. This will require large copper tubing from the tower to the static circuit, and three to four inch copper strap from there to the tower ground. It is very important to keep all leads as short as possible.

I trust my remarks have awakened some old ideas, or served to stimulate some new ones. If you failed to grasp the concept here, just touch your tower during the next static storm, and you'll quickly see the light.

Recommended Procedure for Stereo Proof of Performance

Bernard Wise, President
CGA Electronics Corp.

Transmission of stereo information is a relatively new activity for the FM broadcast industry. Thus, there exist many interpretations of the methods required to prove compliance with the FCC stereo specifications.

At the risk of adding additional turmoil to an already confused picture, CCA Electronics suggests the following procedure. We sincerely feel that the investigation described in the following pages will result in a technically strong stereo system.

Step #1: The equipment should be installed as shown in Fig. 1.

Step #2: The console should be adjusted so that the controls are set such that with a normal setting of the microphone and master faders, the indication on the front panel meter of the console is normal. The limiter amplifier should be set to eliminate any compression and 100% modulation can be achieved on the monitor.

Step #3: All audio information should be removed from the carrier and the 19-kHz pilot carrier injection level should be sufficient to achieve 10% modulation of the main carrier.

Step #4: The frequency of the subcarrier should be measured by either a type approved pilot frequency monitor or a standard counter. This frequency should be 19,000 Hz, plus or minus 2 Hz.

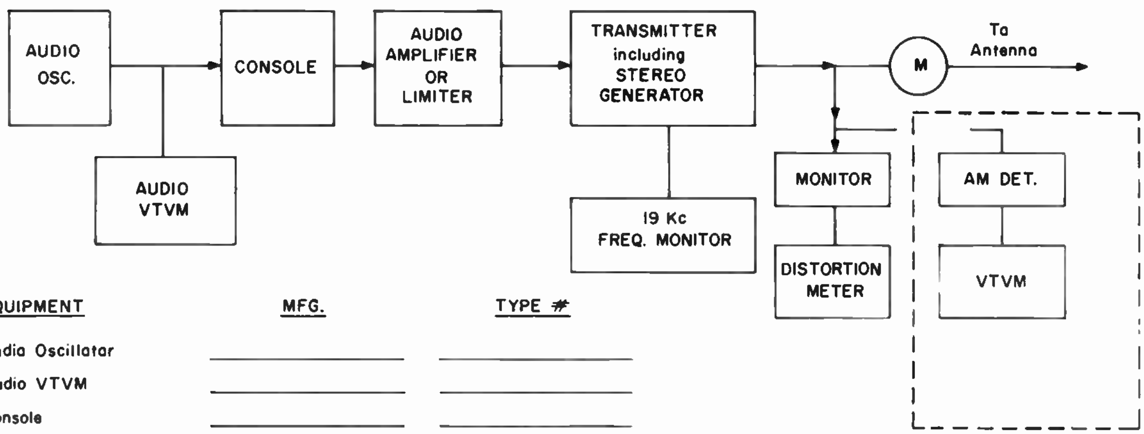
Step #5: The injection of the 19-kHz pilot should be adjusted to change the modulation level from 8 to 10%. The frequency change of the pilot carrier should not be greater than plus or minus 2 cycles. The 19-kHz carrier should be restored for 10% modulation.

Step #6: Frequency Response: Distortion and Separation of the Left Channel: Calibrate the system by applying into the microphone channel a 400-Hz signal from the audio oscillator of sufficient level to achieve 90% modulation on the left channel, 10% 19-kHz injection and 0% modulation on the right channel. If the console has only a mono input in the microphone channel, the master gain control on the right channel can be reduced to 0 in order to achieve the 0% modulation on the right channel. If the console has independent left- and right-input channels for its low-level stages, apply voltage only to the left channel with no adjustment of master gain in the right channel required.

Measure the distortion of the audio signal present on the left output terminals of the modulation monitor.

Using a modern monitor, as exemplified by the McMartin TBM-4500A, measure the separation (the amount of level) in the right channel that exists under this modulation condition (Fig. 2).

ARRANGEMENT OF
PROOF OF PERFORMANCE EQUIPMENT



EQUIPMENT	MFG.	TYPE #
Audio Oscillator		
Audio VTVM		
Console		
Audio Amplifier #1		
#2		
Transmitter		
Monitor (Modulation)		
Distortion Meter		
AM Detector		
VTVM		
(M) Antenna Current Meter		
Monitor (19 Kc)		
Monitor (carrier freq.)		

Fig. 1

Record all three sets of data: audio input level to achieve 90% modulation, audio distortion, and separation on an appropriate form

Repeat this procedure for the audio frequencies 50, 100, 1 kHz, 5 kHz, 10 kHz, and 15 kHz. Record all data on an appropriate form

Step #7: Repeat Step #6 at modulation levels of 50 and 25% but do not repeat separation measurements.

Step #8: Characteristics of Right Channel: Repeat the procedure outlined in Steps 6 and 9, but change the functions relating to the left channel to the right channel. In other words, remove the audio input from the left channel and place it on the right channel and analyze the characteristics of the right-channel transmission. Record this data on an appropriate form.

Step #9: Observe the standard pre-emphasis curve described in Fig. 3. Normalize the audio input levels such that at 400 Hz the resultant audio input level is approximately plus 1 dbm. Using the same factor on the remaining values will result in a normalized set of values. These values should then be plotted for the various modulation levels for both left and right channels on copies of Fig. 3. The response should fall within the FCC limits. For example, the audio input of the system might have been -50 dbm at 400 Hz and -67 dbm at 15 kHz to achieve 90% modulation. The normalizing factor in this case would be plus 51 dbm. This would result in plus 1 dbm (normalized) at 400 Hz and -16 dbm at 15 kHz.

Step #10: Plot the curves on reproductions of Fig. 4 of the distortion values obtained in Steps #7 through 9. They should be below indicated FCC maximum limits.

Step #11: Record the separation between left and right channels at 90% modulation. This level should be better than 29.7 db.

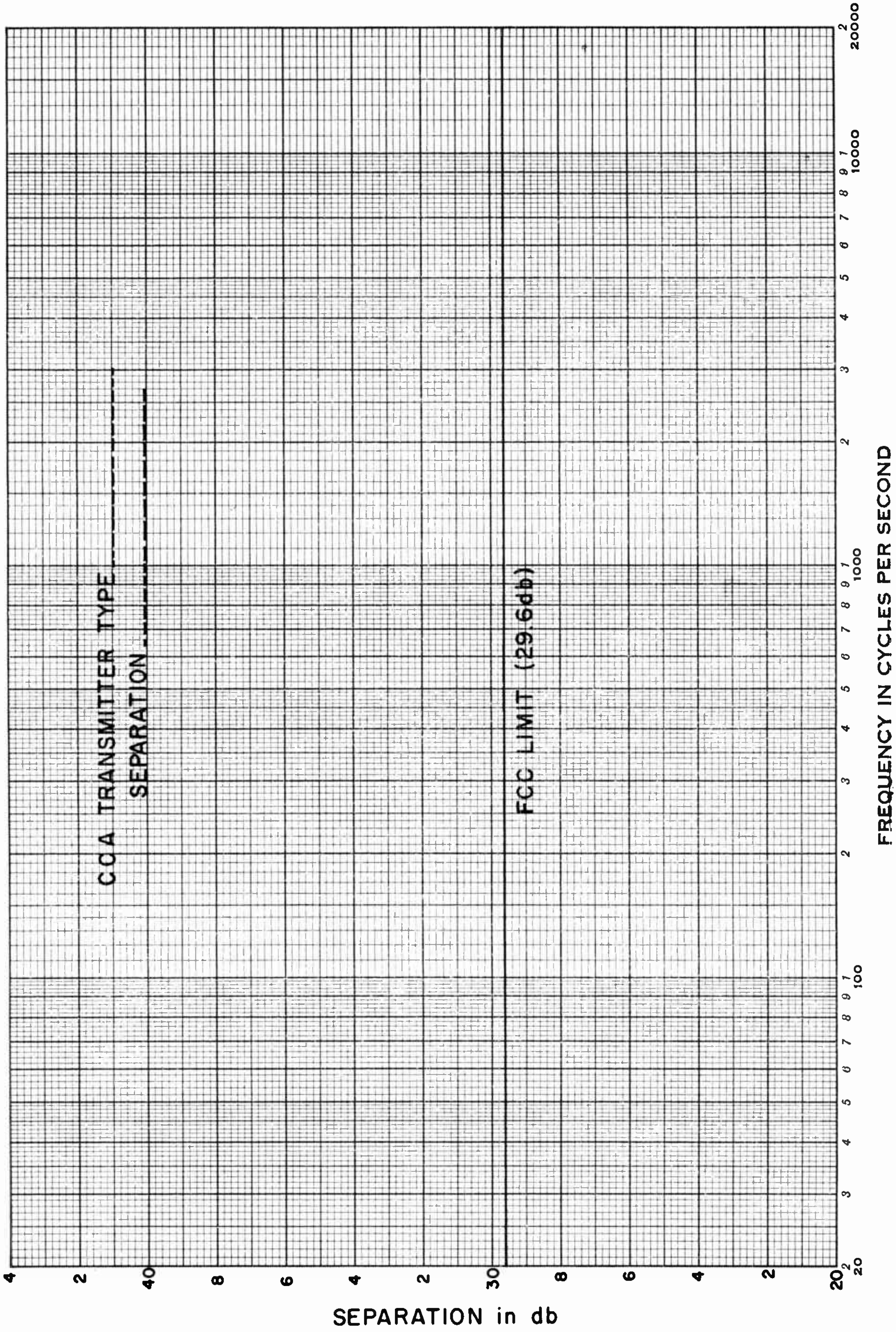

CCA TRANSMITTER TYPE
SEPARATION
FCC LIMIT (29.6db)
FREQUENCY IN CYCLES PER SECOND
SEPARATION in db

Fig. 2

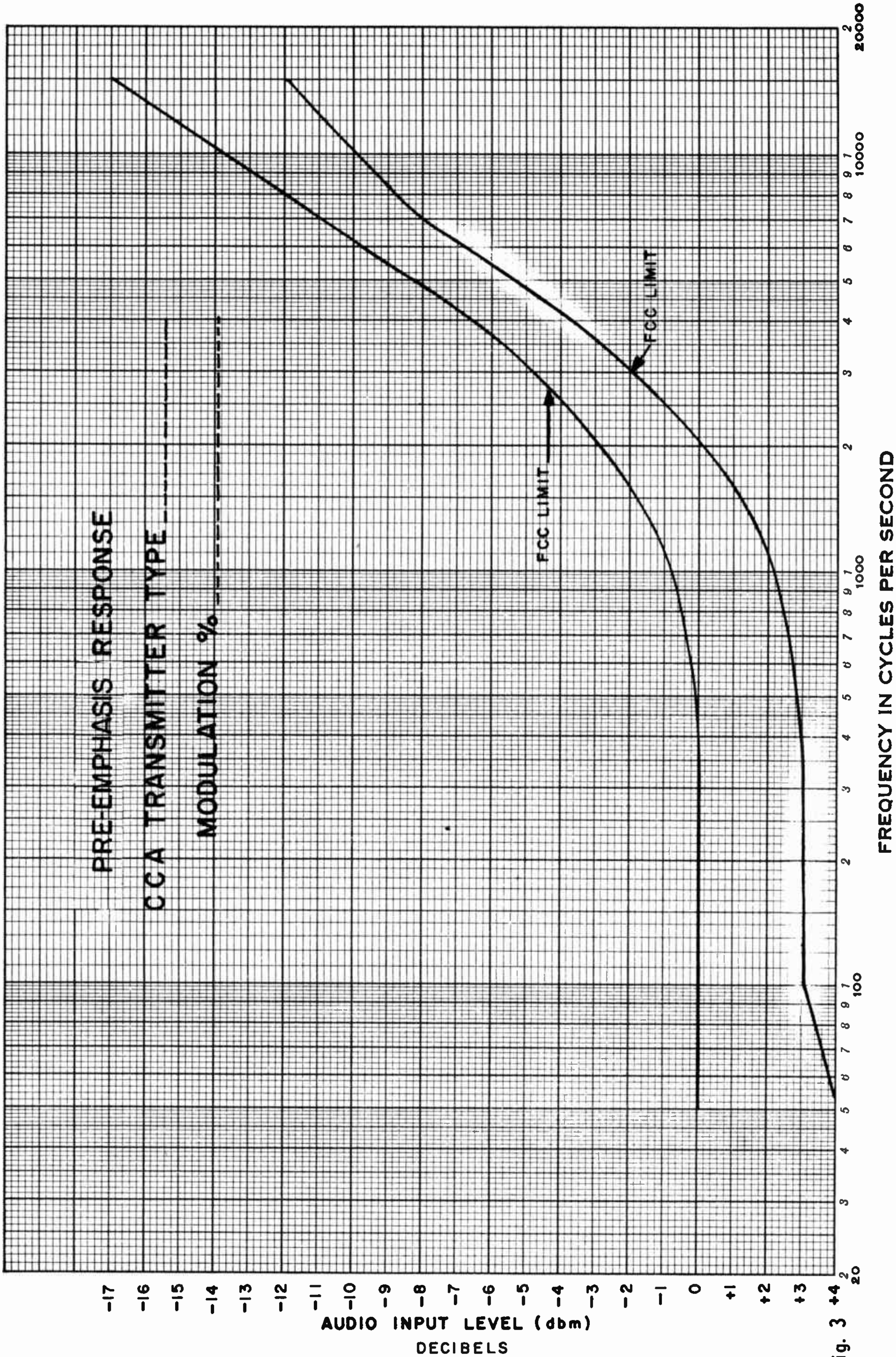

PRE-EMPHASIS RESPONSE
CCA TRANSMITTER TYPE
MODULATION %
FCC LIMIT
FCC LIMIT
AUDIO INPUT LEVEL (dbm)
DECIBELS
-17 -16 -15 -14 -13 -12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 +1 +2 +3 +4
FREQUENCY IN CYCLES PER SECOND
20 100 1000 10000 20000

Fig. 3

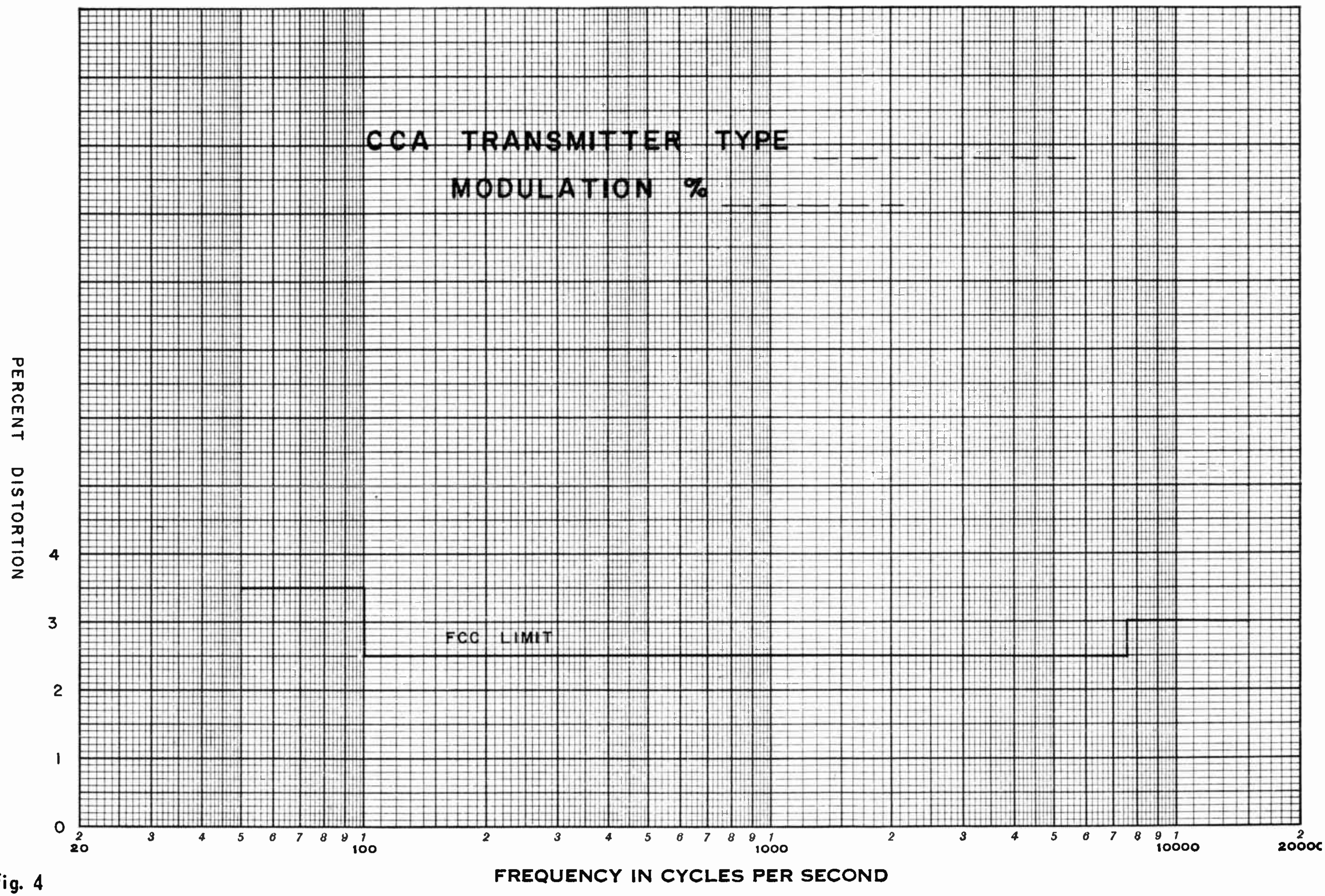

CCA TRANSMITTER TYPE
MODULATION %
PERCENT DISTORTION
0
1
2
3
4
FCC LIMIT
20
100
1000
10000
2000C
FREQUENCY IN CYCLES PER SECOND

Fig. 4

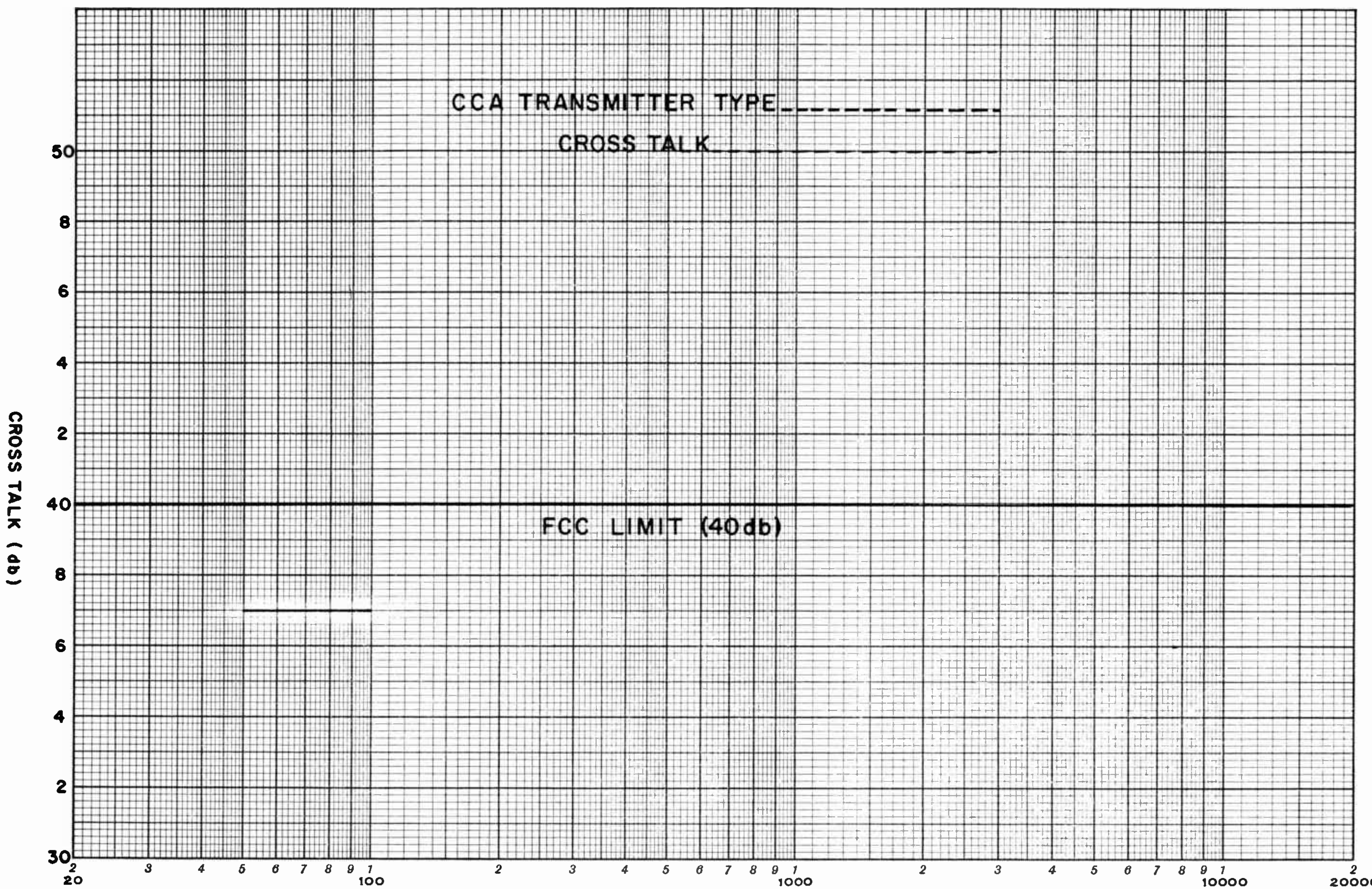
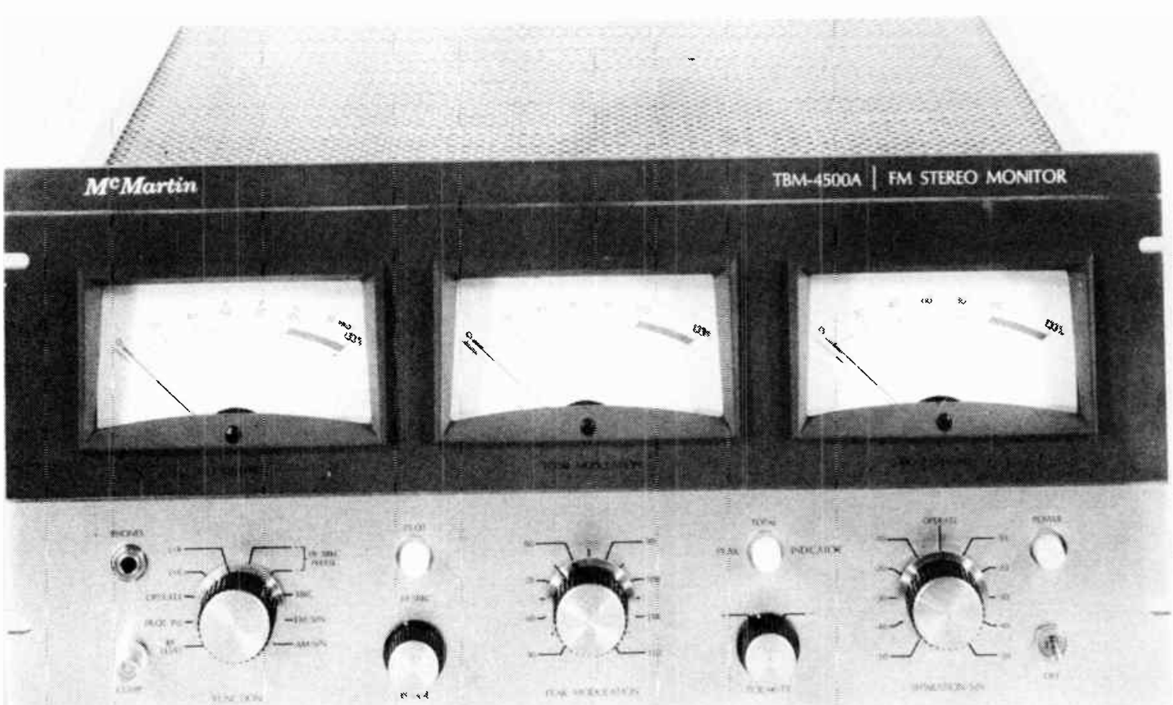

CCA TRANSMITTER TYPE
CROSS TALK
FCC LIMIT (40db)
CROSS TALK (db)
30
2
4
6
8
40
2
4
6
8
50
20
100
1000
10000
20000
FREQUENCY IN CYCLES PER SECOND

Fig. 5

Step #12: Stereophonic Subcarrier Supression: Modern modulation monitors have facilities for measuring the magnitude of the 38-kHz subcarrier. Without any modulation on the left or right channels, this measurement should be at least 40 db below 100% modulation. In addition, either the left or right channels should be modulated with a 10-kHz signal and the 38-kHz subcarrier should not exceed the 40 db level.

Step #13: Cross-talk into the Main Channel by a Signal in the Stereophonic Sub-Channel: Connect the output of the console such that the left and right signals are in parallel but 180° out of phase. Adjust the output level of the system such that it achieves 90% modulation on both channels with 50 Hz audio intelligence. Using a modern modulation monitor it is possible on the front panel of the monitor to observe (with an appropriate switch) the amount of level that exists in the L plus R channel (main channel) from the modulation in the L minus R channel (stereophonic channel). This level should be at least 40 db below 90% modulation. Repeat this measurement at all audio frequencies listed in Fig. 5.

Step #14: Cross-talk Into the Stereophonic Sub-channel caused by the Signal in the Main Channel: Connect the outputs of the left and right channels of the console such that they are in parallel and in phase. This will result in modulation of only the (L plus R) channel and theoretically no modulation of the (L minus R) channel. Using a modern modulation monitor it should be possible to measure the cross-talk between the (L plus R) and (L minus R) channels at all audio frequencies from 50 Hz to 15 kHz at 90% modulation levels. This information should be recorded on Fig. 5. The maximum tolerable cross-talk is such where the level is no greater than 40 db below 90% modulation.



Step #15: Stereo Noise: Remove all of the audio intelligence from the system and keep the stereo generator on with the normal 10% 19-kHz injection. Keep the monitor in the "operate" condition, but observe the percent modulation as indicated on the monitor by using the switches located on a modern modulation monitor. These switches increase the sensitivity of the percent modulation indication and if any spurious signals generated by the stereo generator exist, it will measure them. These spurious signals should be at a level less than 40 db below the 100% modulation level.

Step #16: FM Signal to Noise and AM Signal to Noise: Remove all audio input from the system. Using a modern stereo monitor, it is possible by simply turning an appropriate control to measure both the AM and FM signal-to-noise ratio. The FCC minimum requirements are 60 db for FM and 50 db for AM.

Step #17: Final PA Readings: Record these values on appropriate forms. PA efficiency should correspond to plus or minus 10% of manufacturer efficiency.

Step #18: Carrier Frequency Measurements: Obtain normal calibration of the monitor from a frequency service or approved counter. Modulate the carrier 90% at all audio frequencies and observe that the carrier indication does not shift more than 100 Hz.

Present & Future Utilization of FM SCA Subcarriers

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McMartin Industries Inc., Omaha, Nebraska

The present uses of SCA subcarriers in FM broadcasting are generally well-known. It is valuable, however, to review these, particularly as they relate to specific provisions of Part 73 of the FCC Rules and Regulations.

Basically there are two categories applicable to SCA. The Rules, in defining Subsidiary Communications Authorizations identify these as, first "... transmission of programs which are of a broadcast nature, but which are of interest primarily to limited segments of the public wishing to subscribe thereto..." and secondly, "... transmissions of signals which are directly related to the operation of FM broadcast stations...".

The Rules contain examples of the permissible uses of SCA services falling into these two categories. For those "of a broadcast nature," included are: background music, storecasting, detailed weather forecasting, special time signals, and then a general area defined as, other material of a broadcast nature expressly designed and intended for business, professional, educational, religious, trade, labor, agricultural, or other groups engaged in any lawful activity.

For those services "directly related to the operation of FM broadcast stations" are included: relaying of broadcast material to other FM and standard broadcast stations; remote cueing and order circuits; remote control telemetering functions associated with authorized STL operation; and similar uses. The use of SCA for background music and storecasting is well established and represents a source of added revenue to the FM broadcaster. This application represents by far the greatest use of SCA today.

SCA transmission for uses directly related to the operation of FM broadcast stations has had limited application. There are isolated instances where broadcast program material is relayed to FM and AM stations using an SCA channel. There generally have been regional sports network feeds, frequently involving a number of FM stations, which individually carry the program material themselves and serve also as the program relay source for the next station along the network. To preserve program transmission quality throughout multi-hop systems it is practical to relay the program material without demodulation of the SCA subcarrier. This application eliminates costs incurred by leased telephone lines. With increasing rate structures for intercity telephone lines, the greater use of SCA subcarriers for program relay merits very serious study and consideration by the broadcaster.

To the best of my knowledge, very little use is made of SCA subchannels for remote cueing and order circuits. It appears that this and the program relay applications are permissible uses of SCA subchannels which may have been overlooked by the FM broadcaster as a means of economically and effectively maintaining or improving operations. The use of SCA subchannels as the means of relaying telemetering intelligence from a remote FM transmitter to the control point is a conventional application in available STL/remote control equipment.

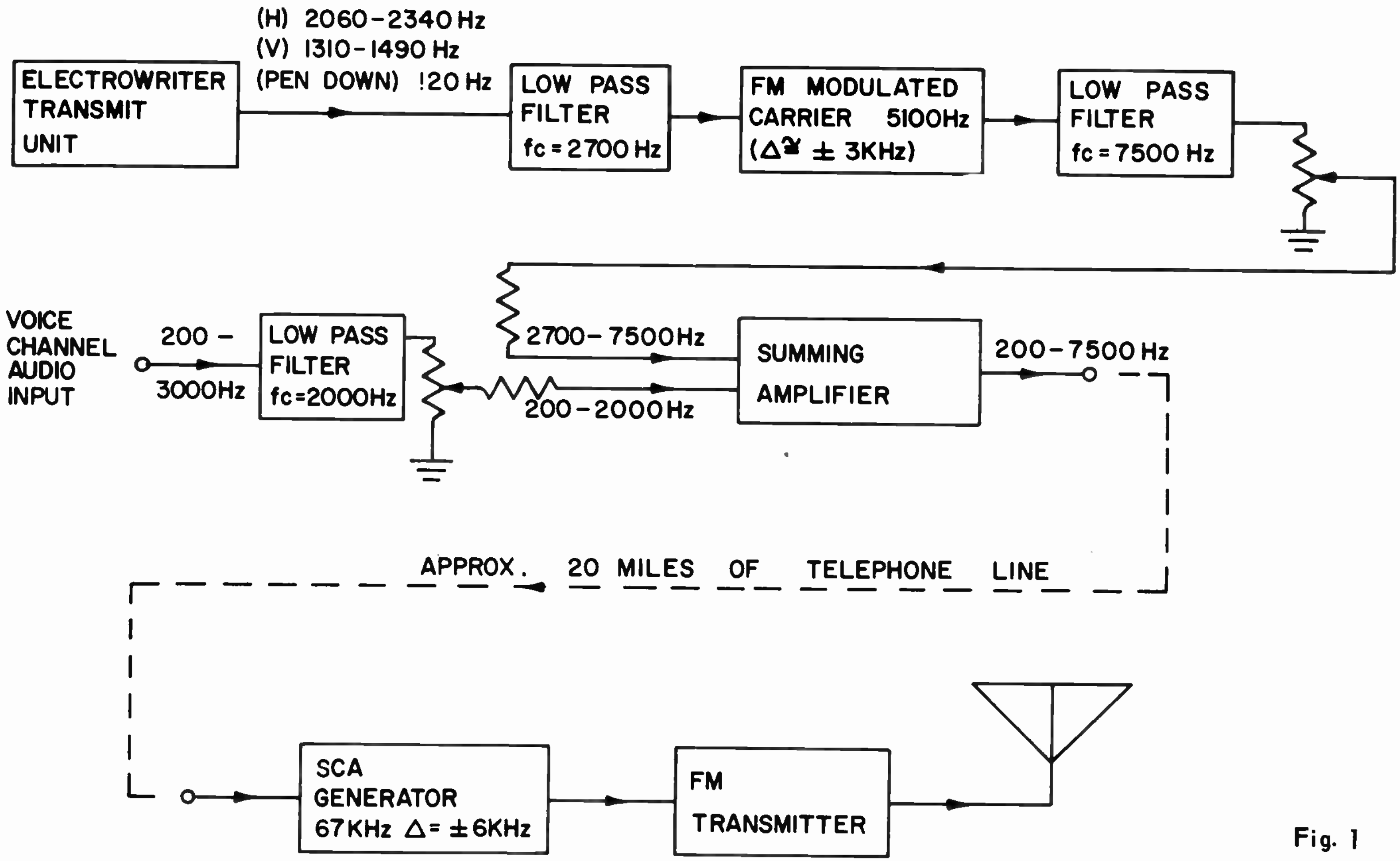


Fig. 1

BLOCK DIAGRAM
TRANSMITTING SYSTEM
ELECTROWRITER/VOICE SIMULTANEOUS TRANSMISSION

To this point, I have discussed the present uses of FM SCA subcarriers. Before proceeding to a discussion of SCA subcarrier systems which are in the developmental stage with future applications, I wish to stress an important point. Whereas the present uses are clearly defined and permissible under existing FCC Rules, it is beyond the scope of this paper to enter into a discussion of the acceptability of future systems within the framework of the current Rules structure. A basic requirement for compliance with the existing Rules is that the proposed operation be either "of a broadcast nature" or "directly related to the operation of an FM broadcast station." This requires FCC review on a case-by-case basis for interpretation and acceptability. I wish to emphasize that although some of the systems to be discussed have undergone on-air tests under Special Experimental Authorization granted by the Commission, as yet they have not been reviewed by the Commission to determine whether or not they fall within the existing Rules structure, or might be acceptable either by amendment of the Rules, or by the promulgation of new Rules.

A number of future FM SCA multiplex applications will be discussed. They differ from existing uses in that the latter generally perform one function per subchannel. The newer uses to be described involve the utilization of a single subcarrier to perform dual functions, one of which is aural and one visual. I will detail one of these systems which permits the simultaneous transmission on a single SCA subcarrier of hand-written information in the form of messages, diagrams, sketches or similar material, as well as directly related voice information.

The device for the transmission of the written material is the Electrowriter, manufactured by Victor Comptometer Corp. The Electrowriter system consists of a "transmit" unit and a "receive" unit. These systems are widely used throughout the world and normally operate by leased telephone line interconnection. It is possible to operate a number of receive units from a single transmit unit. The operation of the Electrowriter system is based on the generation of audio tones which depend upon the location of the pen on the writing surface. The location of the pen and its movement during the writing process generate discrete X-Y coordinate frequencies which vary between 2060 and 2340 Hz for the horizontal travel and from 1310 to 1490 Hz for vertical movement. Whenever the writing pen located at the transmit unit is removed from its rest position, the horizontal and vertical control tones are transmitted simultaneously, turning the receive unit "on." When the writing tip is brought in contact with the transmit unit writing surface, a 120-Hz tone brings the receive unit pen to its writing surface. Subsequent pen travel in writing out the message or diagram on the transmit unit generates appropriate horizontal and vertical position frequency tones which are detected at the receive unit. Using servo-control techniques, the receive unit stylus follows the transmit pen travel and a hard-copy duplicate of the transmitted message is produced.

As is readily apparent, the tone frequencies required for the Electrowriter operation fall in the classic voice frequency spectrum below 3000 Hz. It is quite evident that in order to accommodate the Electrowriter and the associated voice information on a single subchannel, something has to give! This is readily accomplished by using a 5100-Hz carrier and frequency modulating it with the Electrowriter control tones. Fig. 1 is a block diagram of the transmitting portion of the system. Other than being processed by a 2000-Hz low-pass filter prior to feed to the summing amplifier, the treatment of the voice channel is quite conventional.

The control tones from the Electrowriter transmit unit—2060-2340 Hz for horizontal travel; 1310-1490 Hz for vertical travel and the 120 Hz "pen-down" conditions—are fed through a 2700-Hz low-pass filter. This intelligence is used to frequency modulate a 5100-Hz carrier. This FM signal, fed through a 7500-Hz low-pass filter occupies a spectrum of essentially 2700 to 7500 Hz. This signal is fed to a separate input of the summing amplifier. Notice that a guard band located between 2000-2700

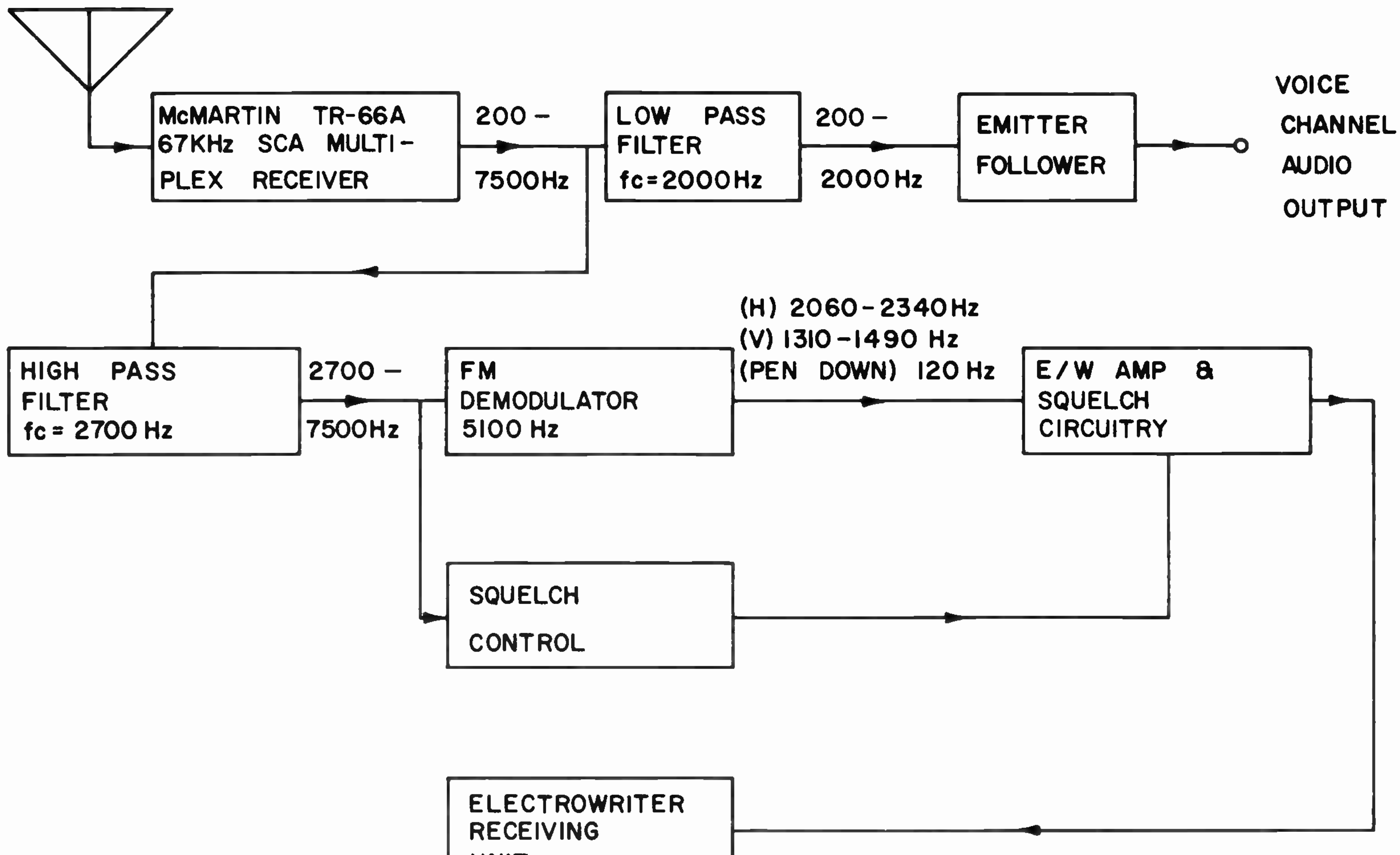


Fig. 2

BLOCK DIAGRAM
RECEIVING SYSTEM
ELECTROWRITER / VOICE SIMULTANEOUS TRANSMISSION

Hz is maintained to minimize the generation of intermodulation products. For the specific tests for which this diagram was prepared, approximately 20 miles of telephone cable was involved between the control point and transmitter site. In this case, the summing amplifier output signal was fed to a standard 67-kHz SCA generator and the FM transmitter, which was carrying full stereo programming throughout the test period.

The receiving system is diagrammed in Fig. 2. A standard McMartin TR-66A 67 kHz SCA multiplex receiver was used. The recovered audio output from the SCA channel contains both the voice channel intelligence and the 5100-Hz carrier, frequency modulated by the Electrowriter control tones, covering nominally a 200-7500-Hz range. The voice information is easily recovered by feeding the signal through a 2000-Hz low-pass filter. A low-impedance termination of the voice channel is provided by an emitter follower.

The remaining information at the SCA receiver output is separated by passing the signal through a 2700-Hz high-pass filter. This contains the 5100-Hz FM signal. This is demodulated to recover the original horizontal, vertical, and pen-down control tones which are then amplified and fed to the Electrowriter receive unit. A squelch control circuit has been incorporated to mute the Electrowriter amplifier in the absence of the 5100-Hz carrier.

Tests indicate excellent reliability. What we have here, in the use of the 5100-Hz FM subcarrier technique for the Electrowriter information, is multiplex-on-multiplex. The initial application is clearly in the educational field. The program material, both written and aural may be recorded on conventional 2-track audio tape. A working demonstration of the simultaneous Electrowriter/voice transmission system using a 67-kHz subchannel was demonstrated in the McMartin exhibit.

Another example of dual use of an SCA channel is the Sight Radio System. It permits the simultaneous use of two independent services. The first is a conventional background music operation. The second, a new service, provides for visual readout of weather, sports, and financial information as well as news headlines. The readout is by means of alphanumerical flap indicator displays. The background music program material is sharply attenuated below 130 Hz. The Sight Radio information is generated by digital logic circuitry with a basic clock reference frequency in the 70-Hz region. Coded binary information is in the form of either two or four cycles of the clock frequency being transmitted at an amplitude approximately twice that of the reference signal.

Program material is prepared in advance on a modified Friden Flexowriter in perforated tape form, which is in turn fed to the system input using tape readers. The information is converted from parallel to series logic, stored, then fed to the SCA generator through a matrixing amplifier which combines the background music program material with the Sight Radio logic information. This combined information, appearing as subcarrier modulation on the FM broadcast signal, is received on an SCA multiplex receiver, demodulated and filtered to separate the background music and Sight Radio information. The latter is then decoded and operates the logic circuitry required to energize appropriate flap indicators to spell out the desired message.

The system is designed with address codes which permit access to three individual areas of the receiving display unit. This permits the display to be updated in any one of the separate information areas without disturbing the others. This system is of particular interest since it carries two distinct, unrelated services: a conventional background music service and a visual display service. To the FM broadcaster, this means two independent sources of revenue, using a single SCA multiplex channel. Both of these systems emphasize an increasing trend toward the transmission of visual information on FM SCA subcarriers.

Slow-scan TV, at reasonable display rates, is readily accommodated on SCA subcarriers. Typical readout times are 7 seconds for a complete picture if a 500-Hz bandwidth is used to 3 seconds if an 8000-Hz bandwidth is available. Work is being done on the use of SCA channels for electronic character generator transmission. In essence, if the desired information can be transmitted over a telephone circuit, it can be handled on an SCA subcarrier.

There has been much publicity devoted to four-channel stereo transmission. Several of the proposed systems utilize FM subcarriers for the third and fourth channel information with the first two channels derived from conventional main channel stereo operation. One system, proposed by Mr. William Halstead, proposes the use of two separate SCA channels, one at 69 kHz and one at 89 kHz, I believe, to carry the third and fourth track information. An application for an air testing of this system is pending at the Commission.

McMartin Industries has proposed a system which uses a single SCA channel with the third and fourth track information carried on a time-division multiplex basis. The 19-kHz pilot injection frequency of the main channel stereo multiplex operation is used as for the time-division switching base. It is certain, that with the present state-of-the-art technology, there are many methods of accomplishing the task. In the event public demand and acceptance dictates, many other systems utilizing FM SCA subcarriers as the basic method of operation will be proposed.

Technical details on the Schrieber system have been sparse but apparently are based on a technique which first encodes four-track information to two tracks, which purportedly can be transmitted over conventional stereo multiplex channels. The information is then decoded at the receiver to provide four separate channels at the output. This is the only system to my knowledge which would not require SCA subchannel operation. Under any circumstance, I foresee a substantial time lapse before four-channel stereo broadcasting can be initiated on a regular, authorized basis.

The technology has reached the point where information, visual and/or aural, can be transmitted on FM SCA subcarriers. It is increasingly evident that RF spectrum space is becoming more and more limited while the demand for services is on the increase. The FM SCA subcarrier may in the future be the vehicle for services of a broadcast nature which are undreamed of today.

The WNBC Radio Installation

Oden S. Paganuzzi
NBC, New York, N.Y.

Another local radio operation! What for? We have seen many of them, but perhaps NBC's New York local operation might provide a new look at an old view. WNBC is no different from any other station operation and a maximum utility-to-cost ratio had to be maintained. This dictated that standard rather than custom equipment be used wherever possible. However, the integration of standard pieces into a custom system gives this plant some unique features.

As shown in Fig. 1, the technical production area encompasses a conference studio, a "disc-jockey" studio, a production pre-tape studio and a tape room. Peripheral to this are two announce booths (program and news), a complete news room and a maintenance and field shop within which are located the automation racks for the FM studio operation. An adjacent area contains a stereo-mix console and recording equipment for the production of the program tapes necessary for the FM automation machines. Notice the absence of a master control area; each studio technician is responsible for the technical quality of the signal transmitted. The tape room also contains all of the plant central equipment. Notice also the incorporation of the music library within the production space and the provision for future expansion space.

Fig. 2 is a photograph of the conference studio control area. The audio console is a self-contained standard-model positioned on a piece of standard studio furniture. In fact, all of the furniture in this complex is part of a standard line of modular studio equipment. The only modification to the console is the addition of a receptacle panel to provide for a complete plug-in operation. No internal changes were made. All external additions, such as normalling jacks between circuits, were made between the console block and final receptacle. The receptacle mounting panel was made to extend below the base of the console to mate with a rectangular slot cut in the table top, thus providing both easy plug access as well as a simple method for positioning the console without additional hardware.

Equipment mounting space consisting of the racks shown in Fig. 3 have been installed at the studio input-output terminal and provide the additional facilities necessary for the operation of each studio. The studio jackfields were pre-wired on a standard basis to a set of locknut strips, thus making possible by means of cross-connects, quick, simple customized jackfields. The simplified block diagram (Fig. 4) highlights this additional equipment, specifically the channel output amplifier and the 7-second delay system. The output amplifier is connected for a low driving impedance to feed many channels simultaneously. This low impedance also provides high isolation for low level monitoring feeds.

Most of us have been confronted at some time or other with the problem of a talk show having live telephone conversation which must be recorded and edited prior to transmission. WNBC has chosen the endless-tape-loop method. The loop is 52 inches (or seven seconds) long, contained within a cartridge pack and run on a modified cartridge machine. The cycle consists of recording, running through the loop, playback, erase and re-record. The choice of tape, length of tape, and cartridge tension required considerable experimentation; however, specially loaded cartridges

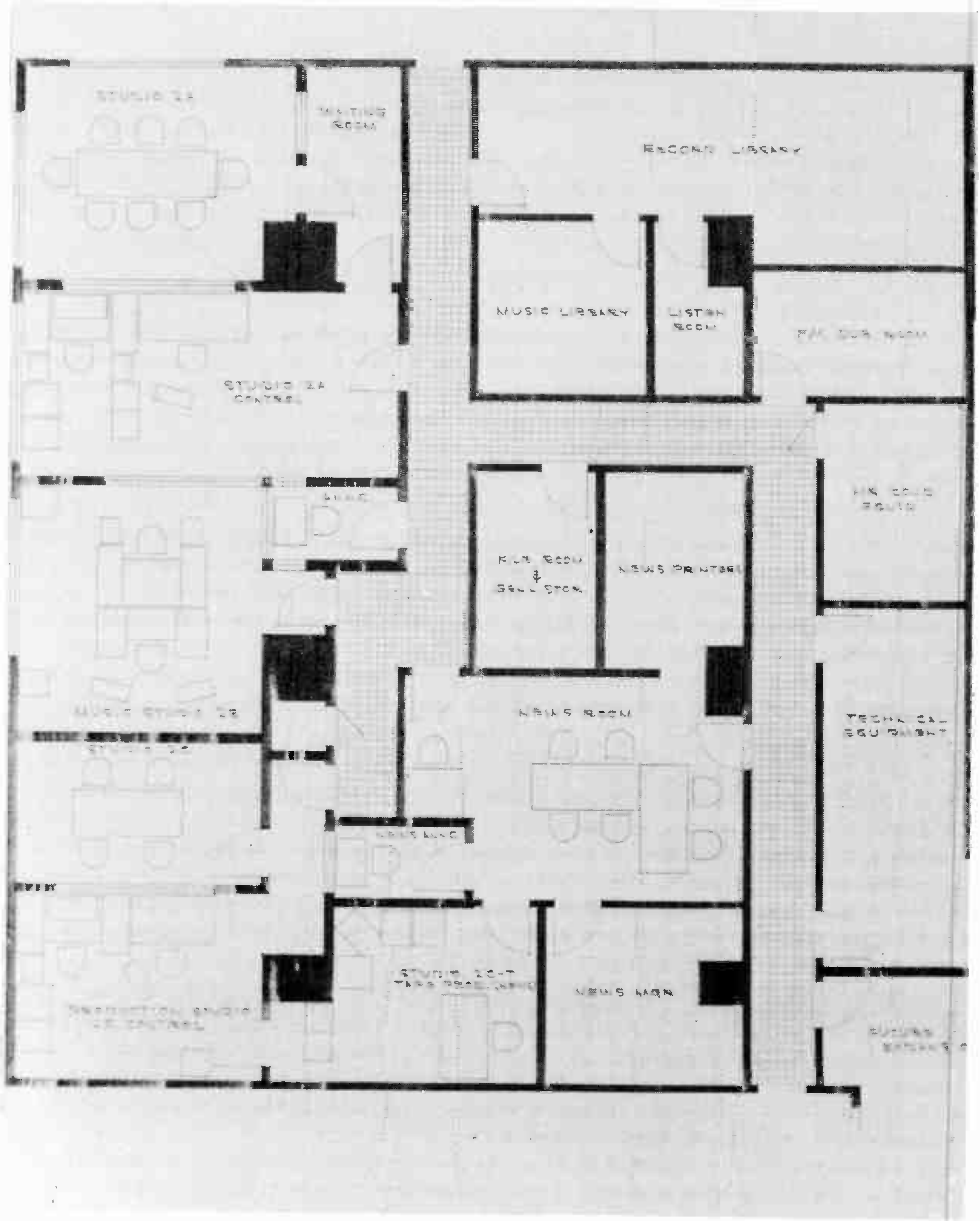

STUDIO 2A
WAITING ROOM
RECORD LIBRARY
MUSIC LIBRARY
LISTEN ROOM
STUDIO 2A CONTROL
NEWS PRINTERS
NEWS ROOM
TECHNICAL EQUIPMENT
NEWS MGR

Fig. 1

Fig. 2

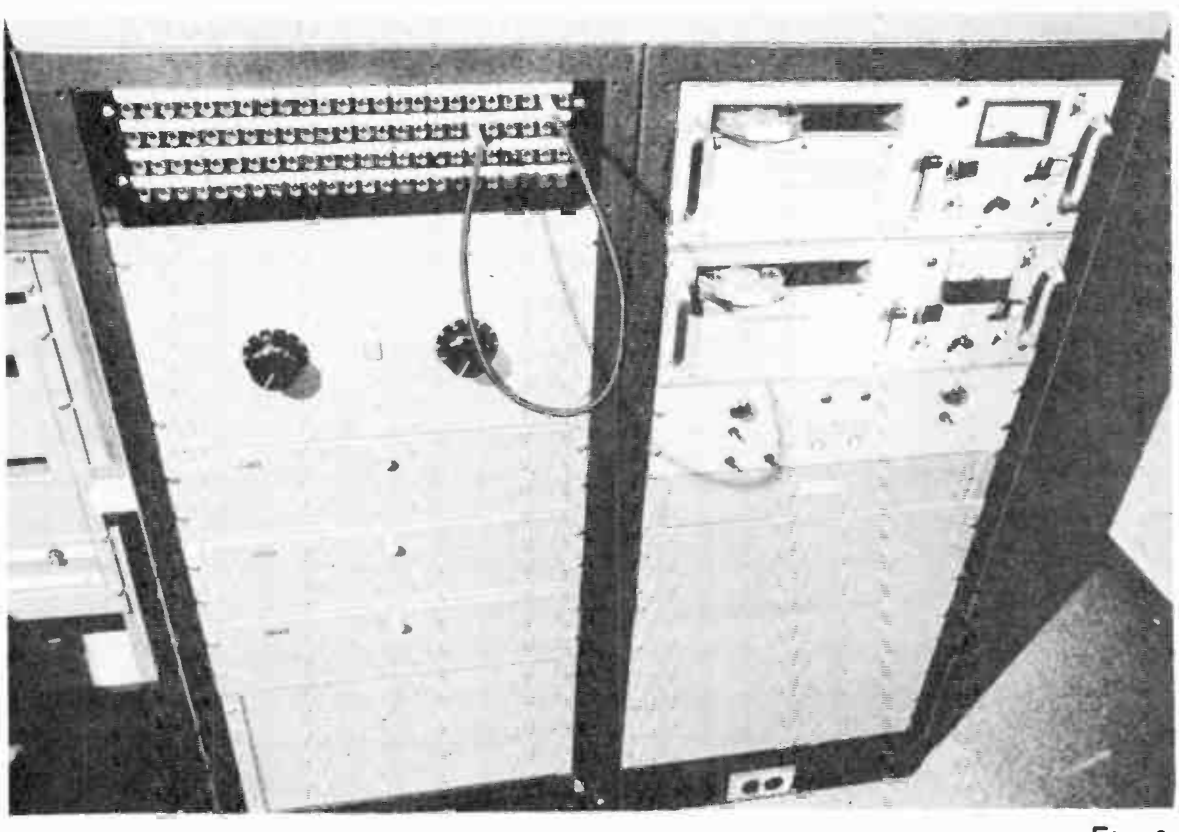
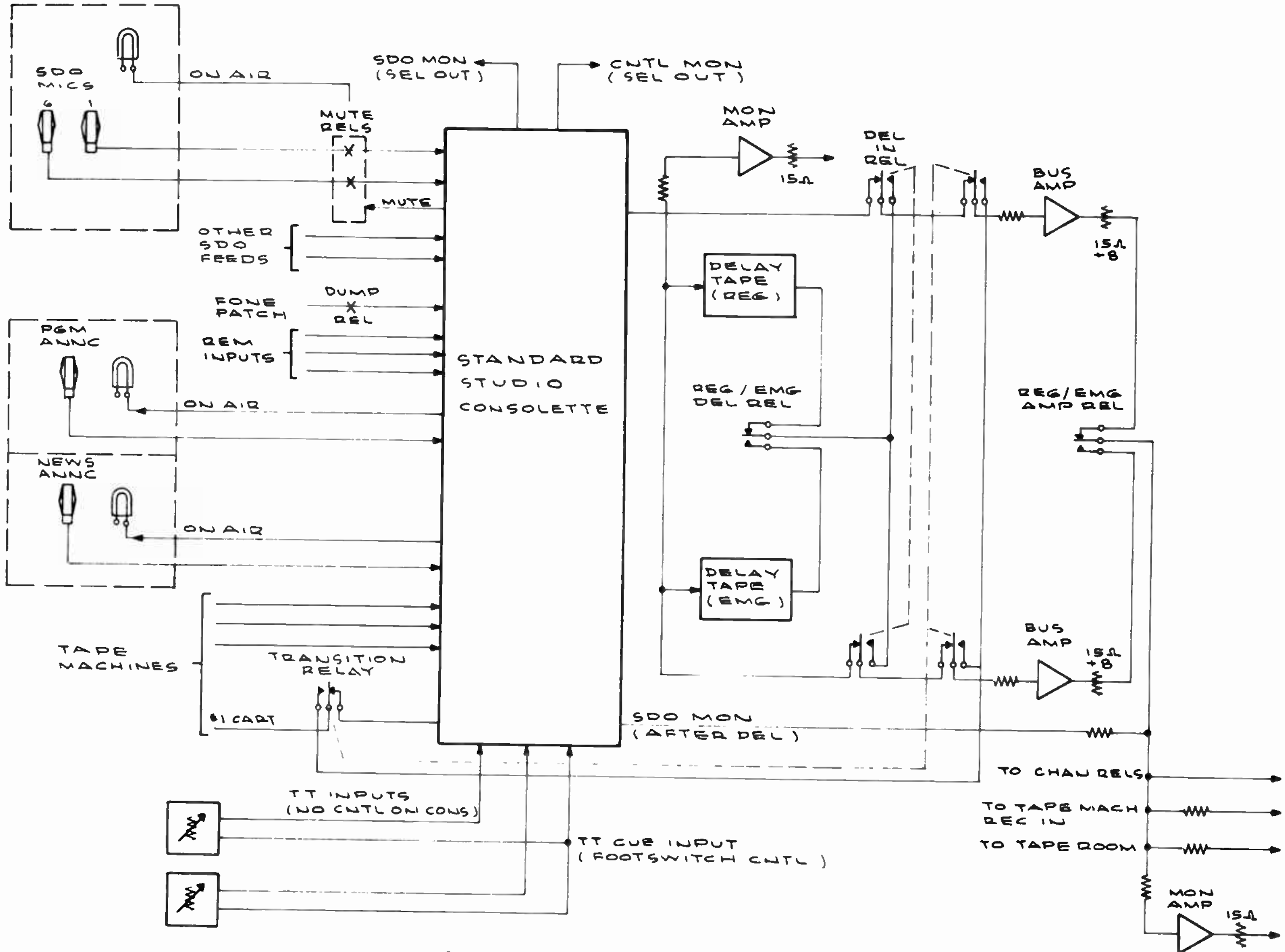


Fig. 3

Fig. 4



SIMPLIFIED BLOCK DIAGRAM
TYPICAL STUDIO

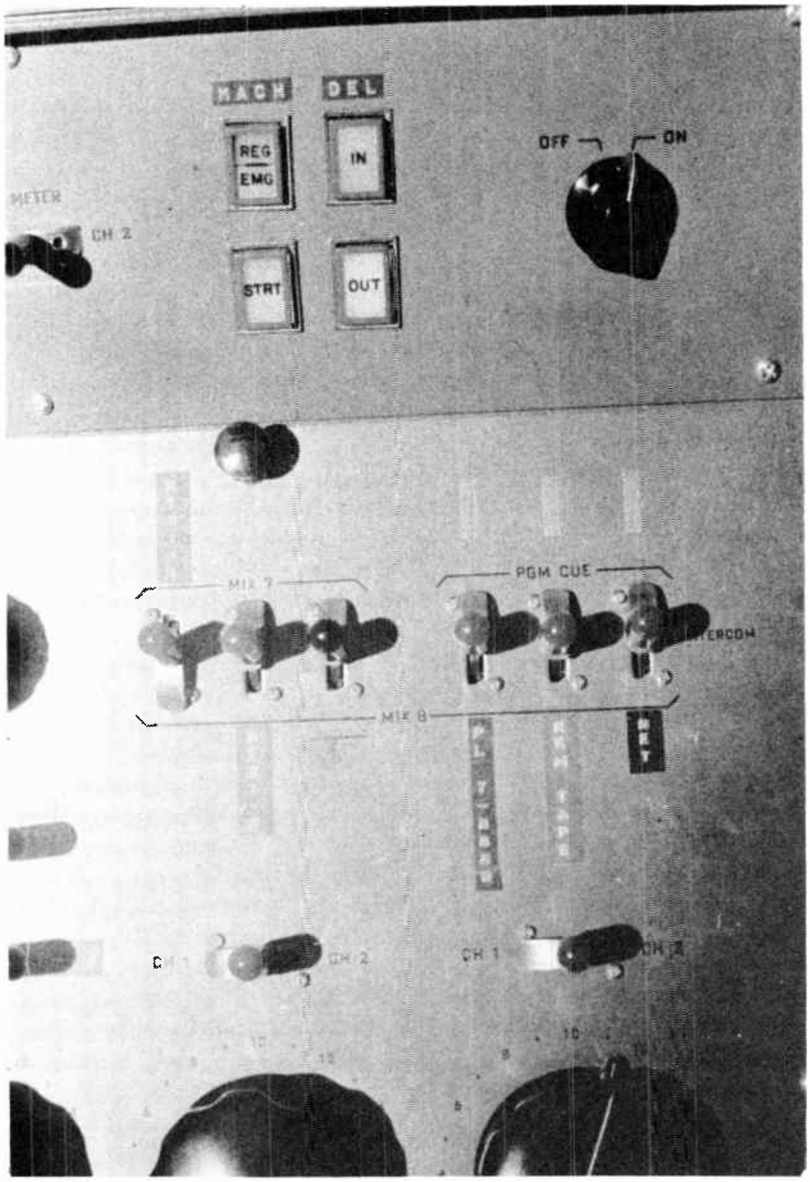


Fig. 5

for this application are now available to WNBC from an outside vendor. When received, each cartridge is checked for physical operation: pinching, binding, and splice accuracy. Simultaneously, a cue tone is recorded on the cue track. This machine provides the heart of the system: the delay unit. However, the problem now is access to the system and how it operates. How do we get in and out of the delayed-time program and additionally how is the air material protected?

To get into the delay mode is very simple; start talking seven seconds prior to air time. However, it is required that the studio not be in operation prior to the delay mode origination. Then too, how is seven seconds of dead air time avoided when going into "delay" in the middle of a program? The solution lies in the use of another program source to fill the seven second prerecorded gap. WNBC uses a standard cartridge machine to provide this need. When the delay mode is activated by the technician (one button), a normal cartridge machine is started and transferred directly to the outgoing lines. Simultaneously the delay machines, regular and emergency, are switched into the console output path. During this period, the control circuitry of the transitional machine inhibits the output of the "delay" machine from going to the output lines, therefore, providing a timing action. The "transitional" tape could be fill music or a short jingle, but the timing does not have to be precise, so long as

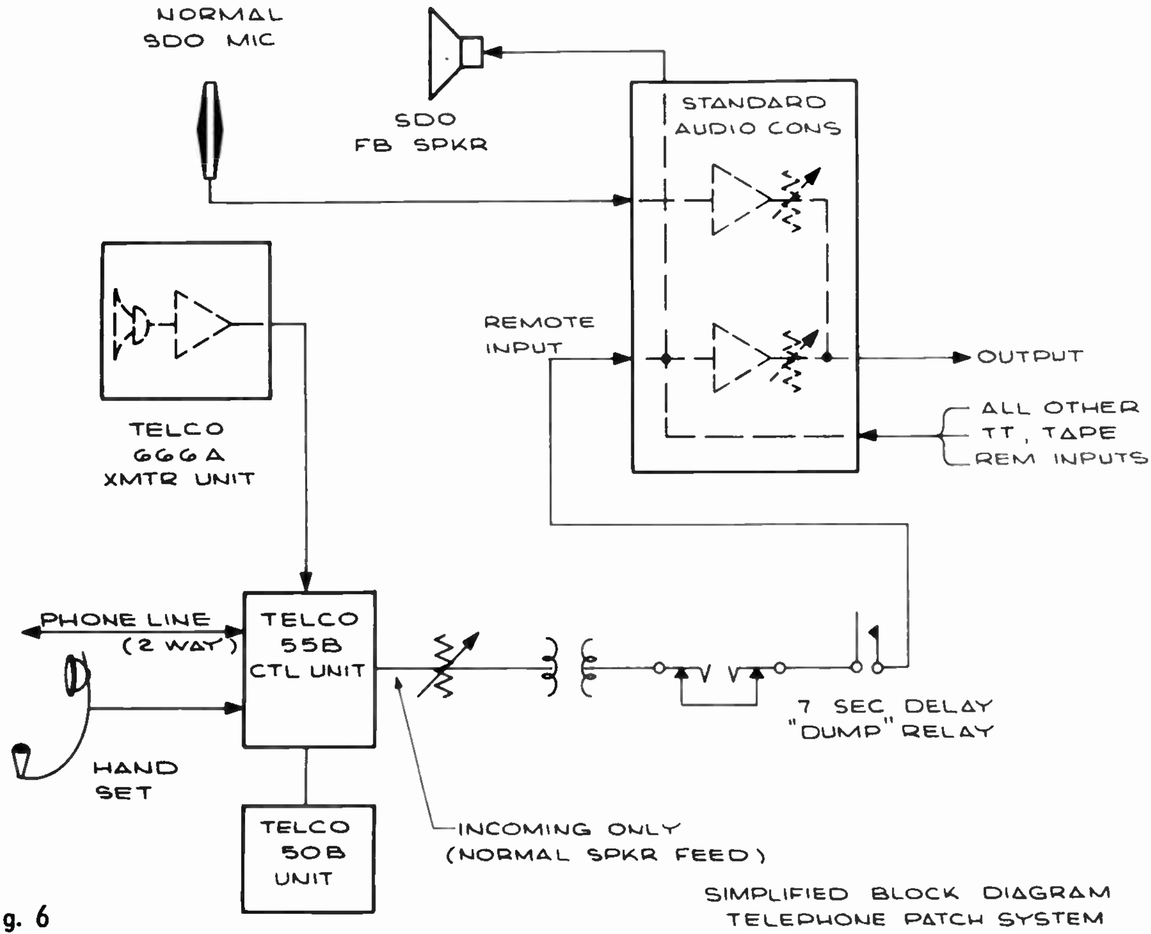


Fig. 6

the studio talk starts seven seconds before the "transitional" tape runs out. The "transitional" tape can be a one minute commercial or a promo or even a half-hour delayed broadcast (see Fig. 5).

I believe that we can all appreciate that it would be impossible for one man to simultaneously monitor both delayed and undelayed audio. The undelayed signal must be monitored in order to protect the on-air content. An after-delay volume indicator provides visual monitoring and a loudspeaker for periodic monitoring allows aural verification. The cue tone previously recorded on the tapes provides an assist in this endeavor. If the regular machine should stop, or the cue tone be off frequency, no cue will be sensed and the system will automatically switch to the emergency machine simultaneously signaling the operator. Should any periodic checks indicate trouble that the relays have not analyzed, manual switching may be affected.

As an adjunct to the 7-second system, a telephone tap has been incorporated. This simply consists of a telephone company 3A speakerphone in combination with a standard filtered beeper-phone. This equipment is installed by the telephone company providing the customer a low-impedance feed to which WNBC has connected a bridging load. (See Fig. 6.) The feed is essentially of a remote nature, incoming only, and is handled accordingly through the console. A cut-off relay is provided such that when the technician, director, or talent decide to dump the delay system, the telephone remote will also be dumped, thus eliminating the possibility of an obscenity on the air. To facilitate the operation of the delay system, tally lights are provided in the studio and control room as positive indications of the operational status; delay-in, transition, on-air and cue.

As operational equipment the technician has as a normal complement one sequenced 4-deck cartridge tape playback machine, two single-deck cartridge tape machines,

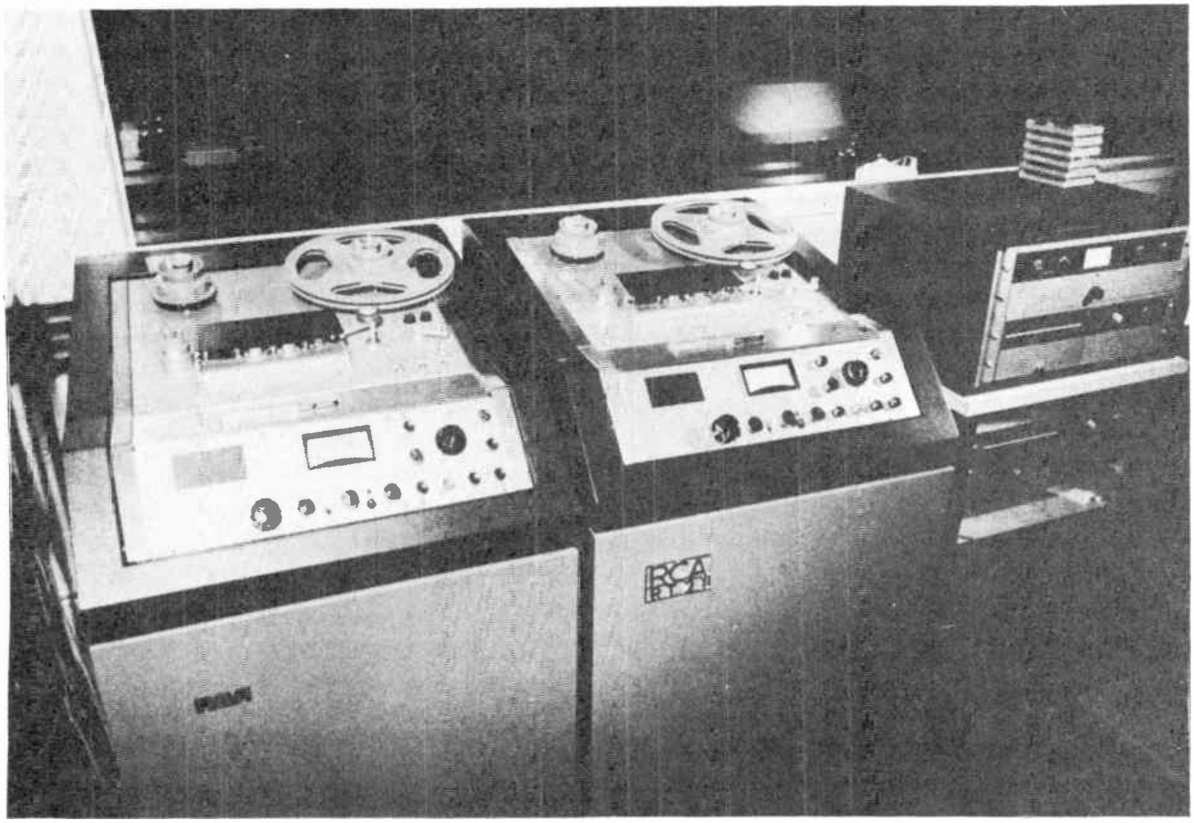


Fig. 7

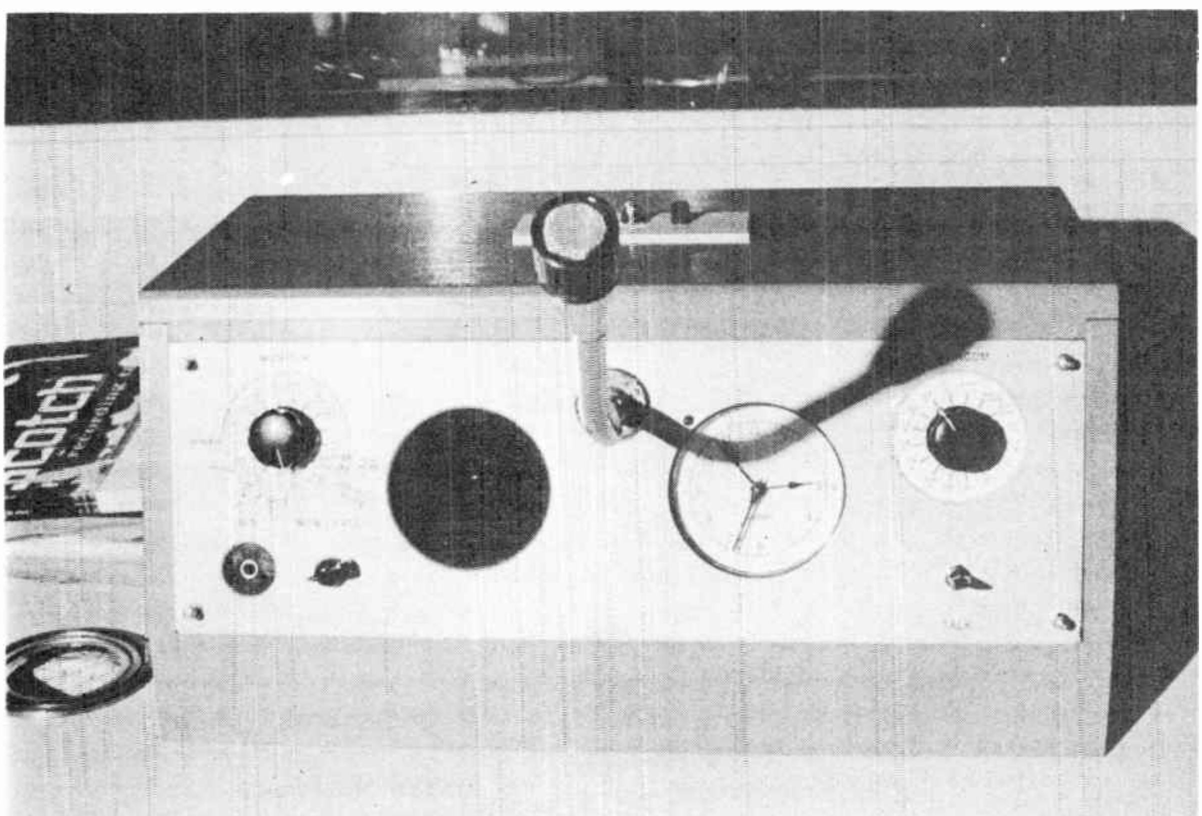


Fig. 8

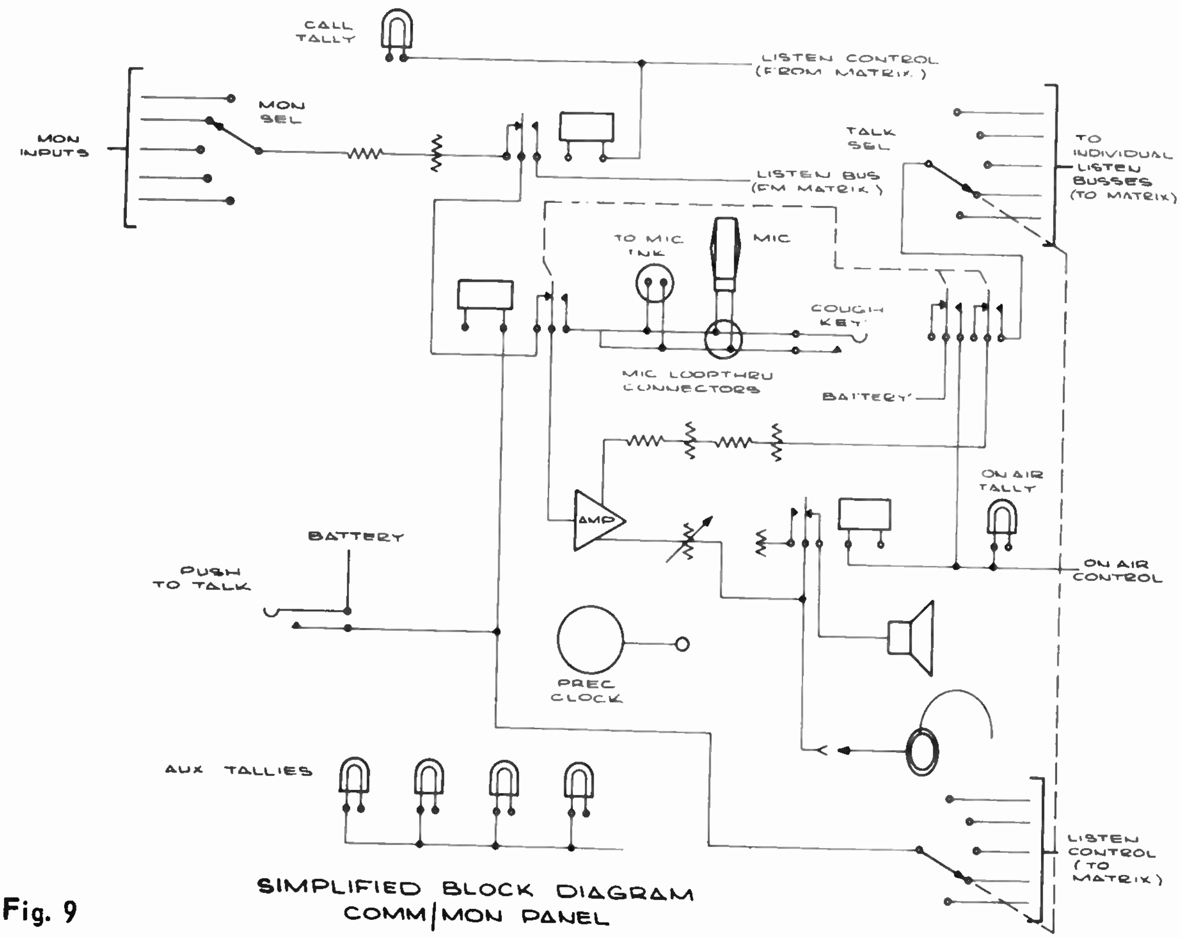


Fig. 9

SIMPLIFIED BLOCK DIAGRAM
COMM/MON PANEL

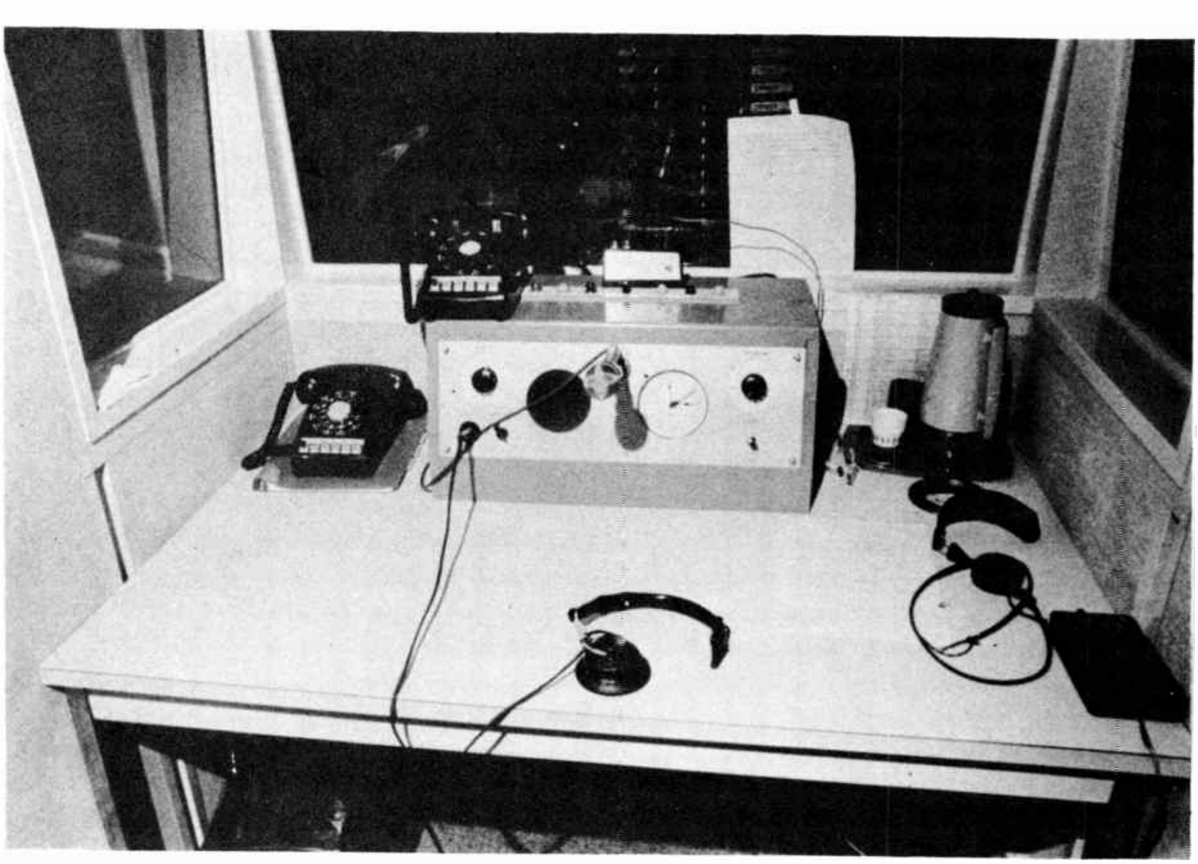


Fig. 10

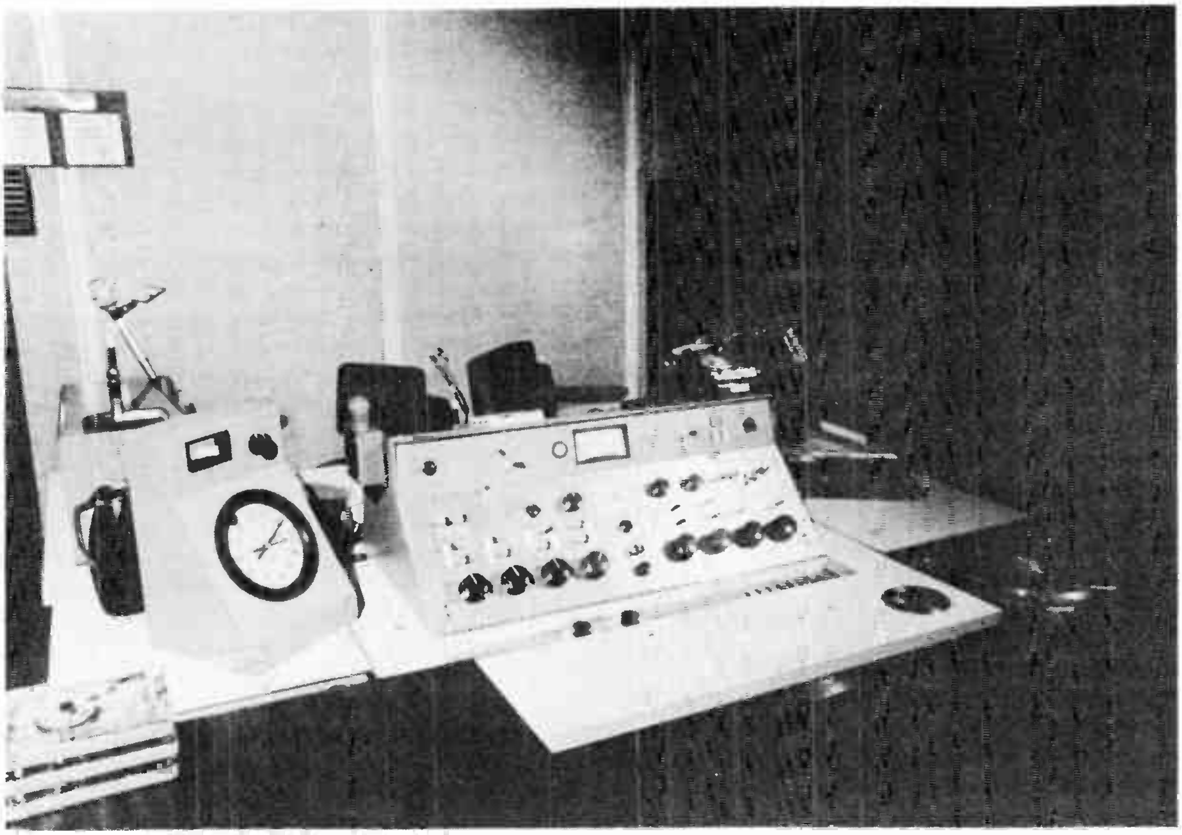


Fig. 11

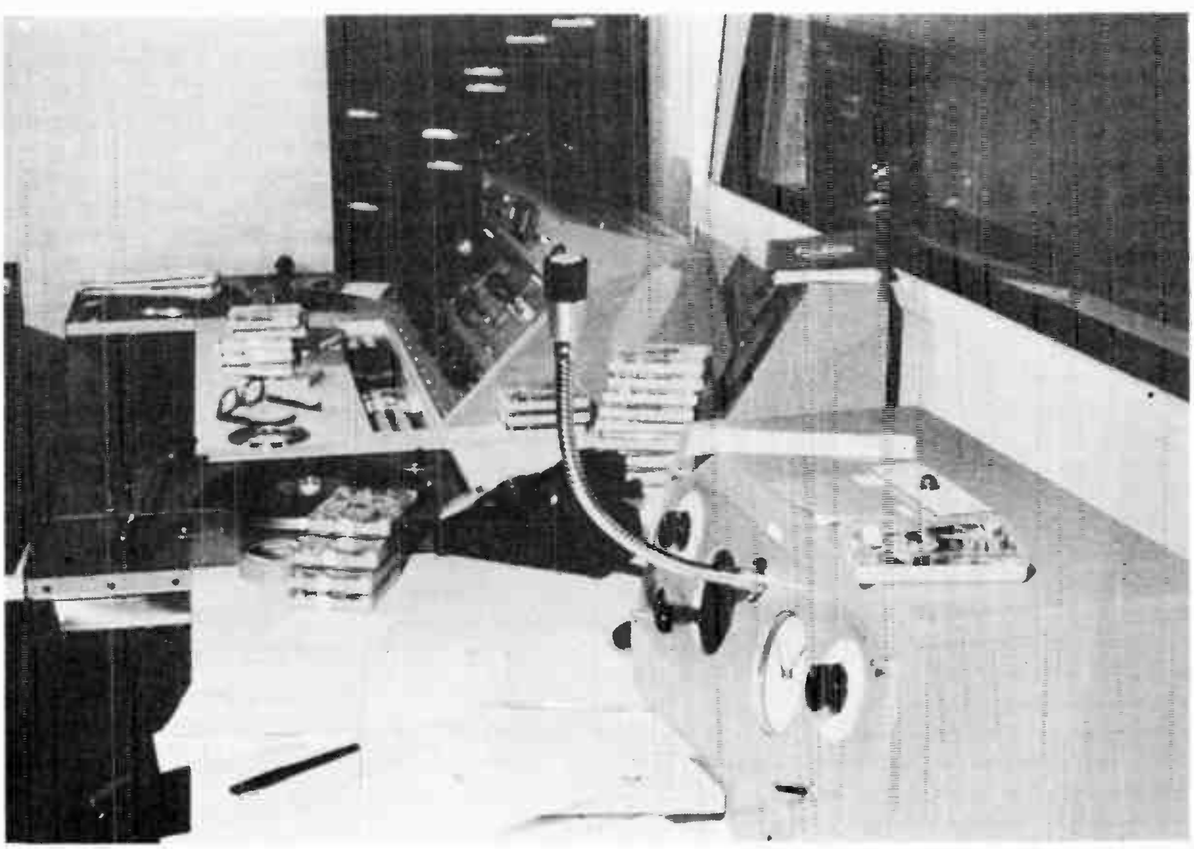


Fig. 12

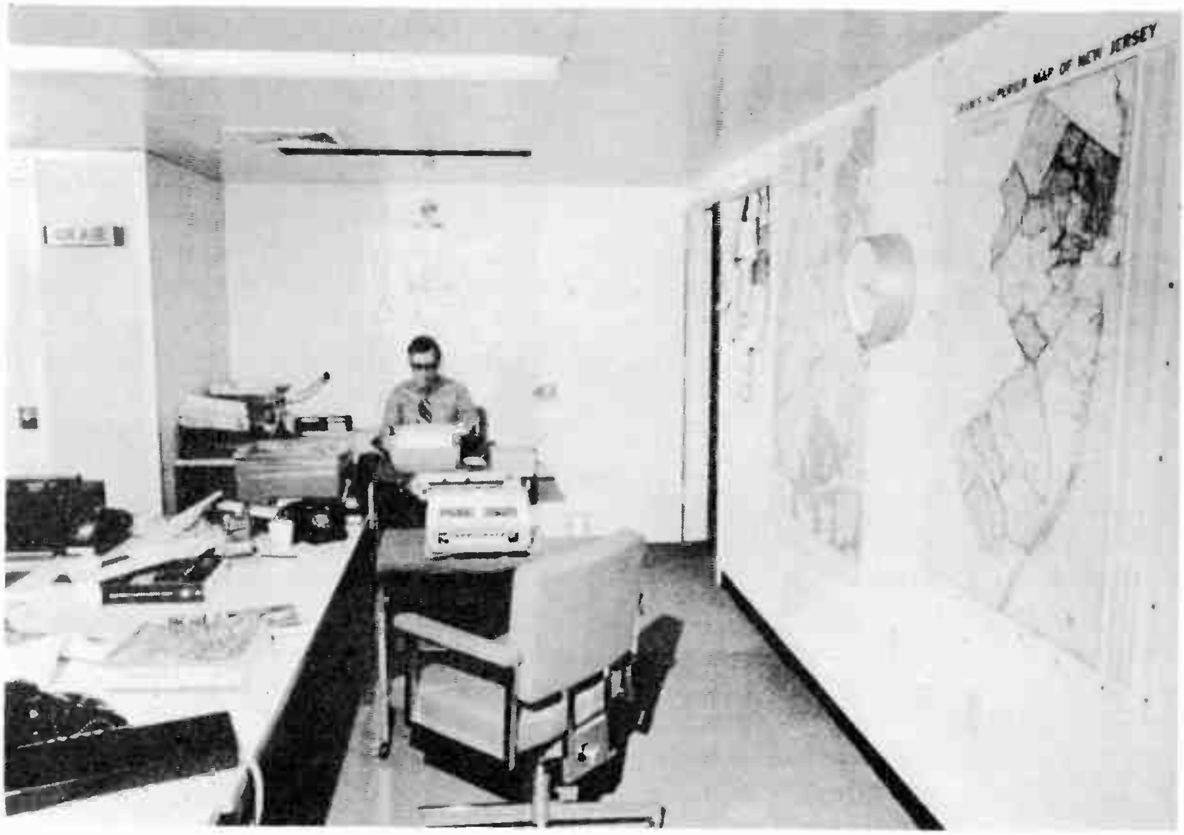


Fig. 13

Fig. 14

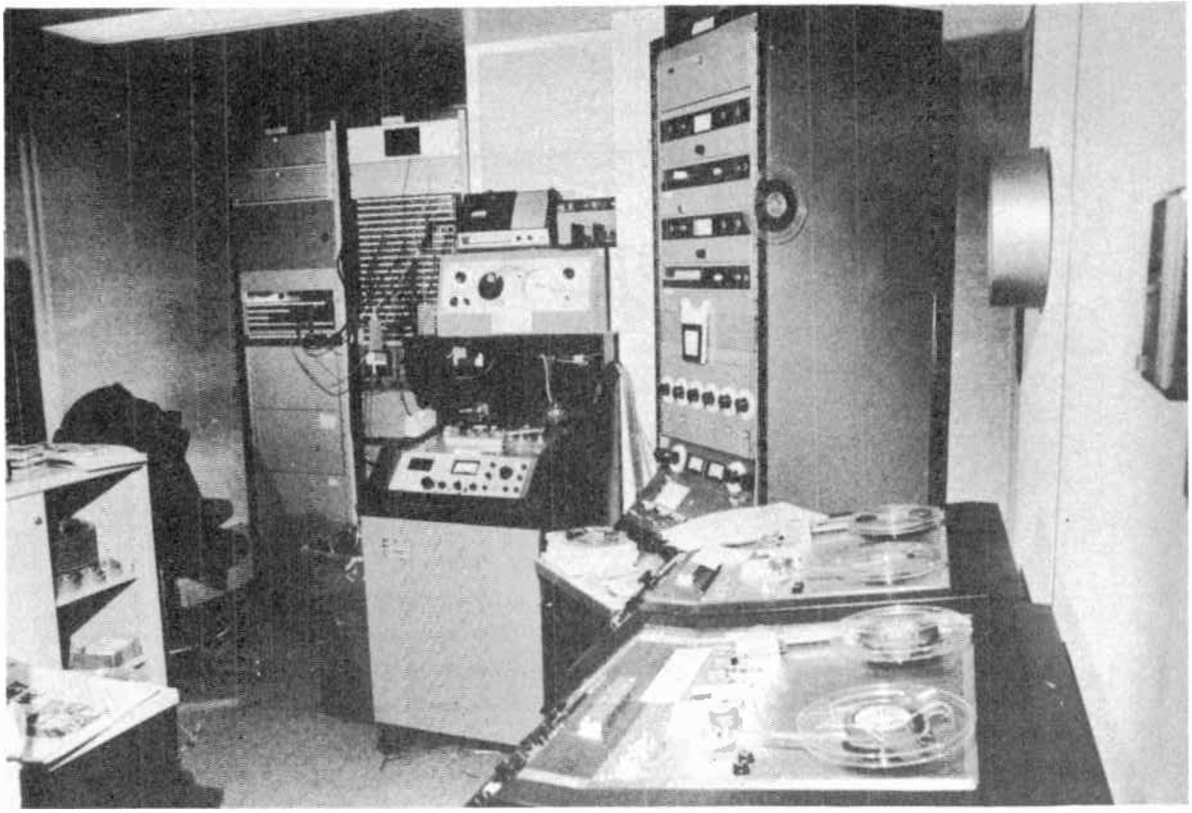


Fig. 15

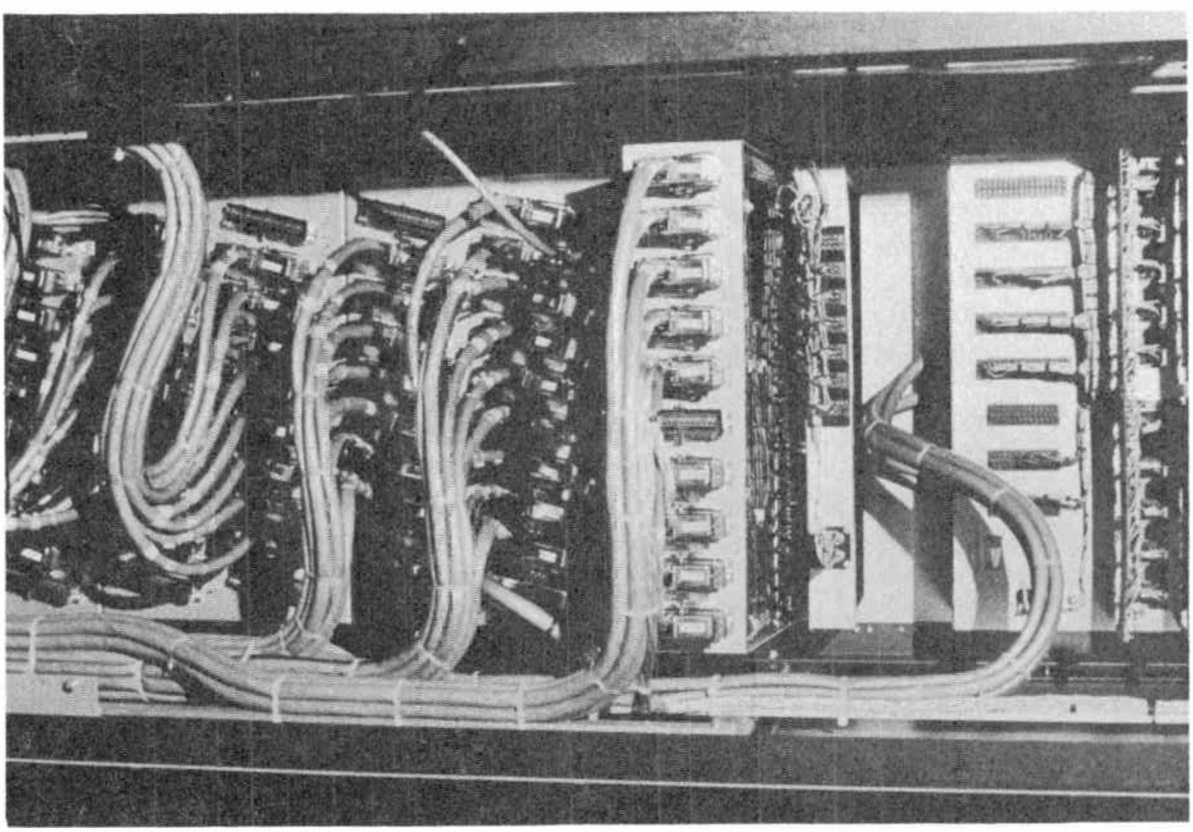


Fig. 16

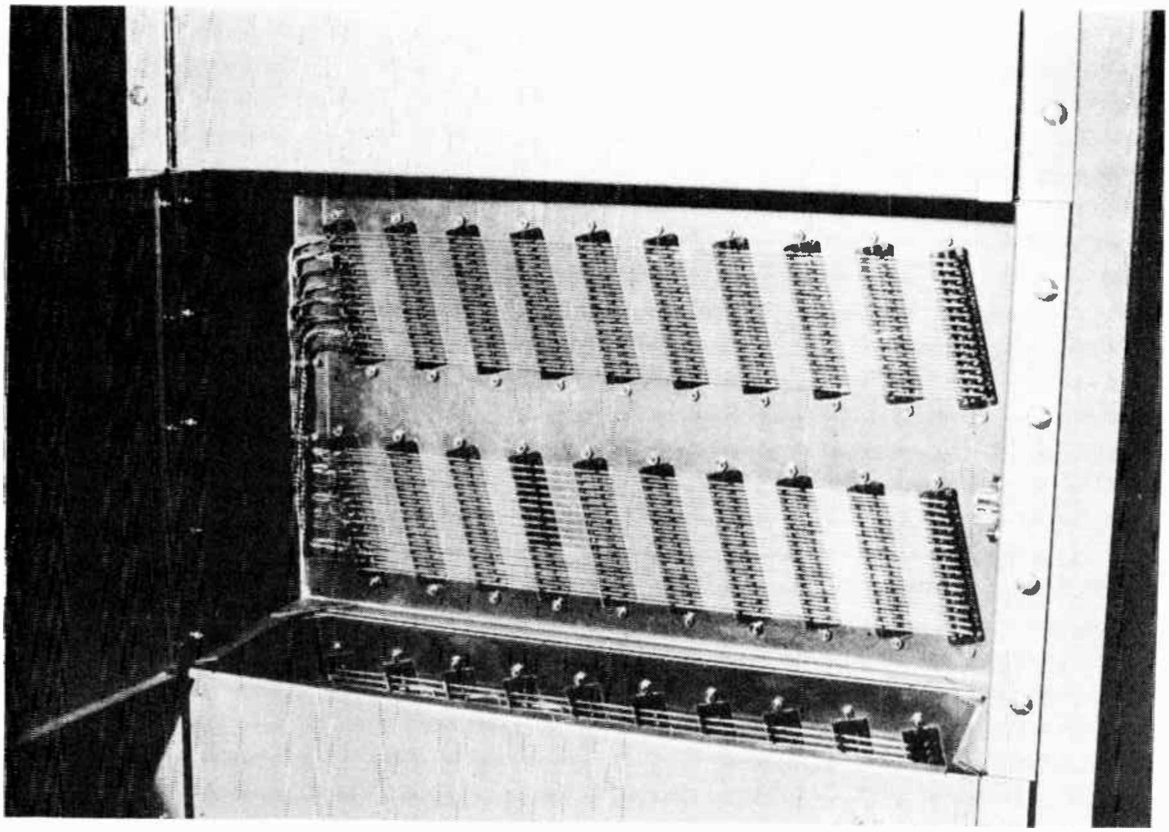


Fig. 17

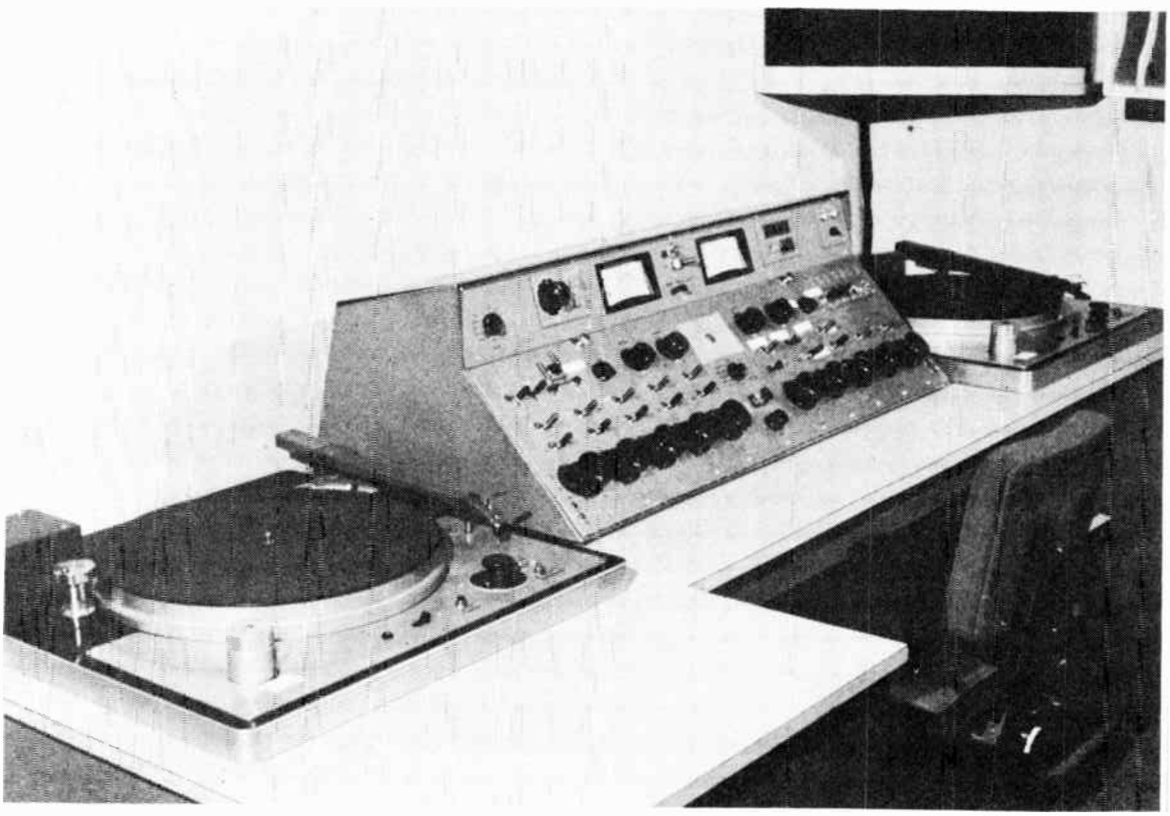


Fig. 18

two reel-to-reel tape machines and two turntables (Fig. 7). Notice the auxiliary panel located in the table top of the console. This panel contains the outgoing line pickup and status keys, remote control keys for a tape machine and communications facilities.

All of the communications monitoring positions are alike in concept, differing only in mechanical construction. Fig. 8 is a photograph of the communications unit located at the director's console in the studio. These units were designed to be universal positions providing intercom, line talkback, program monitoring, clock and status tally lights, all in one package.

Fig. 9 is a simplified block diagram of the package. Observe that the single amplifier is an AGC type. A saturable input transformer inexpensively provides the AGC action and is adequate for this type of service. All of the units in the plant are connected to panels in the tape room which route the various functions and provide the communications matrix. Live studio usage requires that muting relays, headset jacks and signal tally lights also be provided. In addition, the microphone loopthrough circuit permits the use of a program microphone (with cough key) as a communications microphone. Fig. 10 illustrates this application in one of the announce booths.

Fig. 11 is a photograph of the "disc-jockey" studio, again containing the same type of equipment as the conference studio. The fast-type "disc-jockey" operation requires the control studio complex to be located within one room. Should the need arise, modular furniture and plug-in equipment allows rapid changes in configuration.

Fig. 12 is a photograph of the production studio, specifically designed for pre-taping purposes, and, therefore, is equipped with more tape facilities than the other studios. Nevertheless, its program capabilities are generally equal to the other studios. Thus it may act as a substitute studio during maintenance routines or additionally it may be equipped for special use such as elections or conventions. This studio is not normally equipped with a 7-second delay unit but contains, instead, a cartridge playback unit devoted to visitor-tour billboards. When the regular NBC tours view the local station operation, the tour button outside the "disc-jockey" studio is energized by the tour guide. The tape machine then interrupts the tour monitor (normally fed program) and provides a dissertation explaining the plant facilities. The selected recording is made in the form of a promotional by the talent currently on air in the "disc-jockey" studio. Dead air following the dissertation provides time for questions to the tour guide. A second push of the tour button restores the lobby monitoring back to the program position.

Although small in total area, the WNBC news room contains all necessary equipment required for gathering and editing news material (Fig. 13). The central area of the room provides for the news writers and commentators including the editor's main news desk. Adjacent, is the wire room (Fig. 14), the news manager's office, a news booth and a tape room (Fig. 15). Although the tape room is a universal area used by all of WNBC for prerecording, editing, dubbing and repackaging, most of the work is concerned with news. Small as the area is, the tape room contains three reel-to-reel machines, three cartridge machines, a cross-dub assignment panel and a mixing console. In addition to access to all incoming lines, both announce booths and the production studio are available to the mixing console for direct recording. A storage and erase facility and a tape editor's desk is also provided.

As mentioned previously, all the central equipment is located in the rack complement within this room. Included is the channel relay equipment for four studio switching to four outgoing lines. When no studios are feeding the channel relay equipment, the prerecorded FM sources are automatically connected. All timed entry news reports are switched in on time by the automation equipment, but when pre-recorded FM operation is complete, any local studio may operate into the FM channels by merely picking up one or all of these channels. Additionally this method of operation provides ease of

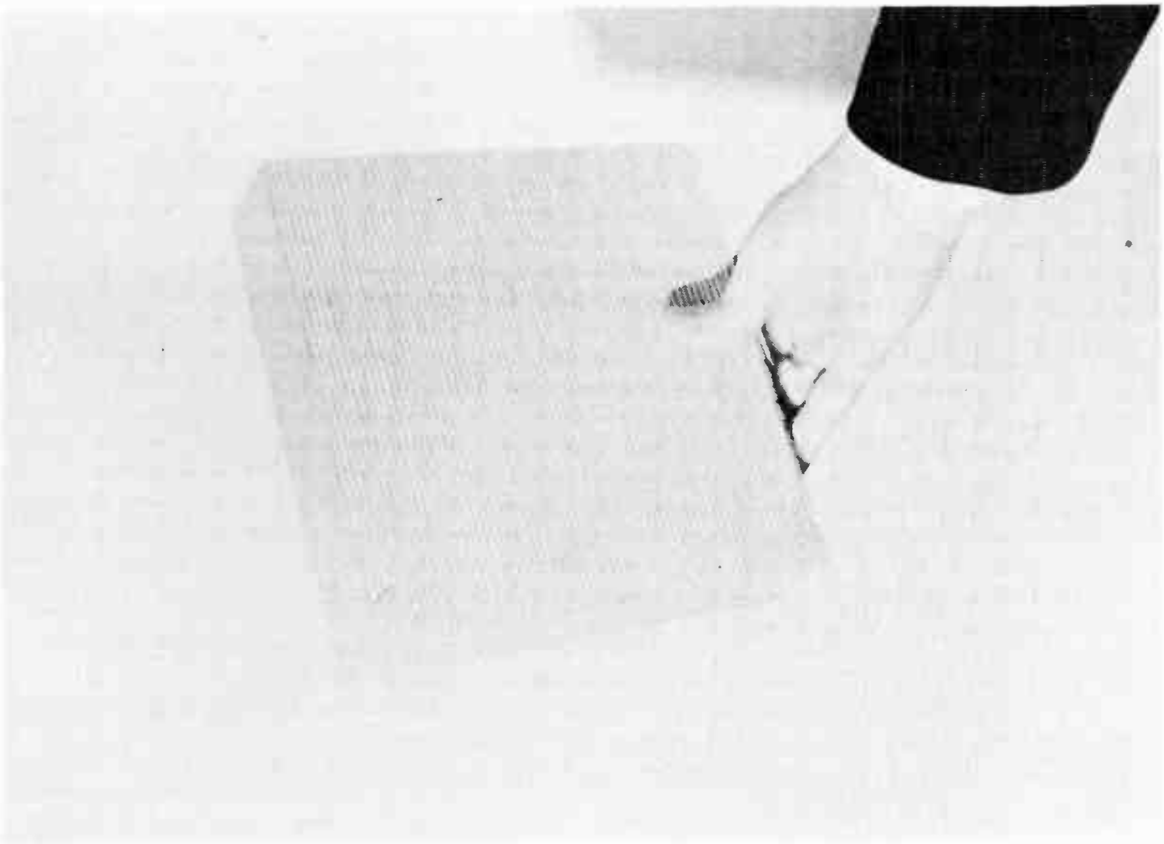


Fig. 19

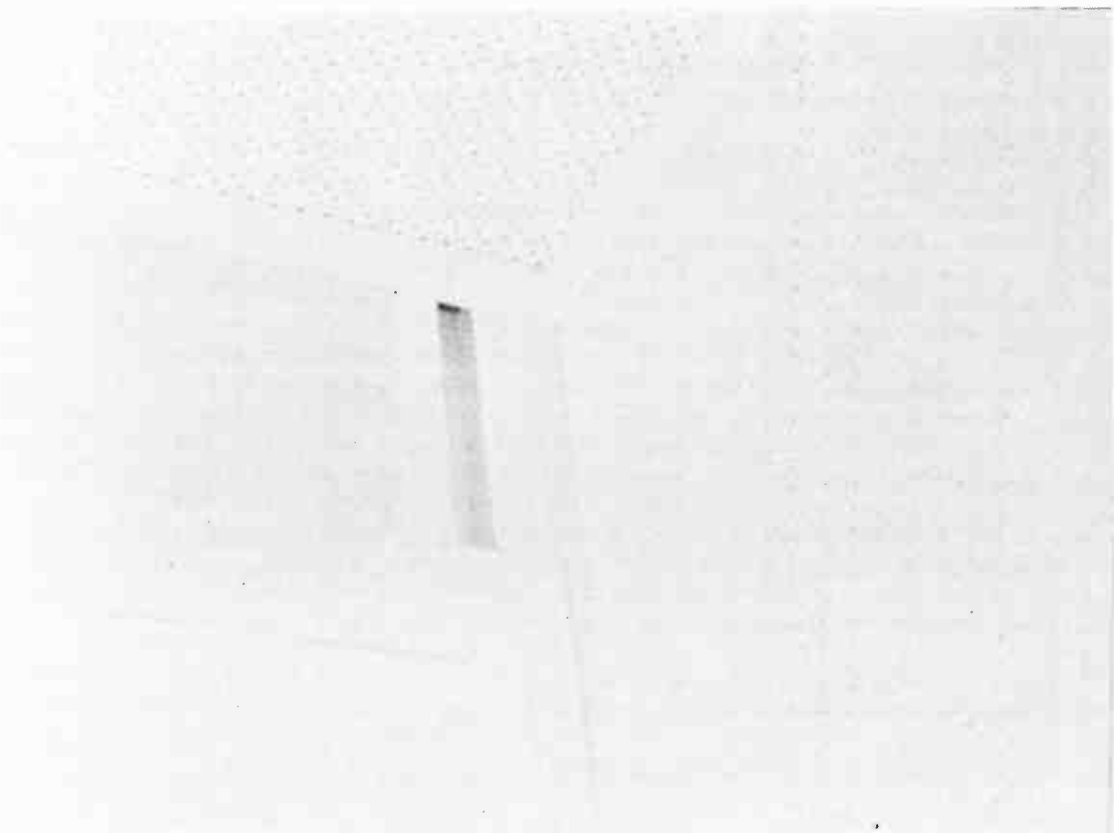


Fig. 20

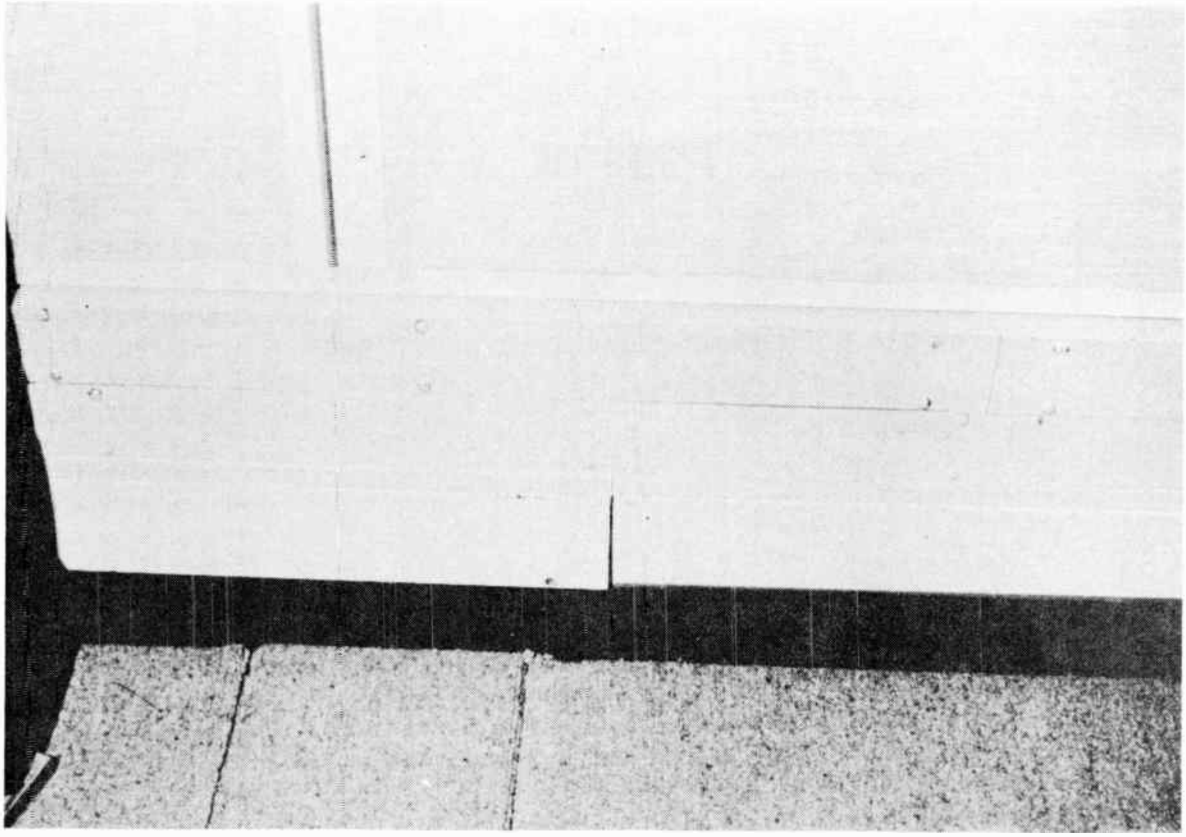


Fig. 21

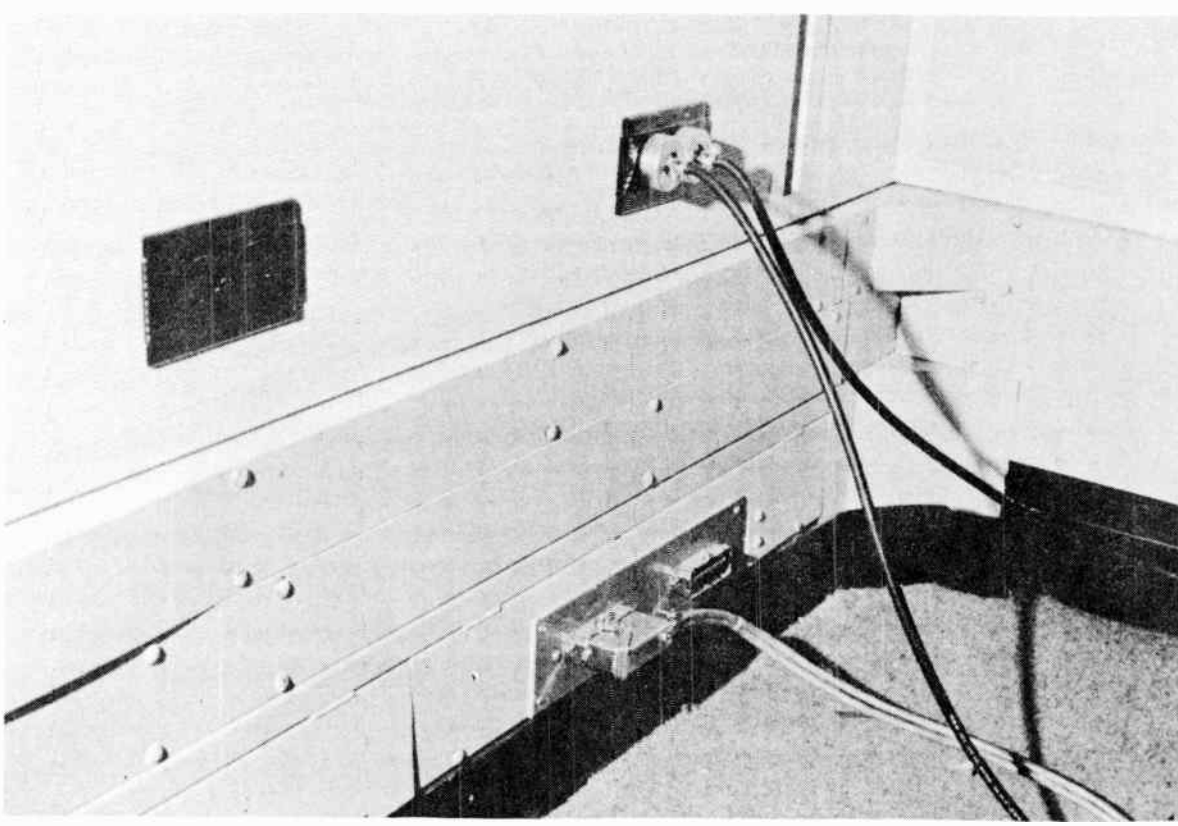


Fig. 22

Fig. 23

break-in to the automatic operation. Figs. 16 and 17 are photographs of the tape racks showing some of the construction techniques used to simplify the plug-wired installation. Notice, especially, the jackfield rear, the multiple receptacle wiring and the rack wiring cable dress.

Fig. 18, is a view of the program dubbing room, specifically devoted to the makeup of program tapes for the FM automation equipment. Complete program mixing facilities are provided along with the equipment to introduce the required trip tones for the automation system. Although not utilized, channel relays have been installed for the entry of this studio as a live broadcast origination point. Simultaneous to live origination, facilities can be provided for recording the material with trip tones, thus providing the basis for a library buildup.

As an additional feature, the entire radio plant has been interconnected to the NBC emergency power system. The system diesel-generator is located elsewhere and is automatically started by sense relays throughout the Radio City plant. Should a power failure occur, automatic changeover relays will trip and operation will be maintained.

Another area of cost saving was affected in the architectural construction. The walls are of standard block and plaster construction and the acoustic finish was achieved by the use of 3-inch vinyl overlay pressed-fiberglass batts set into clip framing. Although the walls are not extremely durable, the clip framing allows simple repairs to be made. The walls, performated hung ceilings, and carpeted floors, have achieved the acoustical characteristics of previously used construction methods considerably more expensive, along with a good looking decor. Figs. 19 and 20 illustrate the methods.

To further take advantage of the plug-in system and allow the use of pre-butted cables, surface mounted duct work was used throughout. The thickness of the wall material allowed the finished wall to appear flush and provide the convenience and look of inset duct work. Fig. 21 illustrates this construction and Fig. 22 shows the tape machine interconnect receptacles built directly into the duct work.

Although rather standard in its choice of equipment it is felt that by virtue of its system concept, the new WNBC plant has a lot of program power packed into its small confines. There is virtually no show format in use that it cannot cope with and possibly some not yet thought of that it would like to try.

Digital Automatic Frequency Control for FM Transmitters

Jack Sellmeyer
Gates Radio Company

Simply defined, an Automatic Frequency Control System is a feedback system intended to reduce or eliminate errors in the frequency of a transmitter. An AFC system as we know it today is commonly applied to a free-running FM oscillator to stabilize its operating frequency. This paper deals with three types of AFC systems in common use in the FM broadcast industry today.

HISTORY OF FM TRANSMITTERS

In the late 1940s several methods of direct FM generation were developed in addition to the original Armstrong system of indirect FM generation. Several problems plagued the early designs, not the least of which was marginal frequency stability exhibited by early AFC systems. In the mid-1940s an improved method of indirect FM generation was developed. This system involved a phase modulation system following a crystal-controlled oscillator. It offered very good frequency stability, low distortion and low noise, in addition to good repeatability. However, with the advent of stereo broadcasting in the early 1960s, it became apparent that phase modulation systems could not provide the necessary bandwidth and tightly controlled phase response required by the FCC-approved stereo transmission system. Once again, development work was carried out on direct FM systems. With the advent of transistors and other solid-state devices, direct FM systems became more practical. Still, however, free-running FM oscillators could not be built on a practical basis which could meet the stability requirements of the FCC Rules. Some means of automatic frequency control was still necessary to meet these requirements. Various means were considered and tried in the development laboratories of various companies involved in the business of building FM transmitters. Of all the systems considered, three have evolved into general use. These are: 1) Pulse Counting Demodulator; 2) Frequency Lock and; 3) Digital Phase Lock.

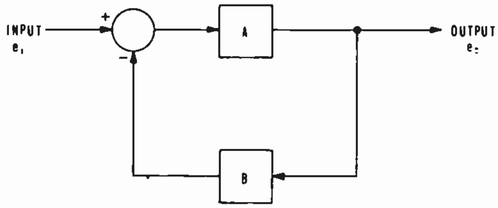
Before looking in detail into the operation of the various systems, it is necessary to return to a brief look at some of the principles of negative feedback. This will provide a better basis for understanding the operation of the first two systems. Fig. 1 shows a block diagram of a system with negative feedback. If the feedback is disabled, the open-loop gain of the system may be determined to be:

$$\frac{e_0}{e_i} = A$$

Similarly, an expression for the closed-loop gain may be determined, or system gain with feedback applied, by the equation:

$$A_f = \frac{A}{1 - AB}$$

where Af is the closed-loop gain, A is open-loop gain and B is the feedback factor.



$$\text{OPEN LOOP GAIN} = \frac{e_o}{e} = A$$

$$\text{CLOSED LOOP GAIN} = A_f = \frac{e_o}{e} = \frac{A}{1-AB}$$

$$A_f = \frac{A}{1-AB} = \frac{-1}{B}\left(\frac{-AB}{1-AB}\right) \quad \text{FOR LARGE VALUES OF AB}$$

$$\frac{-AB}{1-AB} \simeq 1$$

$$A_f \cong \frac{-1}{B} \quad \text{(GAIN IS INDEPENDENT OF A)}$$

Fig. 1

The effect of a change of open-loop gain on the closed-loop gain may be determined by rewriting the basic expression for closed loop gain:

$$A_f = \frac{-1}{B} \quad \frac{-AB}{1 - AB}$$

The factor: $\frac{-AB}{1 - AB}$

may be seen to approach 1 for large values of AB; hence:

$$A_f = \frac{-1}{B}$$

The closed-loop gain is almost entirely determined by the amount of feedback present in the circuit. It can be shown that for a feedback factor of 100, the closed-loop gain of any system can change by no more than 1%. The end result of the application of a large amount of negative feedback to a system is the stabilization of an operating parameter against changes in the active devices inside the loop. It is evident from the previous discussion that in an audio amplifier with a closed-loop gain of 100 (40db) and a feedback factor of 100 that the open-loop gain may vary over a very wide range for a small change in closed loop gain. The same theory is directly applicable to two of the three commonly used AFC systems.

PULSE-COUNTER AFC SYSTEM

The pulse-counter AFC system derives its name from the use of a pulse counter to determine errors in the center frequency of its associated oscillator. Reference to Fig. 2 reveals the operation of the pulse-counter system.

A free-running FM oscillator of center frequency f_c receives two basic input signals, the information signal, and a DC correction voltage from the AFC system. The output of the oscillator is mixed with a crystal-controlled frequency F1. The result is an intermediate frequency usually in the range from 125 kHz to 550 kHz. It should be noted at this point that the crystal oscillator is not necessary to system operation but is used merely as a translation device to reduce the output frequency of the modulated oscillator to a range of frequencies where it is physically possible to perform certain operations on the signal.

The intermediate frequency now contains all modulation components of the original carrier (same deviation and bandwidth) except that the center frequency has been reduced to a lower frequency of approximately 200 kHz. The signal is then fed to a Schmitt trigger, a form of multivibrator which delivers a pulse at its output for each zero crossing of the input frequency. The output of the Schmitt trigger is a series of pulses corresponding to the original FM signal and these pulses are used to trigger a one-shot multivibrator which in turn generates a series of rectangular pulses of accurately controlled duration. The one-shot multivibrator generates one pulse of constant amplitude and duration for each pulse it receives. Thus, it can be seen that the output of the one-shot multivibrator is an accurately controlled pulse train which contains all of the information contained in the zero crossing of the original IF signal. The number of pulses in a given length of time, and hence the frequency of the output of the one-shot, is the same as the frequency of the IF signal.

The next step is to pass the output of the one-shot multivibrator through a low-pass filter to remove the IF component from the signal. The remaining components consist of a DC signal whose level is proportional to the input frequency and an audio component. This is precisely the same system used in many of today's frequency and modulation monitors. The audio component is filtered out and the DC component applied to the modulated oscillator correction input. If the system has sufficient gain, the output frequency of the oscillator will be controlled very accurately by the AFC system. The same expressions for closed-loop error response developed for the audio amplifier case apply directly in this case.

Assuming that the pulse counter and reference oscillator are perfectly stable and the feedback factor is very large, a very small error in center frequency is possible. For instance, let us assume a feedback factor of 100 and a center frequency error in the modulator of 200 kHz, the expression:

$$\Delta f_c = \frac{1}{B} \Delta f_c$$

gives an error with AFC of only 2 kHz, or a reduction of 100:1. It is not uncommon to expect performance of this order in modern pulse-counter systems.

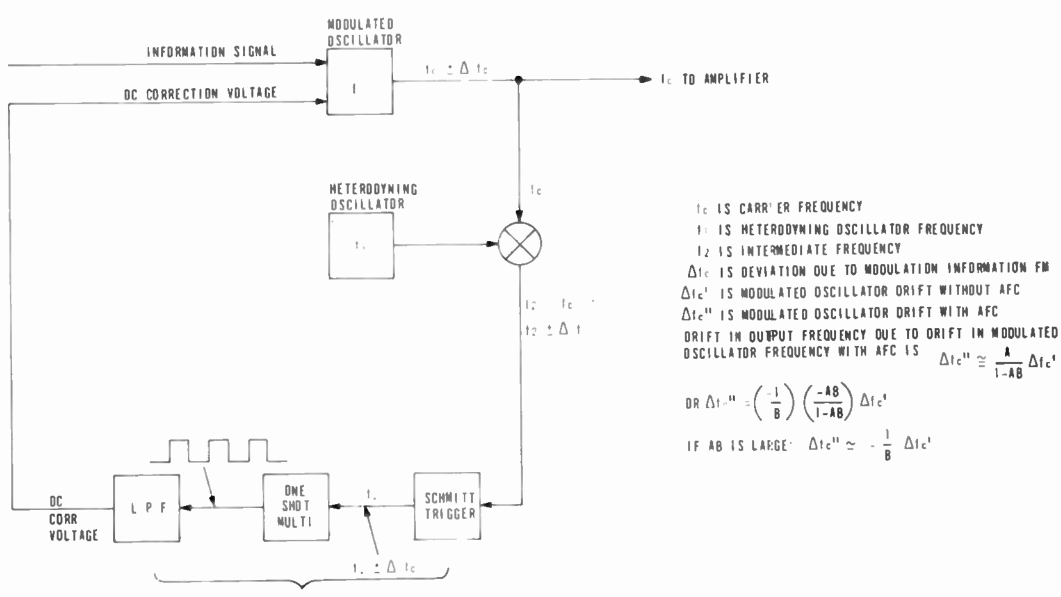


Fig. 2

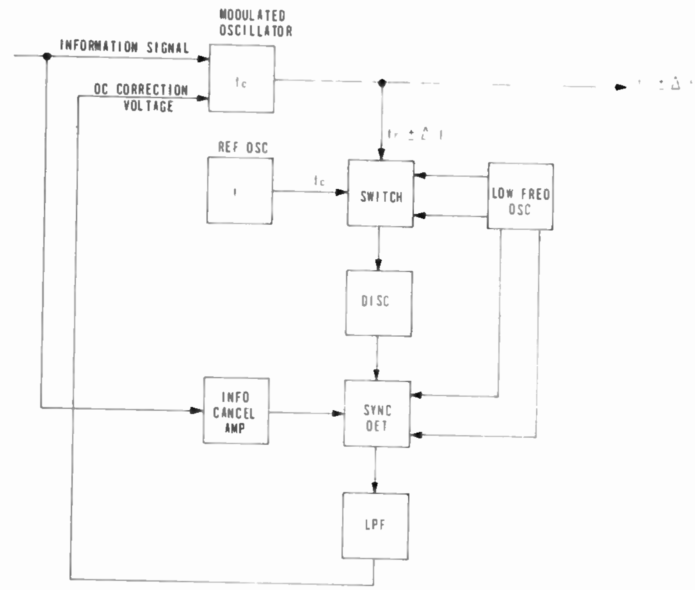


Fig. 3

It would seem desirable to have a system which is affected by as few parameters as possible, with a nearly ideal system being affected only by the stability of a single crystal oscillator. Then, the advantages of the extremely good frequency stability of the phase modulated transmitters of the 50s and the superior bandwidth and low distortion of the direct FM systems of the 60s could be married together in a single unit! The Gates digital AFC system was developed to accomplish this requirement.

DIGITAL PHASE-LOCK AFC SYSTEM

In the Gates TE-3 exciter, the phase of the output signal of the modulated oscillator is compared to the phase of a crystal-controlled oscillator and the output frequency of the modulated oscillator is controlled solely by the crystal oscillator. This eliminates all of the factors contributing to the overall frequency stability of the other commonly used AFC systems, except for the stability of the crystal oscillator.

The factors affecting the ability of the pulse-counter AFC system are: 1. Stability of translation oscillator; 2. Stability of the pulse counter circuit; 3. Drift in the modulated oscillator, and, 4. Loop gain of the system. All of these factors contribute to the overall frequency stability of the transmitter.

FREQUENCY-LOCK AFC SYSTEM

The frequency lock system (Fig. 3) functions in a manner quite similar to the pulse-counter system previously described but differs in the fact that it is referenced to a crystal-controlled source rather than to a DC voltage as the pulse counter is, in effect. A stable crystal-controlled reference is compared with the FM signal from the modulated oscillator several times per second and the difference is detected in a discriminator circuit. The output of the discriminator contains a DC voltage proportional to the difference between the input and reference frequencies as well as a component of the original information signal on the carrier. In order to prevent the information signals from interfering with operation of the AFC system, a portion of the information signal is gated into the discriminator circuit out of phase with the information signal in such a manner as to cancel the information component. The DC component is fed to a low-pass filter circuit and then to the DC correction input circuit of the modulated oscillator to correct its operating frequency. Again, this type of AFC system can only correct the operating frequency in proportion to the initial error in the modulated oscillator. While very good performance may be obtained through the use of this method, frequency stability is affected by several factors. These are: 1. Stability of the reference oscillator; 2. Loop gain; 3. Drift in the modulated oscillator.

For an explanation of the operation of the Gates digital AFC system, refer to the block diagram in Fig. 4. The nature of an FM signal must be examined before possible circuit approaches can be evaluated. Consider an FM carrier with center frequency f_c modulated by an audio tone of frequency f_m. The mathematical expression for this signal will have the form:

$$e\ (t) = E_c \quad \cos\ (2\ \pi\ f_c t + \frac{\Delta\ f_c}{f_m}\ \cos\ 2\ \pi\ f_m t)$$

where e is the voltage at any time t, Ec is the maximum carrier voltage, and $\Delta\ f_c$ is the frequency deviation of the signal due to modulating frequency f_m. Of the above terms,

$$E_c \cos 2\pi\ f_c t$$

represents the center or average frequency of the carrier and the term:

$$\frac{\Delta f_c}{f_m} \quad \cos\ 2\pi\ f_m t$$

represents the instantaneous departure from center frequency due to the modulation. The term: $\frac{\Delta f_c}{f_m}$

is the modulation index of the system and may be seen to have a value of from 5 for 75 kHz deviation at 15 kHz to 3750 for a modulating frequency of 20 Hz.

This term also represents the instantaneous phase deviation of the FM carrier. It becomes a very important parameter when we consider locking the phase of the radiated carrier to the phase of a standard oscillator. The figures given previously for instantaneous phase departure of the carrier are in radians and when converted to degrees it may be seen that the largest phase shift we must contend with occurs at the lowest modulating frequency and is approximately 215,000 degrees—a very large number that is certainly out of the range of any common phase detector. Thus, it is evident that the desire to phase lock the modulated oscillator directly to the reference oscillator cannot be accomplished directly. But advantages may be taken of the fact

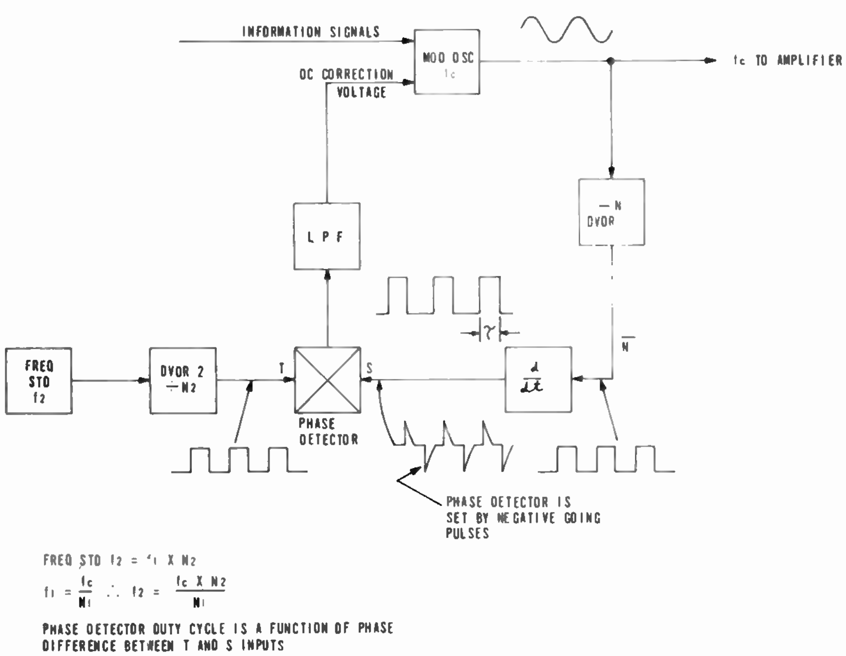


Fig. 4

that the frequency is divided by some number (N). The deviation is also divided in the same proportion, hence the instantaneous phase departure by the same number. If our phase detector is a device having a usable range of approximately 180 degrees, half the range may be used in order to be conservative in our design, so arbitrarily the maximum phase detector swing must be limited to 90 degrees. The required division ratio (N) may be determined according to the expression:

$$N = \frac{215 \times 10^3}{90}$$

and N is approximately 2500, a large number but one which is easy to realize as we shall see later. From this discussion it may be seen that if the center frequency of the modulated oscillator remains constant and if a division ratio of 2500 is used, the operating range of the phase detector will not be exceeded by modulating the oscillator 75 kHz at 20 Hz. This division ratio and the other parameters assume, however, that the modulated oscillator center frequency remains constant, precisely the opposite of known conditions! Another expression for our division ratio N must be determined which will allow a reasonable range of drift for the modulated oscillator. This expression will have the form:

$$\Delta\Theta = \frac{\Delta f_c + \Delta f_d}{f_m}$$

for the phase deviation at the operating frequency. It has been previously stated that phase shift must not exceed 90 degrees at the phase detector so the expression may now be written as:

$$N = \frac{\Delta\Theta}{90}$$

Now plugging in the numbers for f_c, the frequency deviation at worst case of 150 kHz, f_m, the lowest modulating frequency of 20 Hz, and f_d, the drift range of the modulated oscillator of 200 kHz, the maximum phase deviation at operating frequency is 17.5×10^3 radians or approximately 10^6 degrees. Hence, the required division ratio N is approximately 11,000.

Integrated circuit binary flip flops have recently become available which combine excellent reliability, small size and low cost. It was decided to use such units for the divider section of the AFC system. The nearest binary number to 11,000 is 16,384, the equivalent of 2^{14}. Thus only 14 binary dividers are required. This is realized by the use of only seven small integrated circuits. The output of the last stage of the divider is a square wave with a repetition rate of 5.3 to 6.6 kHz, depending on the operating frequency. It is fed to a differentiating network to produce a sharp, narrow negative-going pulse for each cycle. This pulse is then fed to a bistable multivibrator similar to the type used in the divider chain. The pulse feeds the direct set input of the unit and causes the multivibrator to set to one state for each pulse it receives from the divider chain. The toggle input causes the multivibrator to switch back and forth between its two possible states and is fed from a crystal-controlled reference frequency that is precisely the same as the input from the dividers. The output of the multivibrator is then a square wave whose duty cycle is a function of the relative phase of its two inputs.

As long as the relative phase of the two inputs remains less than 180 degrees the output of the phase detector is a function of the phase difference. This output is amplified and filtered to remove the comparison frequency from its output and fed back to the modulated oscillator in the form of a DC correction voltage. As long as the loop remains locked, the frequency of the modulated oscillator cannot change on an average basis, only on an instantaneous basis. The relative phase between the reference oscillator and the modulated oscillator is the only parameter which can change on a long-term or average basis. Hence, the output frequency is determined only by the reference oscillator frequency and not by any of the elements within the loop. The reference oscillator is operated in the 1300 to 1700 kHz range in order to obtain crystals which are both small in size and exhibit good stability. This is 1/64th of the operating frequency. The reference frequency is then divided by 256 to reduce its frequency to that of the phase detector.

The crystal is enclosed in a proportional oven to eliminate problems caused by the common bi-metallic thermostats. The overall system is capable of excellent frequency stability over a wide range and is limited only by the stability of the reference oscillator. Thus it can be seen that the digital phase-lock AFC system allows us to combine the merits of crystal control with the merits of direct performance and obtain the advantages of both systems with none of the disadvantages.

To sum up the advantages and disadvantages of the three systems studied, it has been shown that both the pulse-counter and frequency-lock systems may be used to produce a very stable FM signal where stability may approach that of a crystal. Both systems, however, have a common fault in that they are proportional systems and any error in center frequency is not corrected but merely reduced in magnitude. It has also been shown that the new Gates TE-3 exciter using digital automatic frequency control combines the advantages of Direct FM performance with that of Direct Crystal Control.

A Time & Control Code for Video Tape Editing

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Electronically-controlled editing of video tapes is used widely throughout the television industry. Several manufacturers are producing electronic editing equipment which allows rapid and precise location of previously recorded program material for editing and rerecording onto a final assembly tape. The exact portion of the source material selected to be transferred can be previewed and refined as necessary prior to actual recording on the assembly tape. New program material can also be precisely inserted to replace a selected portion of a previously recorded tape.

Most of the electronic editing equipment in current use operates from a control code recorded on the cue track of the video tape. The codes used by the different equipment manufacturers accomplish the required control, but are individually unique. As a result, tapes made using one manufacturer's editing system cannot be used for further editing operations on recorders using different equipment. In many cases this does not represent a problem if a studio facility is equipped with only one type of editing system. Why then should the industry, and particularly the end user of the edited tape, be interested in editing code standardization or the development of new and different codes from those currently in use?

There are several very good reasons. To name a few:

(1) Original program material, produced at one facility, can be edited at another facility which may be equipped with editing equipment of different manufacture.

(2) As new and improved editing equipment becomes available, it can be added to expand or upgrade a facility without obsoleting the existing equipment. Tapes made on the different systems can be interchanged for editing.

(3) Editing operations can be extended to other video and audio equipment. This includes double system sound using currently available audio recorders. None of the codes now in use is optimum for this type of application.

(4) To date the editing code has been used only to identify time and video frame number. The usefulness of the editing systems can be extended by also providing auxiliary information in the basic code. Information, such as reel number, scene number, take number, camera number, elapsed running time, or special instructions can be recorded on the tape for later use by the editing personnel or automatically controlled editing systems. None of the codes currently in use has adequate provision for auxiliary data.

(5) Up to now the editing code has been used only during production of the program tape and serves no purpose in actual broadcast operations. Recording auxiliary control information on the final program tape would facilitate the development of automated broadcast systems. Such systems have become economically practical with the advent of versatile, low-cost mini-computers selling in the $10,000 price range. In an automatic system, control information in the code on the program

tape could select and start a designated auxiliary projector or video recorder, switch the program to the designated unit at the proper start time and return to the main program tape and stop the auxiliary unit on completion of its specified task.

Full discussion of the possibility of automatic operation is beyond the scope of this paper. However, the possibility of almost totally automatic operation is apparent. Any control code which may be adopted as a standard should allow for handling auxiliary data for this purpose.

In September of 1969, the Electronic Engineering Company of California proposed a new editing code which the originators believe will satisfy the objectives listed above. The characteristics of the proposed code were covered in some detail at the 106th Conference of the Society of Motion Pictures and Television Engineers on October 2, 1969.

The proposed basic code pattern for the 30-Hz video frame rate consists of 480 code bits occupying a time span of one second. The 480 bits represent 30 sixteen-bit words, each, in turn, divided into two 8-bit subwords. The information contained in the one second code pattern consists of:

30 frame number codes in two-digit binary-coded-decimal

3 time-of-day codes, hours, minutes and seconds in two-digit binary-coded-decimal

25 eight-bit auxiliary control codes

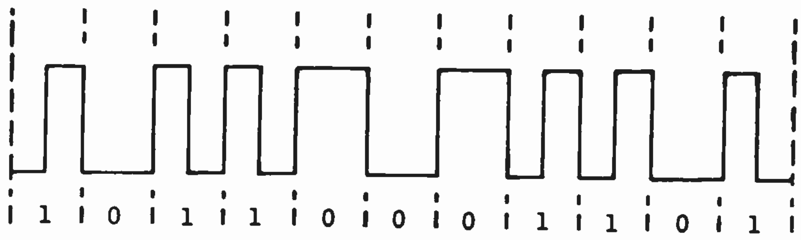
1 eight-bit synchronizing pattern

The proposed code would be recorded on tape using a form of phase modulation commonly called "Bi-Phase-Mark" or frequency doubling. Fig. 1 shows a square wave-form of this type of modulation. This wave-form provides at least one transition per bit period and is, therefore, self-clocking. An extra transition occurs in the middle of the bit period when a binary "1" is recorded. Bi-Phase space modulation, which is the opposite form (a zero is recorded as an extra transition), was originally proposed. The change to the Bi-Phase-Mark mark form was made simply because it is easier to visually recognize binary ones when viewing the recorded waveform code in a diagram or on an oscilloscope.

Fig. 2 illustrates a portion of the code bit pattern for the 30-Hz frame rate. Each video frame within a one-second interval is identified by two binary-coded-decimal digits appearing in the last half of each sixteen-bit word associated with each frame. The first half of the word is used to define time of day in hours, minutes, and seconds (carried in frame words 1, 2 and 3) or auxiliary control coding in frame words 4 through 28.

The first half of frame word 29 carried the synchronizing pattern which is used in decoding during playback to establish the beginning of the one-second interval and frame word 1. A special synchronizing word is necessary when using phase modulation since there is no way to uniquely recognize the beginning of the one-second interval from the modulation waveform.

For reliable, trouble-free operation the possibility of false indication from normal combinations of data or from random errors should be minimized. The probability of false indication decreases as the number of bits in the synchronizing word increases. For this reason the proposed synchronizing pattern for the 30-Hz frame rate is composed of an arbitrary bit combination in the first half of frame word 29, together with the BCD code 29. The synchronizing pattern for the 25-Hz rate uses the same arbitrary bit combination followed by BCD code 25.



A transition occurs at the beginning of every bit period

"One" is represented by a second transition 1/2 bit period later

"Zero" is represented by no second transition

Fig. 1

In the case of the proposed 30-Hz editing code there are 6546 possible combinations of sixteen-bit frame words, allowing for the full range of 256 possible combinations for the 25 control words. Since the data is recorded serially, there are 16 x 6546 or 104,736 possible matches between the data and the synchronizing word. This number doubles to 209,472 when taking both forward and reverse tape motion into account.

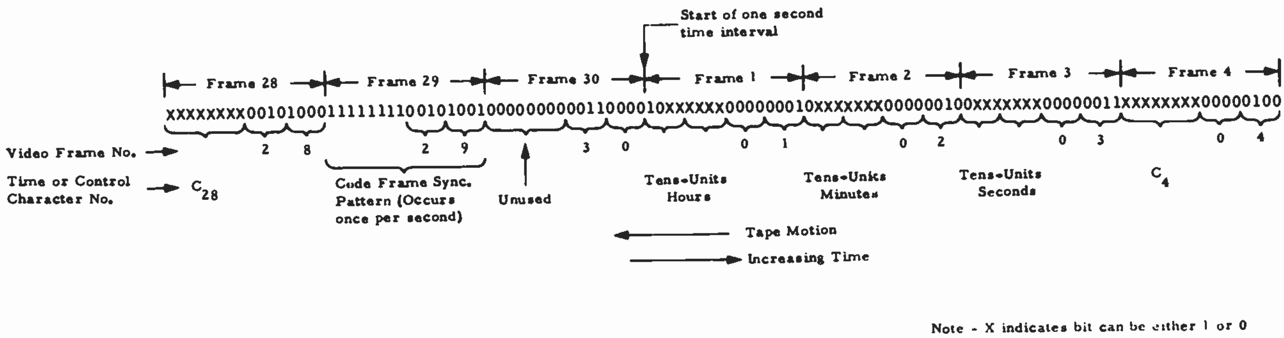
The task of comparing such a large number of combinations to test each potential synchronizing pattern is best suited to a computer operation. Consequently, a FORTRAN IV program was written and 57 runs were made on an IBM 1130 computer to test seventeen possible synchronizing patterns.

Experience with synchronizing codes in serially transmitted data from missiles and satellites has shown that random bit patterns are much better than repetitive or symmetrical patterns when the data is comprised of pure binary numbers. Because of this the earlier patterns tested used a random combination of ones and zeros in the first eight arbitrary bit positions. However, as the testing progressed it became apparent that the random pattern is not optimum when using the two-digit BCD frame codes which have only 25 or 30 possible combinations compared to the 256 combinations for a true eight-bit binary number.

Consequently, the finally chosen synchronizing pattern is 1111111110010101 for the 30-Hz frame rate and 1111111100100101 for the 25-Hz rate. These patterns produce no unwanted sixteen-bit matches from any possible data combination with either 25- or 30-Hz operation in both forward and reverse tape direction. The more promising patterns were also tested for unwanted fifteen-bit matches to determine the effect of one-bit errors in the data. The finally selected 30-Hz pattern shows 15 fifteen-bit matches in forward and 15 matches in reverse tape direction. The 25-Hz pattern shows 14 fifteen-bit matches in forward and 6 matches in reverse tape direction.

The proposed editing code resolves the problem of drift between time and the frame rate for the NTSC color system (29.97 frames per second). The cumulative drift, if uncorrected, would result in a time error of 3.6 seconds in a one-hour program. To correctly relate the frame number to the physical location of the frame on tape, it is necessary to synchronize the code to the frame rate. If this is done, the start of the one-second time interval will drift relative to the video frame interval at the rate of one millisecond per second.

The start of the one-second interval will drift through one frame period in 33 1/3 seconds (1000 frames). The drift can be corrected by deleting frame count 30 once each 1000 frames as shown in Fig. 3. In this way the frame coding will always be synchronized to the actual video signal, and the relation between the frame code and time of day will always be within 33 1/3 milliseconds. The periodic deletion of frame code 20 will not cause any operational difficulties providing the deletion is taken into account when playing back the recorded code. This can be handled relatively easily



PROPOSED TIME AND CONTROL CODE FOR VIDEO EDITING

FOR 60 Hz VERTICAL SYNCHRONIZING RATE

Fig. 2

in the decoding logic. The code pattern for 25-Hz operation is essentially the same as in Fig. 2, except that the codes for frames 26 through 30 are deleted and the synchronizing pattern is carried in the first half of frame word 25.

The proposal for use of a 16-bit basic word of two eight-bit half words was based on making the word size compatible for operation with computer-controlled systems. The eight-bit half word for the control codes is compatible with the American Standards Code for Information Interchange (ASCII), which has generally been adopted as standard for the computer and communication industries.

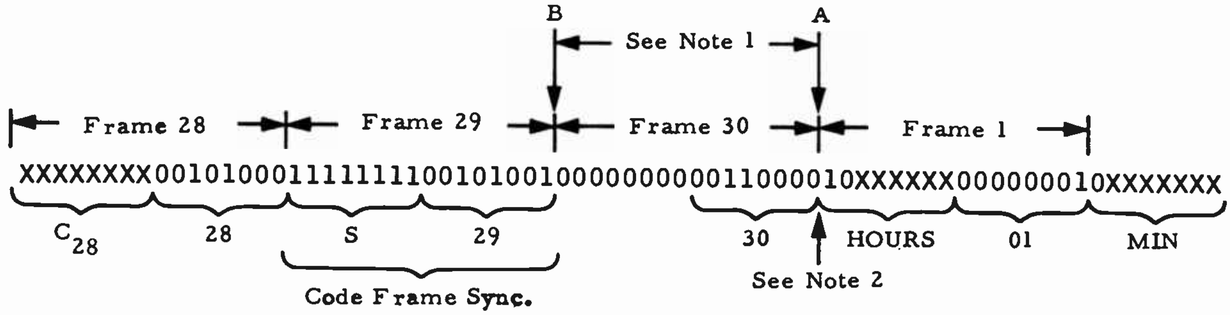
The 480 bits resulting from thirty 16-bit words, when recorded on the tape using the proposed Bi-Phase Mark modulation, will result in a mixture of 240- and 480-Hz frequencies. It is coincidental that the 240-Hz rate corresponds to the frequency recorded on the control track of the video tape. It has been suggested that consideration be given to combining the functions of editing code and control track into one channel, thereby freeing the cue track for voice annotation or foreign language dubbing. Although no investigation has been made into the combination of the two functions, there is no apparent reason why the control track pulses could not be derived from the code modulation.

Such a combination would eliminate a potential problem in some video recorders in which the positioning and timing tolerance of the cue track head can introduce displacement up to a full frame between the cue track and video signal. Displacement of this magnitude could introduce editing problems when tapes are recorded and played back on different machines. However, this particular problem can be solved directly by providing more accurate alignment of the cue track head.

The question has also been raised concerning the possible use of the editing code to provide information on the color carrier phasing on alternate frames of the NTSC color system. Correct color phasing is required at splice points to prevent an undesirable color flash which can occur for one frame period if the phasing is incorrect. This problem is actually beyond the scope of the editing systems as now used, since there is no input to the system at the time of initial recording which defines the color phasing.

If such an input could be provided, the editing code could undoubtedly be modified to indicate correct phasing for splicing. It is also possible that the editing systems could be designed to automatically choose the correct phasing by testing the color phase of the new material against that preceding the splice point to advance or delay the recorder as necessary to provide the correct phasing at the splice point. Similar color phasing problems exist in the European PAL and SECAM systems.

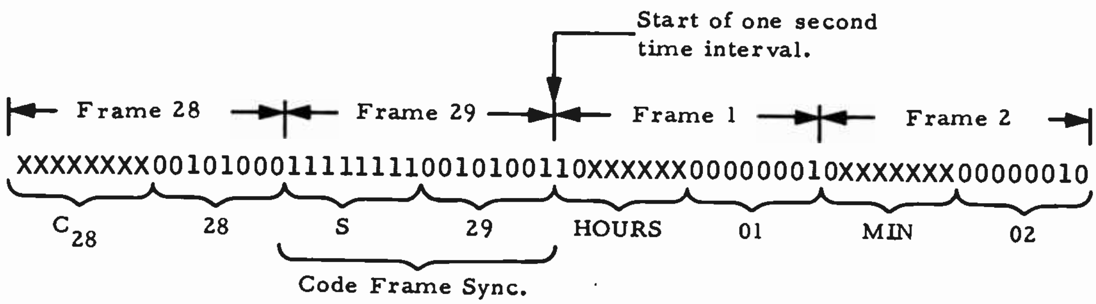
The originators of the proposed code described above believe it fulfills the important performance features for an editing control code. Summarizing briefly, these are:



(a) NOMINAL CODE PATTERN

Note 1 - Start of the one second time interval will drift from A to B (33 1/3 MS) during a period of 33 1/3 seconds (1000 video frames).

Note 2 - Unused bit position in hours code is assigned a value of 1 for use in determining whether or not Frame 30 is present during decoding process.



(b) TIME RESYNCHRONIZING CODE PATTERN

Fig. 3 Frame code skips from Frame 29 to Frame 1 once each 33 1/3 seconds (1000 video Frames) to return start of one second time interval to point A.

(1) The code contains sufficient information to unambiguously locate any desired video frame within a reel of tape.

(2) The code is readable with the tape operating in either forward or reverse.

(3) Forward or reverse tape motion can be sensed directly from the code pattern.

(4) The code is insensitive to tape speed.

(5) The frequencies generated when the tape is in fast forward or fast reverse are contained within the normal broadcast audio range up to speed ratios of 30 to 1. With special playback amplifiers, higher rates can be used.

(6) The code waveform is capable of transmission over telephone lines and amplifiers.

(7) The code waveform is not affected by 180° phase reversals which may be introduced by transformer coupling or recorder head phasing.

(8) The phase modulation makes code insensitive to amplitude variations and noise.

(9) The code resolves the drift between time of day and the NTSC 59.94 vertical synchronizing rate.

(10) The code provides the information necessary to synchronize two or more video tape machines or other recorders.

(11) The code is usable on any type of recorder, providing a recording channel of normal audio bandwidth (assuming fast forward or reverse speed is not greater than 30 times normal speed).

(12) The code provides space for control and auxiliary information in addition to the basic time and frame coding.

(13) The code format is compatible for operation with computer controlled systems.

The Electronic Engineering Company of California is in the design phase of a family of new video editing equipment which will use the editing code described here. Although it would be premature to describe the equipment at this time, a few items related to the use of the code can be covered.

Phase modulation systems generally use sine-wave modulation, which would seem to be appropriate when the signal is to be processed through linear amplifiers. However, the phase linearity of the amplifier is also important, and an amplifier with low amplitude distortion may not correctly reproduce a phase-modulated signal. Investigation into this problem has shown that the effects of phase distortion can be minimized by using square-wave modulation for the code as illustrated in Fig. 1.

The square-wave modulation is also less sensitive to noise near the zero axis crossing and will tolerate more baseline shift which can result from the low-frequency response characteristics of the amplifier. Using this type of signal the unmodified cue track amplifiers of a typical broadcast video recorder (in this case an RCA TR60) will suitably record and reproduce the code waveform.

Another factor which must be considered in system design is the effect of signal dropouts on the reliability of the system. In any self-clocking system, a loss of signal which results in a loss of clock will throw the system out of operation until synchronism is re-established. Even though such dropouts may occur infrequently, it is desirable for the equipment to be able to operate through an isolated dropout without a loss of synchronization. In the decoding equipment being designed a free-running clock will be synchronized with the incoming code and in the absence of the correct clock signal will run free until the normal clock is re-established.

Similarly, an error bypass circuit will be incorporated which will ignore a failure to detect either the synchronizing code or correct time code up to three consecutive times (one to three seconds) before initiating corrective action. This type of error bypass is particularly useful when operating with noisy tapes.

The end user of electronic video tape editing equipment may understandbly be more interested in the performance features and human engineering aspects of the operator's controls than in the basis of the control code used to operate the system. However, the usefulness and reliability of editing systems are closely related to the control code, as is the longer term potential for automatic computer controlled systems. It is the opinion of the author and his associates that the appropriate organizations within the broadcast industry should review matters concerning video tape editing in general, including consideration of the feasibility of establishing an industry standard editing code, and the advantages and related problems which would result from standardization.

The ABTO Color Film Process

Albert W. Malang, ABTO, Inc.
New York, N. Y.

In a twenty-minute spot, it would be a little difficult to effectively cover the entire subject of color photography and diffraction, so, I will rather rapidly go through three basic areas and skip the normal pleasantries and funny lines which precede some papers.

Color photography for television is a generally poorly understood subject. Since this audience is primarily clinically oriented, I would suggest to you this analogy. If you consider the process which I am about to describe to you in a context of being the FM for which regular photography is the AM equivalent, I suspect you will find it far easier to grasp the new technique.

Color film processes generally break down into two basic categories. One in which three discrete black-and-white images are physically separated in order to represent a record for red, green and blue, which to most people in the industry has generically become termed the "technicolor process," and the second is the technique in which three essentially black-and-white picture records representing red, green and blue are sequentially sent which together on one piece of film which are generically known by "a chrome process," Kodachromes, Anscochrome, Ektochrome. The list is legion.

We have essentially chosen to describe our new process in the context of what we call ABTO Color in the sense that the fundamental lies somewhere between the two previous processes. Essentially what ABTO color does is record three discrete color separation images rather than record them geographically isolated on separate frames of time. We have a technique for super-imposing them physically one on top of each other while maintaining the ability to separate them completely on playback with a minimum of crosstalk between the seams. There are three independent records.

Aside from that physical distinction, the taking characteristics are deliberately oriented in the direction of making the taking color telemetry as similar to Ektachrome as possible and the plate-making characteristics as similar to Ektachrome as possible.

ABTO Color is primarily determined by a physical phenomenon known as "diffraction." Now, for those of you who have been away from your physics books for a reasonable while, there are probably more varieties of diffraction than I could list and, perhaps, anybody else here. The particular phenomenon which we take advantage of has been identified with a man named Fraunhoffer. The Fraunhoffer diffraction technique I will attempt to describe for you, and it is that device—that mechanism—which enables us to separate once again the three superimposed images that we have created in the camera. Working systems are obviously select and more complex, but in order to comprehend the principles behind this technique, I have made the diagram in Fig. 1 as simple as I know how, and, hopefully, simple enough to communicate the theory behind it.

Diffraction

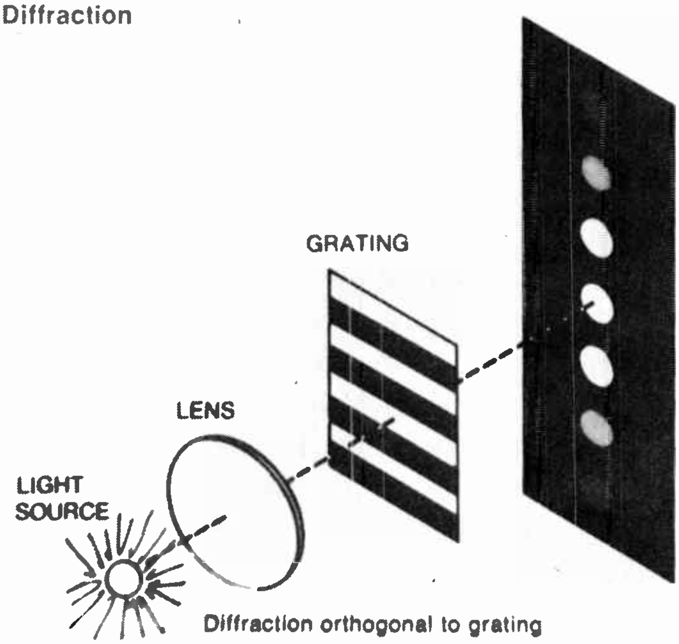


Fig. 1

In order to utilize the diffraction, one must record somewhere in the system a diffraction grate. The ABTO color technique we have chosen to interpose in the taking film camera is a grated structure in the optical plane immediately preceding the film. If you will consider that this very elemental diagram (Fig. 1) represents the optical and image area of a film taking camera, then, the one piece of glass present in the lens is the taking lens of the camera, and it is the normal taking lens.

For simplicity sake I have chosen a scene composed only of the primary colors, and, hopefully, that will make the analysis somewhat easier. In the region immediately preceding the film emulsion, an optical element, which essentially is three superimposed gratings actually displaced from each other or located from each other. That grating is, then, placed essentially in intimate contact with the emulsion.

For analysis purposes, then, the grating effectively records or creates in an image blank a line structure dependent upon the colorimetry of the scene. Now, if you will concentrate your attention for the moment on the sides of the red barn Fig. 2, the red light from the sides of the barn in passing through the essentially horizontal structural grating, the alternate red and clear lines will create a horizontal grating structure in the image plane at the same grate as the grated structure, and that grating structure, in turn, will record on the black-and-white emulsion as a horizontal grating structure.

The mechanism for the blue and green is virtually identical; however, the axis of the green is rotated. In the event there is a secondary color, what is recorded is the appropriate mixture of the two constituent primaries. Therefore, for a simple scene of red, green and blue elements, if one were able to examine the emulsion with a fairly fine, fairly high-powered microscope during the taking process, one would see in the scene elements the presence of one or more grating patterns.

Now, it is important to understand that if a particular primary is absent, the grating structure is not recorded. For understanding purposes, the grating has been shown in terms of a red, green and blue line structure (Fig. 1); in practical matter of fact reality, the modality is magenta, cyan and yellow, and where you see a primary color in Fig. 1, its subtractive primary or secondary, if you will, is the actual color present.

If you think about that for a few moments, I am sure you will find it quite understandable that should that primary not be present, then, the intensity of the light in the clear space and in the grating space will be essentially the same and no grating structure recorded. That should suffice for the recording process. So, now we have constructed

Camera

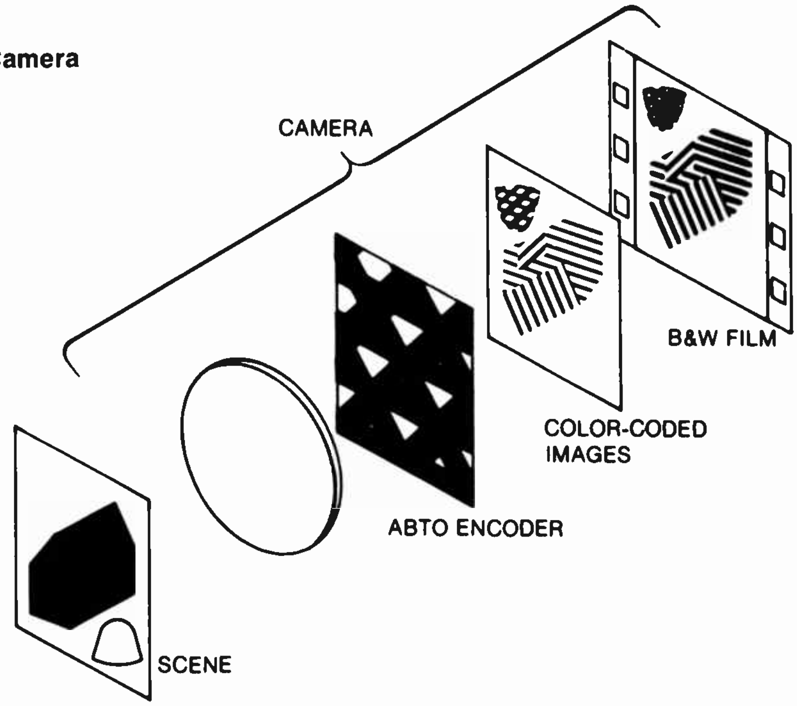


Fig. 2

on a color-blind emulsion a record of the scene with all of the details and with its color appropriately recorded in some fashion as a grating structure.

Well, now that we have a grating structure, what do we do with it. In Fig. 2, I will attempt to communicate to you the fundamental effect from the Fraunhoffer diffraction. Fraunhoffer diffraction says if one has a line grating, and it is illuminated, essentially polymated light from a point in source, if one places a screen at a point where the light source is being imaged, rather than just a single image of the light source, we will get several images. The image of the light source which is coincident with the axis of the optical system will, in effect, be the base image or the zero water image of the light source and will be the brightest.

However, in a line going out from that zero water image, there will be a rather substantial quantity of additional images of the light source, and they will occur in diminishing intensity as they travel out from the center.

For mathematical purposes, the first pair adjacent to the central light are known as the first order diffracted image; the second, the second and the third, the third. They diminish in intensity to a mathematical predictability which can be analyzed by vessel functions, and if one is interested in the energy content of the side image, it is virtually the identical vessel function that you now use for analyzing side-band energy of your FM transmitters utilized to determine the energy of the side orders of the diffracted image. It is done in selecting for miniscule physical dimensions. The tracks also indicate that the axis of these light images will always be perpendicular to the axis of the grating.

Now, in Fig. 2 it may not be readily apparent from an examination of a simple single grating from the diffraction system, but I suggest to you an experiment if you want to test the theorem for yourself. If I were physically able to reach up and rotate the grating in that diagram, the string of images of the light source would rotate with the grating, and if I were physically able to reach up and add a second grating, let's say, perpendicular to the one that is existing there right now, there would occur a second string of light spots perpendicular to the first existing there now and only those two, and if I were to similarly be able to reach up and add yet a third grating and choose some appropriate angle between the three gratings, 45 degrees or 60 degrees, it really isn't too important, there would be yet a third line of images of light source, and, again at the same angle to the predecessors to the grating axis.

Projector

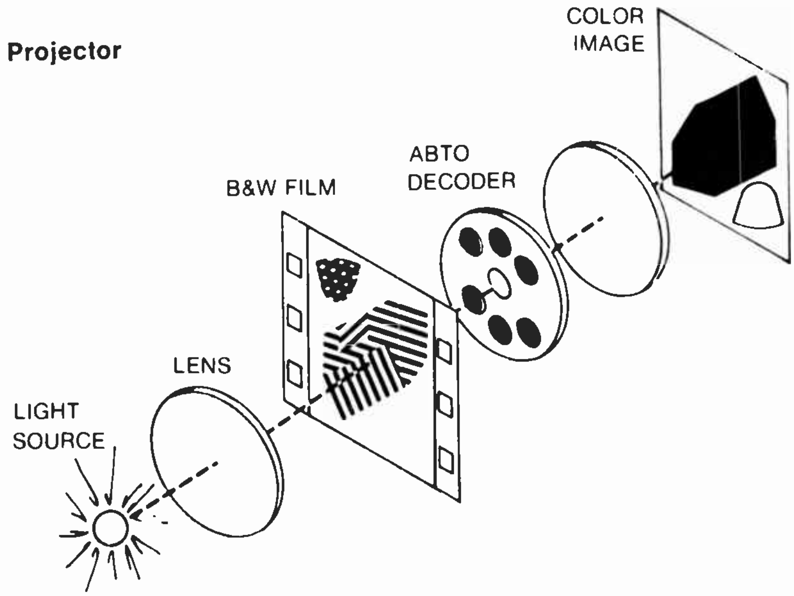


Fig. 3

Now, that is the part of the technique that we have to color process, and for simplification purposes, we discard all of the orders of energy beyond the first. So, the process utilizes only the zero order and the first order.

Now, how do we apply the technique in reconstructing the color image? In Fig. 3 the same piece of black-and-white film that we managed to place an image on earlier in the camera is placed in the gate of the projector, and the film itself serves as a grating in the playback technique since the original optical grating placed in the taking camera is quite effectively duplicatedon film, and the Fraunhoffer formula says if you use an effectively pointed light source and image that pointed light source essentially at the color image on the film plane and re-image that light source at some focal plane beyond the film, and in this case the focal plane involved is the second identified as ABTO Decoder, you will re-image the light source in multiplicate.

Now, I think it should be fairly obvious if you have accepted the explanation of the previous illustration of the effective front diffraction and the angular displacement between them in order to reconstruct the color image from our simple black-and-white grating image, we merely need add in the appropriate physical position of the re-image light source a suitably colored port to color the displaced image of the light source in the color we choose, and, then, recombine all of that light again, and we will have a reconstructed full-color image.

There is one small error in the artwork of Fig. 3 in that the second piece of glass up to the lights precedes the decoder when, in fact, it should succeed it. It is the normal projection lens of the projector, and it is the projection lens which would be used if the regular process were in effect. There is no need to change the projection optics (basic projection optics of the projector) in order to take advantage of diffraction. It is merely necessary to interpose a subordinate optical system.

So, in this case the sides of the little red barn which have appropriately recorded a horizontal grating diffracts the image of the light source orthogonal to that grating and appropriate visible dimensions out from the center. There will appear to be shafts of light representing the desired intensity of light which the scene desires for the red content, and two small parts in the decoder are appropriately colored with a red transmissive element, and the two first-order red light source images are,

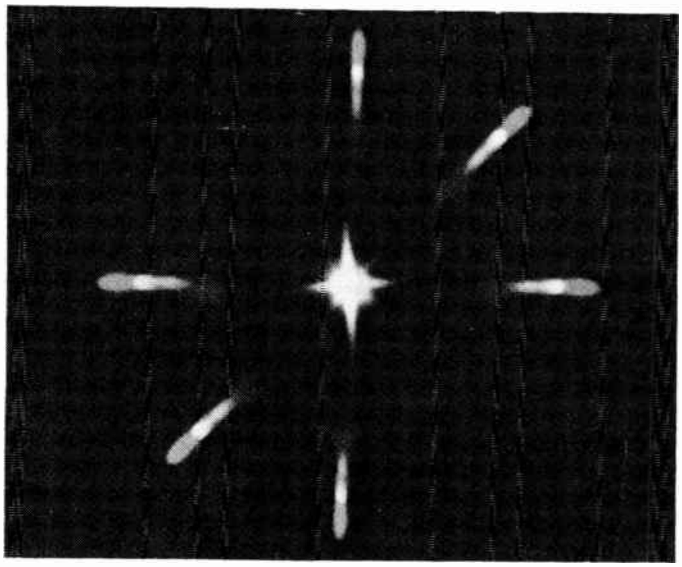


Fig. 4 Basic Fraunhofer Diffraction from ABTO film recording showing 3 images spatially separated.

then, transmitted through that color grate, recomposed and passed through the projection lens on to a screen and constitute the red element of the scene, which is virtually identical for the blue and for the green.

Fig. 4 is a photograph rather substantially magnified of the images of the light sources as they exist in the physical plane immediately in front of the ABTO Decoder, and the central port is the zero light level and the three pairs of secondary images of the light source are photographs of the recorder here for a scene which wasn't a little red barn with a blue roof and a green door—if I remember the sequence correctly—but it was for a frame recorded image which would have all three color elements in.

In brief summary, then, the ABTO process offers, we believe, some intriguing advantages. The economic ones, I suspect, are fairly obvious. Aside from the economic ones, the technological ones would be summarized in the following fashion. For the first time, I guess, the taking of colorimetric characteristics are not physically tied to the actual role of film, but are a function of the equipment and can be different with different applications without requiring a large variety of black and white stocks in order to make records.

In this particular case you have seen demonstrated in our exhibit the films—all commercial stock. I am sorry I don't recall the number.

FROM THE FLOOR: Plus 8.

MR. MALANG: I am sure many of the Kodak gentlemen can give you the number or the people in the booth, but the taking colorimetric characteristics are physically separate from the film itself. The playback characteristics are physically separate from the film itself, and they can be chosen to almost any criterion that dichroic or ditechnology permits. Both the encoding plate and decoding plate can be made by several techniques, using organic isochromatic layers and combinations of the two, and this permits a variety, a matching of sets of characteristics that wedding the dye to the emulsion does not permit because it just gets physically too complicated.

We are also of the opinion that there is the possibility as it progresses that the color gamut on playback will in all likelihood be wider or greater for the diffractive technique because, again, of the physical separation and because the decoding need not be—I mean to developing chemicals—and need not be several other physical characteristics that are in the playback film.

It is also quite likely that dichroic technology will be capable of reaching spectral points beyond that. In our view, then, diffractive technology should in large measure play the very great role in television in the immediate future, not only in the area of film, but in several others.

I would bring to your attention that in addition to ourselves, there are other applications of diffractive technology being used in the television industry. In particular, I would single out the large-screen projection device being shown by General Electric, I believe, and covered by a very thorough paper by Dr. Hood in the past SEPT, a slightly different application of diffraction, and, of course, there is the application of diffraction components to assist in utilizing diffraction for the RCA one-tube color camera; so, we see a very bright view for diffraction techniques for television in the near future.

TV Tape for Automation of Station Breaks

L. V. Hedlund
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In recent years there has been a trend to more and more usage of short recorded messages on both tape and film, largely for use during station and commercial breaks. This has created a tremendous problem because of the large number of spots which must be handled in a short time. To make matters worse, the cost of experienced equipment operators, maintenance personnel, and studio equipment itself has continued to rise. It has been obvious for some time that there is an important need in the broadcast industry for an automation system capable of handling these sequences of short messages. To gain wide acceptance, such a system would have to satisfy both the small station with no other automation equipment as well as the larger user who may already have some degree of automation. With these requirements established and with the rapid advancement in the state of the art which has occurred during the past few years, RCA set out to develop an automation system with enough flexibility to meet the needs of the broadcast industry.

After consideration of the various recording systems available or in development, it was decided that the new system would make use of a magnetic tape cartridge, using the quadruplex recording format. This approach was the only one which would provide the desired operational flexibility and performance capabilities required for broadcast use. In the cartridge concept, each cartridge contains one complete recorded message and appropriately placed start cue and end cue for use in the internal automation of the machine. Cartridges can then be used in any combination to form a complete station break or other sequence of short messages. Growing from the cartridge concept came the idea of a completely automatic transport having provisions for automatic threading and unthreading of the video tape in the cartridge.

To produce a satisfactory system it is obvious that each event should form an integral part of a continuous sequence of events. This is accomplished by using two basically independent cartridge transports capable of producing a continuous program without video or audio interruption.

The concept of a cartridge magazine (Fig. 1) was developed which would feed cartridges to the two transports automatically. The magazine would be placed in front of the two self-threading transports, with one transport, called the A transport, to the left, and the other transport, called the B transport, to the right. The magazine would hold a number of cartridges in individual carriers or bins, and have a capacity sufficient to meet the programming needs of the average station over a reasonable length of time.

It was also realized that the number of events or cartridges which would be played in a group or sequence of cartridges would vary and that a means should be provided to handle this situation. The idea of the Automatic Sequence Control was then conceived which would permit programming a specific number of cartridges to play automatically on command. The cartridges would be played in numerical order and the machine would then stop with the next sequence ready to play upon receipt of a single play command.

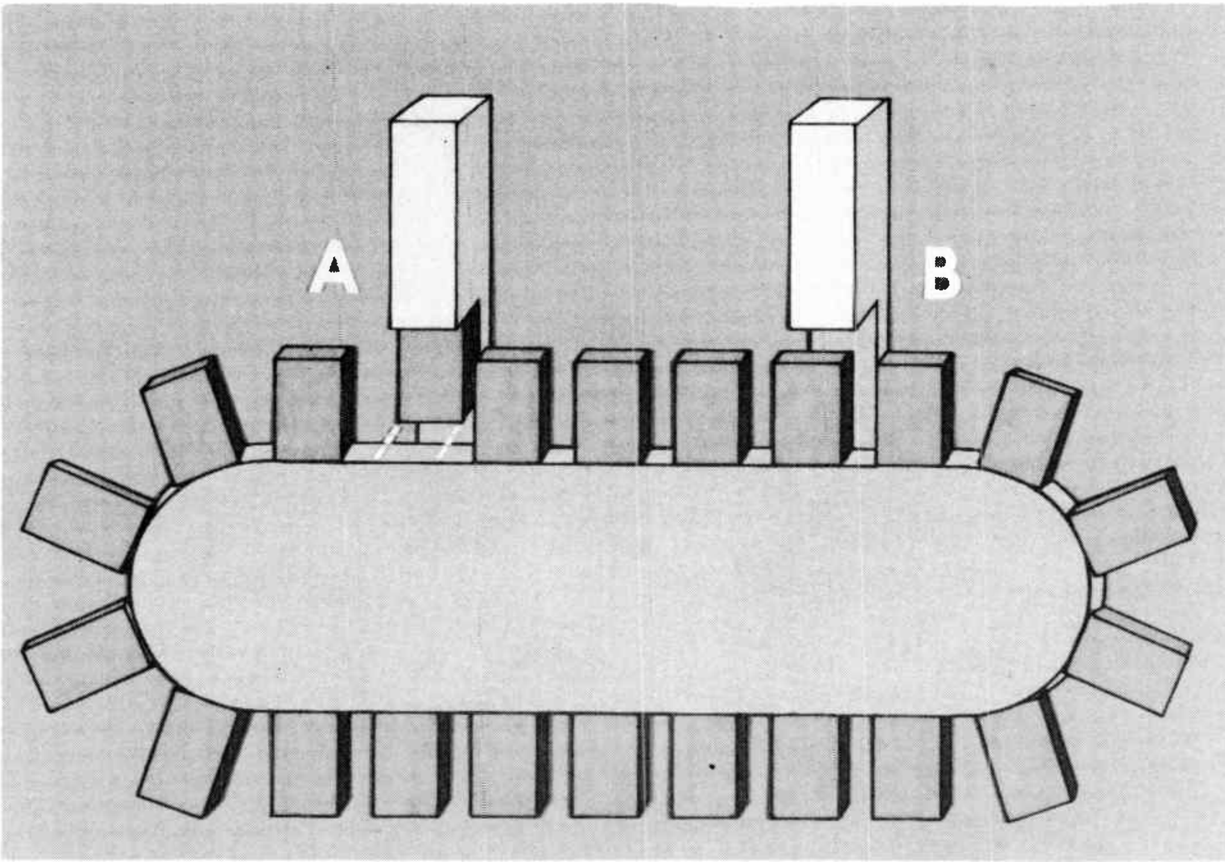


Fig. 1

Up to this point, we have concerned ourselves with the playback operation of the system. But to provide maximum utilization of the equipment, the system must also have recording capability. This in itself is not new, but the concept of automatic record duration is. The operator would be required only to tell the machine through the use of a set of thumbwheels how long the recording is and the machine would automatically record the exact message length and the appropriate start and end cues. The cartridge will then automatically rewind and recue, ready to be previewed.

In the cartridge system both transports are not required to play at the same time; therefore, the reproduce electronics can be shared between the two transports. In a similar manner the transports are designed to record the same video signals and the record electronics can also be shared. Carrying this argument one step further, the cartridge recorder can be slaved to a standard reel-to-reel master recorder and the common electronics shared. In installations where it is not desirable to have this master/slave combination, a signal processing unit can be used to obtain greater versatility.

CARTRIDGE AND MECHANISMS

The cartridge (Fig. 2) is a molded plastic unit 3 3/8 x 2 5/8 x 5 1/8 inches and has the capacity to hold adequate tape for three minutes of program. The cartridge when removed from the recorder is completely enclosed to protect the tape during handling and storage.

The cartridge (Fig. 3) is composed of a U-shaped molded plastic frame and two wrap-around doors closing the three open sides. The tape is captured between two plastic

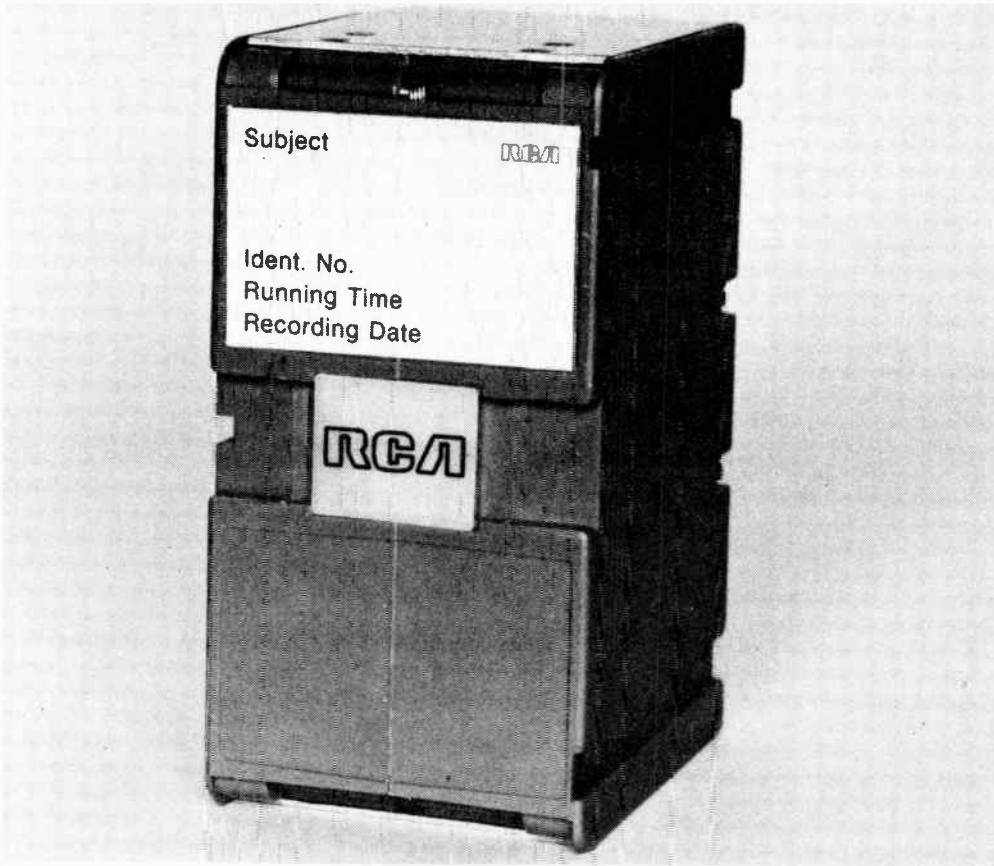


Fig. 2

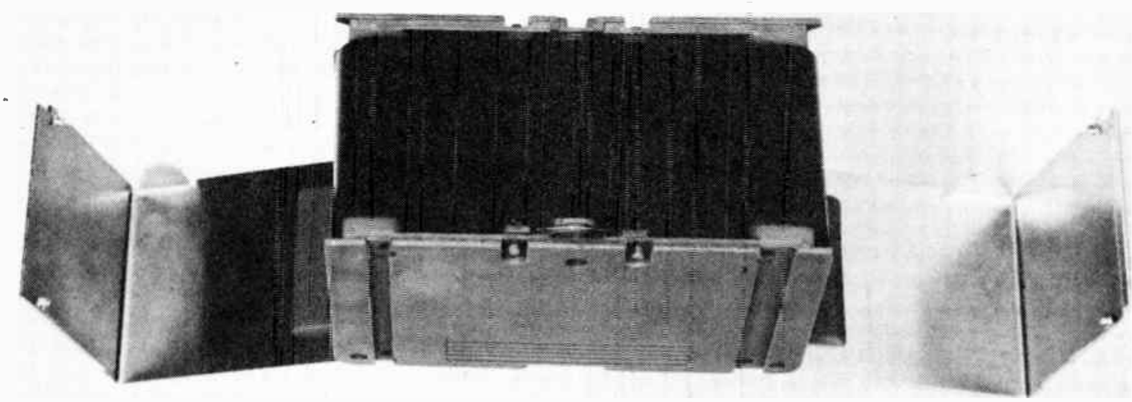


Fig. 3

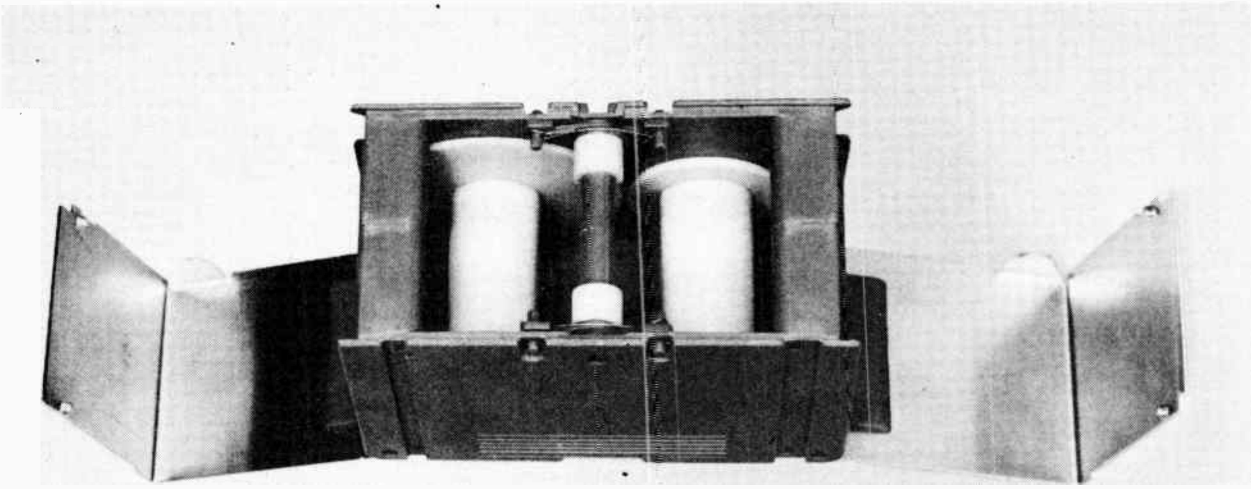


Fig. 4

Fig. 5

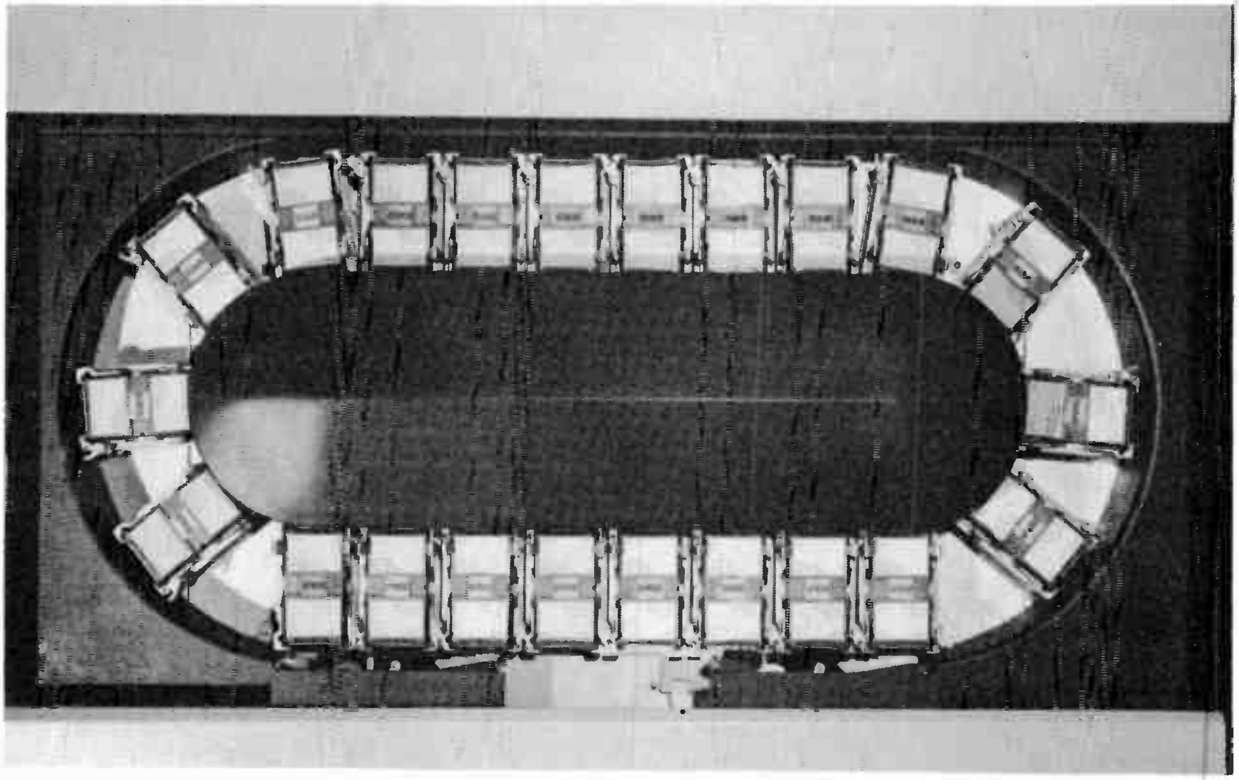


Fig. 6

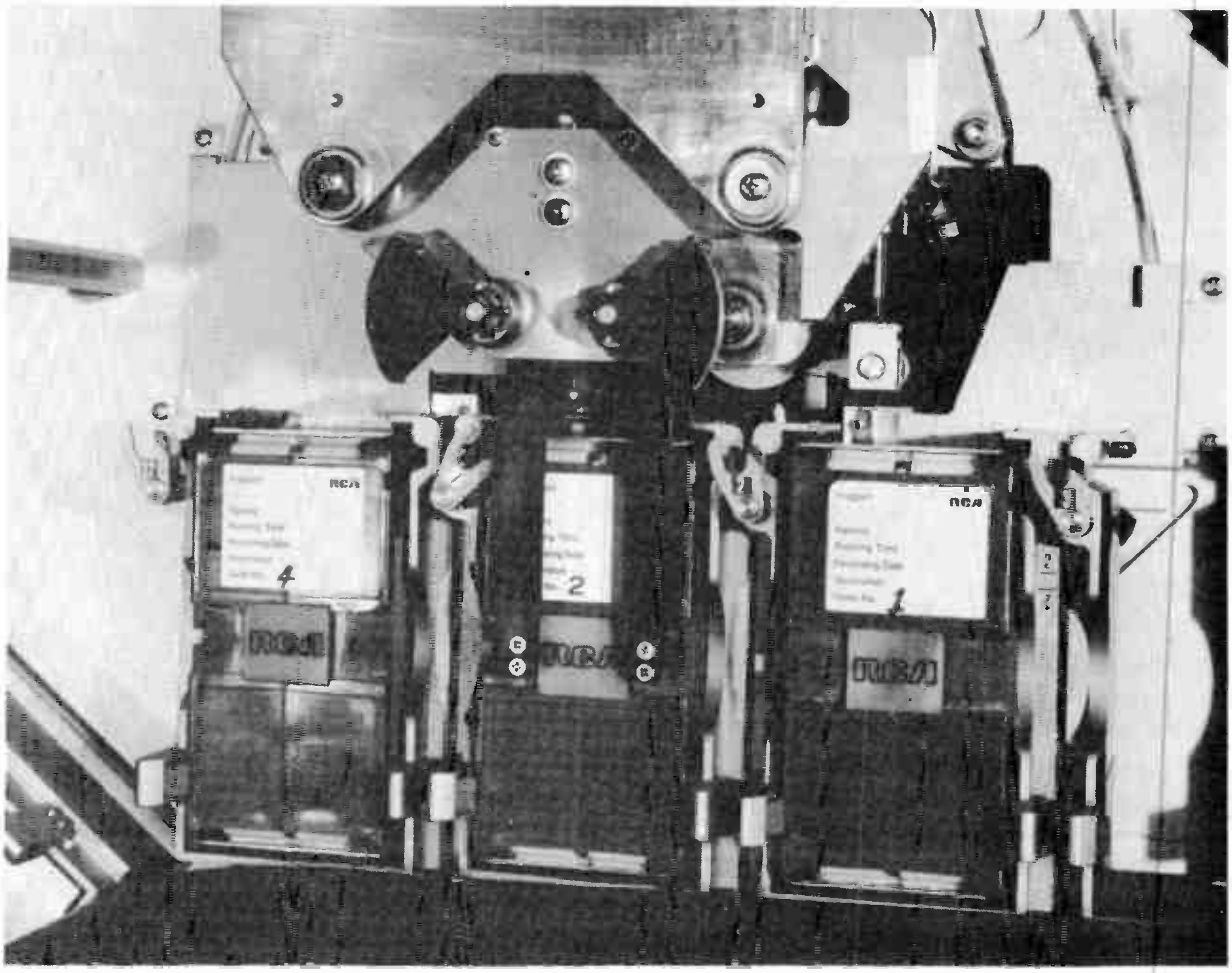


Fig. 7

reels and wrapped around the outer edge of the cartridge. The plastic reels (Fig. 4) are loosely supported by the frame to keep them approximately in position for engagement by the reel drive. The reels are spring loaded against one side of the frame to secure them during handling. Since the tape is always returned to the supply reel before the cartridge leaves the recorder, the tape is protected by the full flange during handling.

To minimize the size of the cartridge, the take up reel is placed close to the supply reel. As the tape is transferred from the supply reel to the take up reel it builds up into the area originally occupied by the tape on the supply reel. The openings in the top and bottom edges of the frame (Fig. 5) permit entry of the tape extractor pins behind the tape to withdraw the tape from the cartridge. The two holes in the left side of the cartridge permit entry of the reel drive into the cartridge and pins on the drive shafts engage the teeth on the reels. As the drive shafts enter the cartridge, the reels assume positions determined by the drive shafts and do not contact the cartridge frame.

The vertical row of blind holes on the side of the cartridge are to provide a means of coding the cartridge. For example, the presence of a plug in the bottom hole indicates to the control system that the cartridge is prerecorded and is not to be used for recording. The slots running along the side of the cartridge are for alignment of the cartridge and are keyed to prevent wrong insertion of the cartridge. The white tab in the cartridge front is used to grip the cartridge by the automatic loading mechanism in the magazine.

The magazine (Fig. 6) is the cartridge storage device and the physical interface between the operator and the rest of the recorder. The magazine contains 22 individual bins for storing cartridges. The bins are mounted on a continuous belt which can be indexed on command, clockwise or counterclockwise, to get the desired cartridge to line up with the entry portals to the interior of the recorder. The indexing is accomplished by a photoelectric sensor which controls the actuation of a clutch and gearhead motor. To stop the bins in the proper alignment with the mechanism for transferring the cartridge through the entry portal, a pneumatic clamp grabs a precision tab on the belt and cushions the stopping shock while precisely aligning the bin for transfer.

All of the bins are continuously accessible to the operator for loading or unloading. The operator needs to know which bins are not available for loading. To accomplish this, small V-shaped and numbered flags are used as shown in the closeup picture of the transfer station (Fig. 7). These flags, by their position, visually indicate the status of the bin. If the flag is tipped to the right it physically blocks the entrance to the bin and indicates that a cartridge has been transferred from that bin into the recorder and, therefore, is not available for loading.

To transfer the cartridge into the recorder, each entrance portal is equipped with a transfer station. The transfer station contains pneumatically-actuated claws and carriage. The claws engage the cartridge in pockets behind the white tab and as the carriage travels, pushes the cartridge through the entry portal. To retract the cartridge the reverse procedure is followed and the cartridge is pulled back into the bin.

In addition to the mechanical mechanism, the magazine contains the logic required for it to perform the basic functions of indexing clockwise, counterclockwise, and transferring in and out. A photoelectric reader provides continuous information to the recorder control system on the belt location. The transport (Fig. 8) contains the automatic threading mechanism in addition to the normal transport tape-handling elements. To thread the tape, the transport first forms the tape into a triangle approximating the tape path and then inserts it into the path. In this rear view, the tape triangle is formed to the left on the tape path and then moved to the right, inserting the tape in the slot between the vacuum guide and the headwheel in a manner similar to what is done in manual threading. When the tape is in the tape path, the triangle is

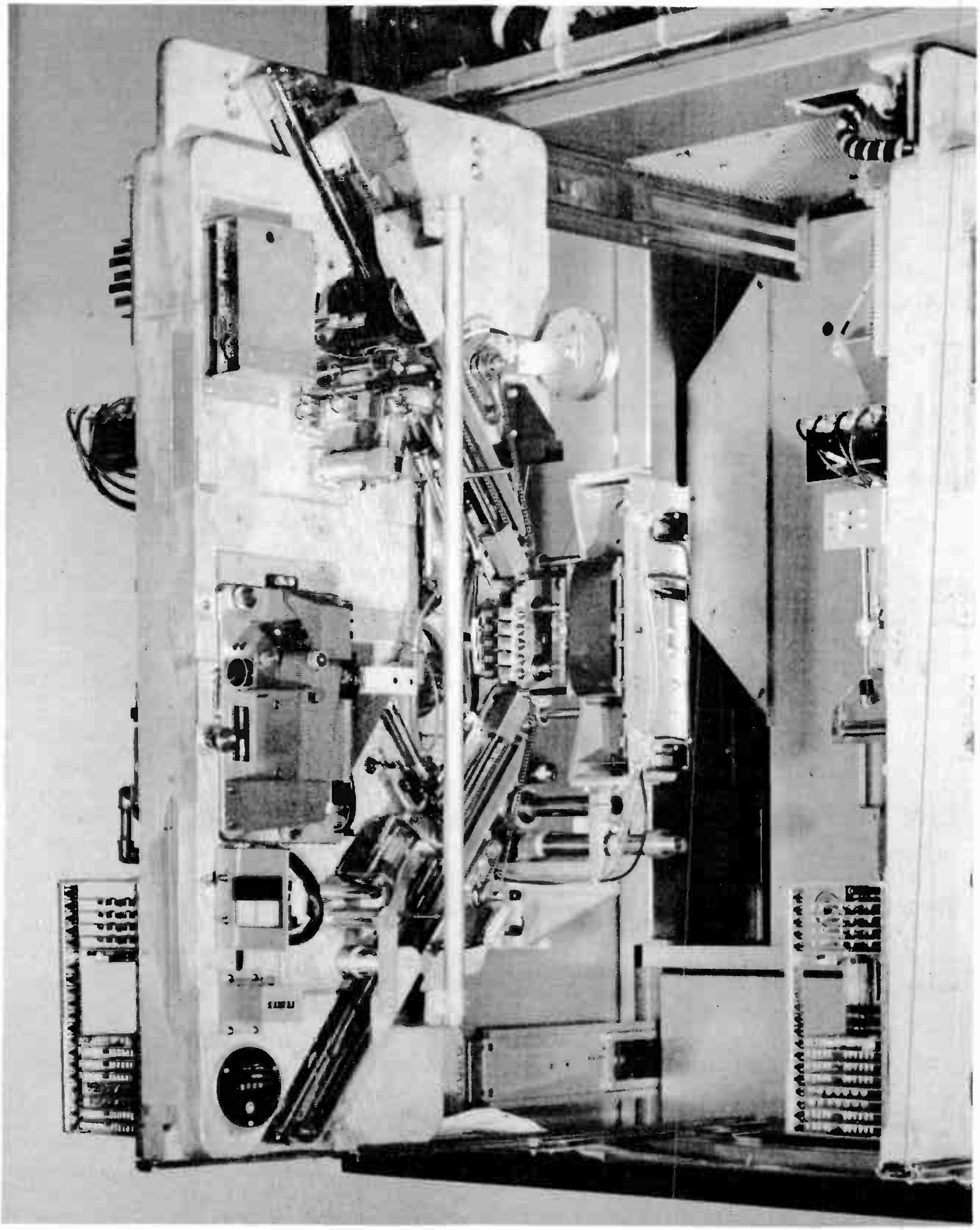


Fig. 8

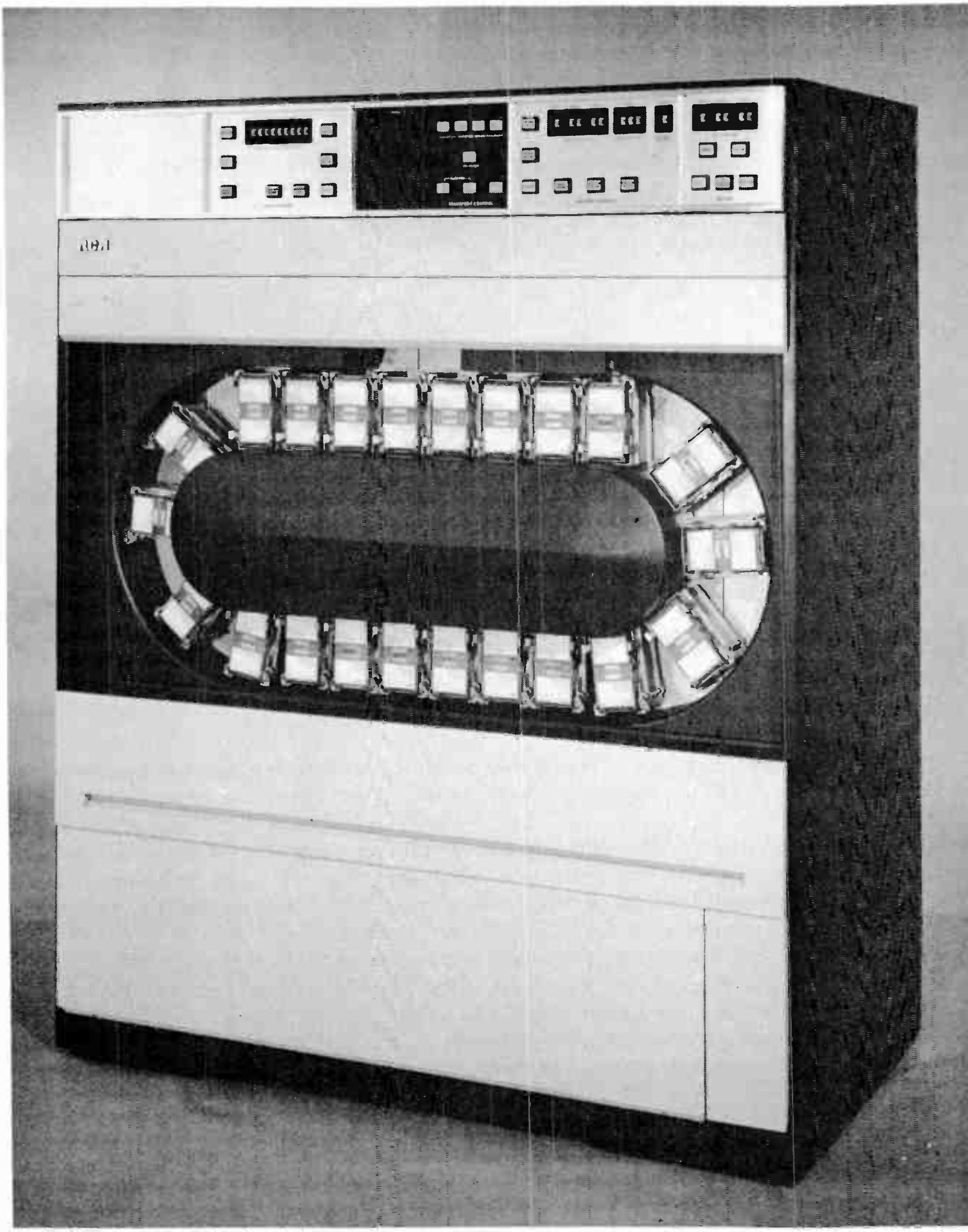


Fig. 9

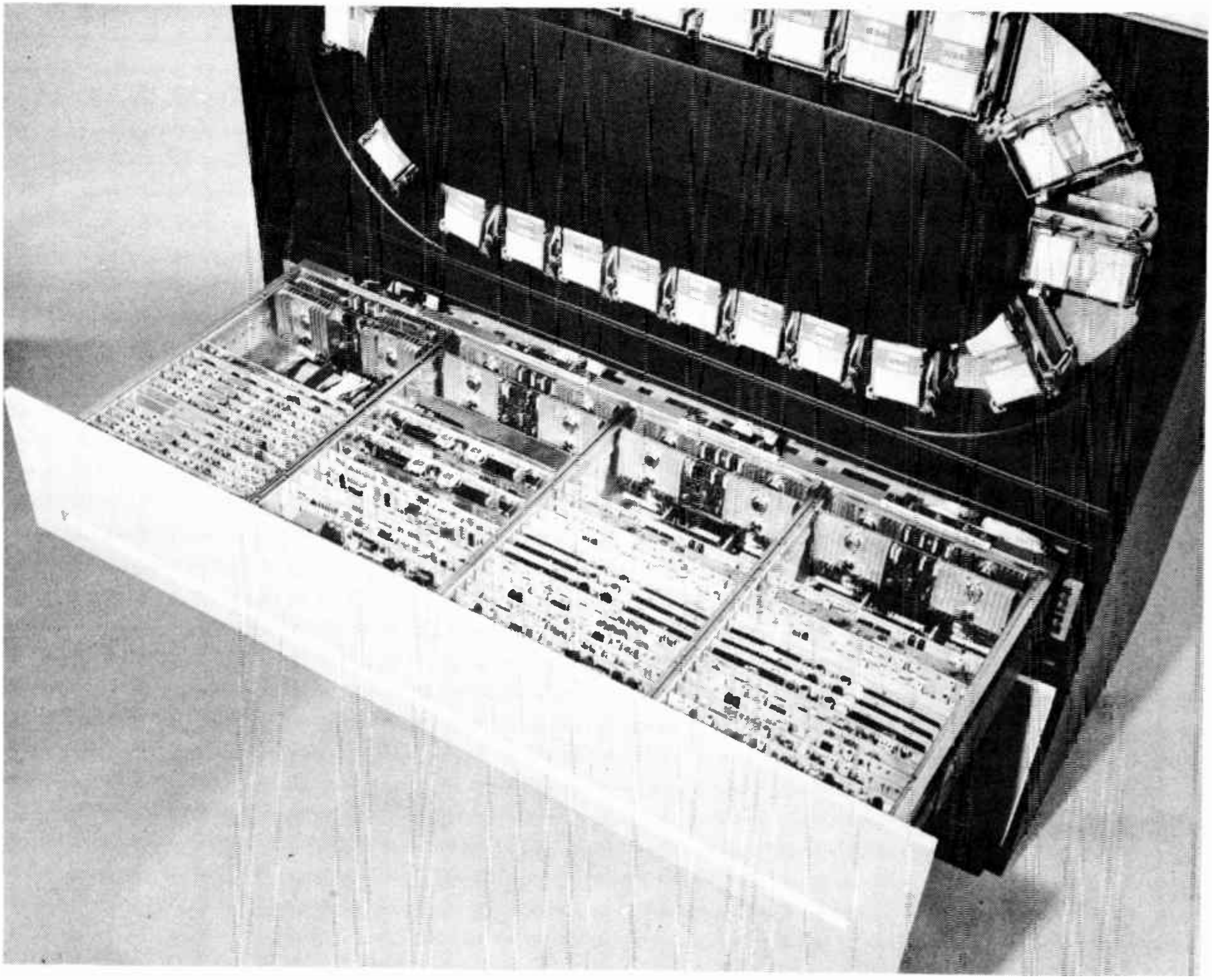


Fig. 10

allowed to collapse and the reels take up the slack tape. The transport is now ready to record or play in the normal fashion. To unthread, the reverse procedure is followed.

To provide long tape life, the tape path and the threader have been designed to minimize contact with the oxide side of the tape. The cartridge reels are wound oxide side out so that the tape extract fingers do not ride on the oxide. In the tape path, only the erase heads and the guiding elements contact the back side of the tape. A urethane coated capstan is used to provide the necessary tape drive force without the use of a pinch roller and contacts only the back side of the tape. A urethane coated capstan is used to provide the necessary tape drive force without the use of a pinch roller and contacts only the back side of the tape. Therefore, the only elements that contact the tape on the oxide side are the video, the control track, the audio and the cue record play heads.

In addition to the usual signal electronics which are mounted close to the magnetic transducers, the transport contains the control logic required to thread and unthread the tape. Photoelectric sensors have also been included to detect reflective foil markers placed on the backside of the tape to indicate start and end of the tape.

In addition to being a portion of the cartridge and tape-handling mechanism, the transport is an integral part of the servo system. A low inertia DC capstan motor is used to obtain a synchronized color picture in less than two seconds as required by the system to achieve an acceptable cycle time between successive cartridges.

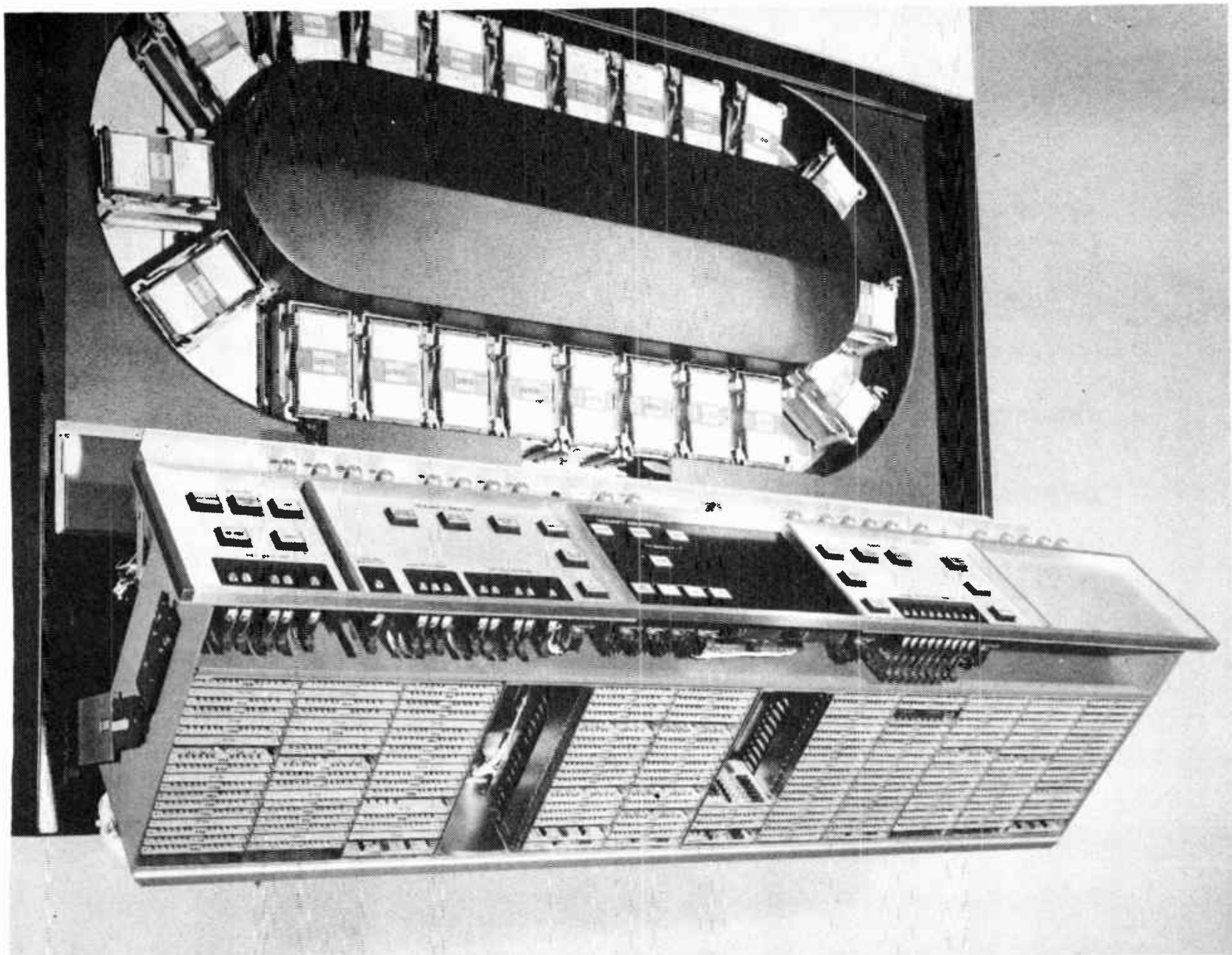


Fig. 11

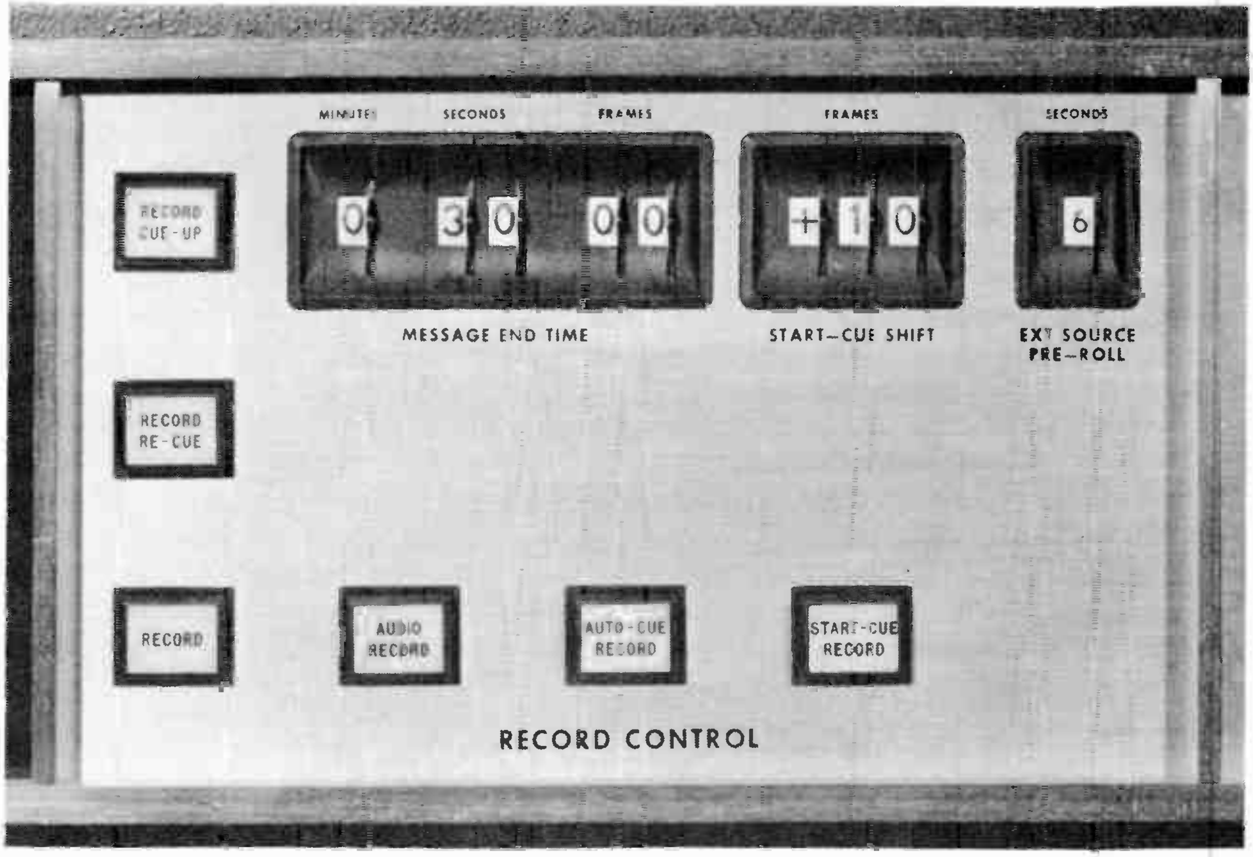
THE COMPLETE SYSTEM

The console design and the location of the electronics and mechanisms has been human engineered to be consistent with the overall emphasis on simplicity and convenience to the operator. The magazine is located in the front, center portion of the console (Fig. 9), and in this position all of the cartridges are accessible to the operator. The transports are mounted vertically with the headwheels to the rear of the machine and the receiver of the automatic threader mechanism in line with the magazine transfer stations and directly behind them.

The signal and servo electronics (Fig. 10) are located in a drawer that runs the width of the recorder immediately below the magazine. The drawer can be slid out, completely exposing four nests containing printed-circuit cards. The control panels are conveniently located above the magazine on a slide-out drawer containing the control electronics (Fig. 11). The control drawer can be swiveled to provide access to the printed circuit cards and to the wire wrap connections on the under side of the nest. The control electronics consists of 215 standard integrated circuit logic cards of which there are only 22 different types.

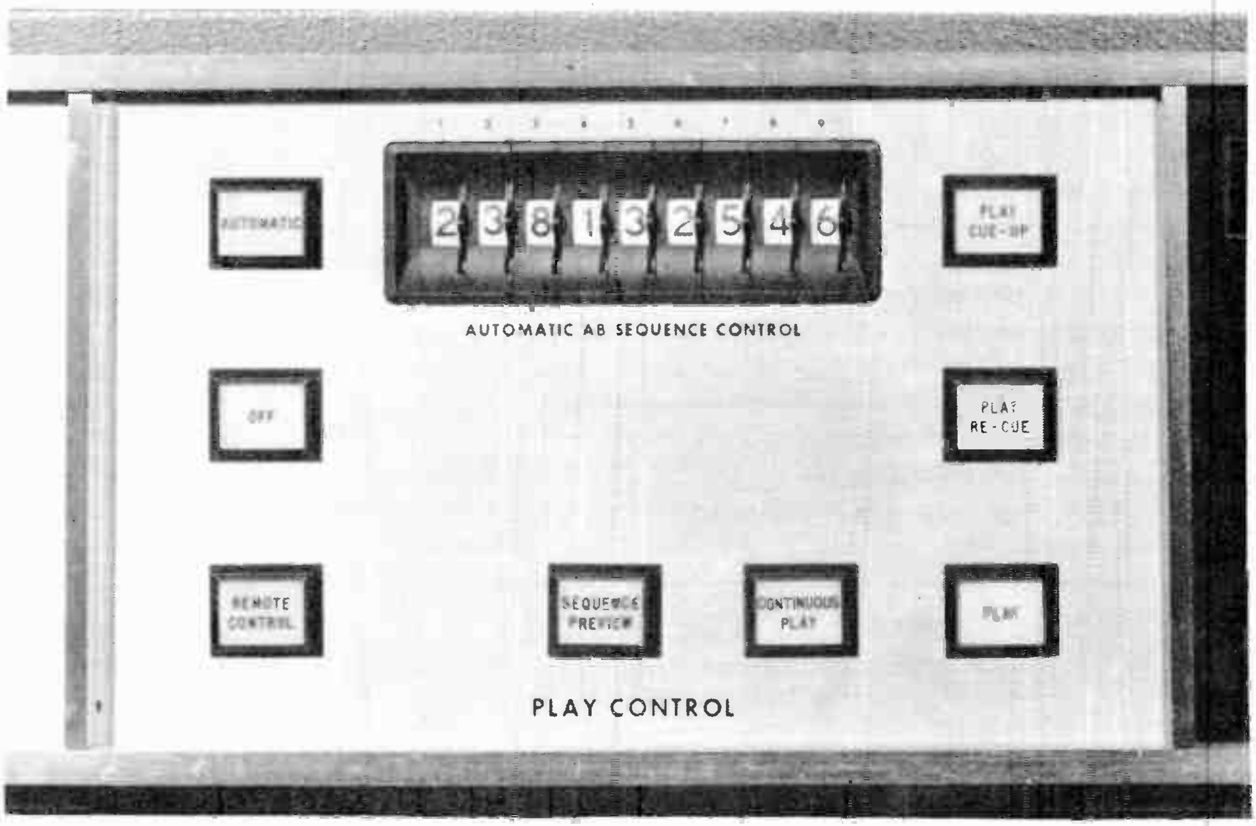
CONTROLS

The operational controls are grouped into three individual control panels. There is the Record Control, the Play Control, and the Transport Control panel and they are located side by side across the top front of the machine and make up the complete control center.



MINUTES
SECONDS
FRAMES
FRAMES
SECONDS
RECORD CUE-UP
MESSAGE END TIME
START—CUE SHIFT
EXT SOURCE PRE—ROLL
RECORD RE-CUE
RECORD
AUDIO RECORD
AUTO-CUE RECORD
START-CUE RECORD
RECORD CONTROL

Fig. 12



AUTOMATIC AB SEQUENCE CONTROL
PLAY RE-CUE
REMOTE CONTROL
SEQUENCE PREVIEW
CONTINUOUS PLAY
PLAY CONTROL

Fig. 13

The Record Control Panel (Fig. 12) contains three groups of controls. The first is a group of thumbwheel registers which provide the input to the automatic record function. The Message End Time register is the most important in this group and controls the length of the recording and the location of the start and end cues. There is also the Start-Cue Shift register which can be used to shift the effective start of the message by plus or minus 29 frames. Finally there is the external Source Pre-Roll register which can be used to control the starting of an external piece of equipment which is to be used as the source for a recording to be made on the cartridge machine.

The second group consists of the Record Cue-Up and Record Re-Cue controls which are used to select the Cueing of the cartridge before a recording can be made. The third and final group of controls are used to make a recording. The Record button is used to make a complete recording and the Auto-Cue Record is used to make a new start cue and a new end cue. Both of these record functions are controlled in length by the Message End Time register. Finally, there is the Start-Cue and Audio Record buttons which are used to control these respective functions. After any one of the recording cycles just described has been completed, the cartridge automatically rewinds and recues ready for previewing.

The subject of record control and automation is not complete without consideration of record standardization. An inherent requirement is that recordings or individual cartridges must be played with the recorder at one condition of adjustment, since there is no possibility for an operator to make individual adjustments for each tape. This kind of performance is possible because the system includes all of the automatic correction devices available (guide servos, velocity error corrector and line-by-line chrominance amplitude compensator); the electronics is designed to have excellent long-term stability of adjustment, and—most importantly—all recordings are certified for correct performance in the system at the time they are made.

This last point warrants more explanation: Normal operation of the system requires that a set-up routine be performed periodically, probably daily in most installations. In this routine procedure, the playback system of the cartridge recorder is equalized for optimum playback of a standard test cartridge. With the playback system adjusted this way, the machine's own recording is then checked and adjusted, if necessary, to insure that the playback system and its automatic correction devices are still in center-range. This will guarantee that the system is recording in a range that can be accommodated in playback, even when interchanged into another machine. When recording a program, one must still exercise care that the signal being recorded is correct, since the cartridge system at best can only re-create the signal provided to it for recording.

Located on the Play Control Panel (Fig. 13) is the "Automatic AB Sequence Control" and the Automatic pushbutton which is used to select this mode of playback operation. There are nine thumbwheels in the sequence control and each position represents a sequence which can be programmed to play automatically up to eight cartridges. There are also controls to select the Cueing or Playing of the cartridges as well as previewing an Automatic Sequence.

The controls on the Transport Control Panel (Fig. 14) are used to select the transport option in which the machine is to operate and the magazine position. This panel has a cartridge-reject control and finally a reset control which is used to stop all operation of the machine and to reset all logic functions to the initial conditions. The second half of this panel is a back-illuminated warning and status indicator.

At this point in the presentation, I have described all of the unique pieces of the system. I would now like to describe, in some detail, the operation of the machine in the mode which is no doubt the most interesting and most useful, the Automatic AB Sequence.

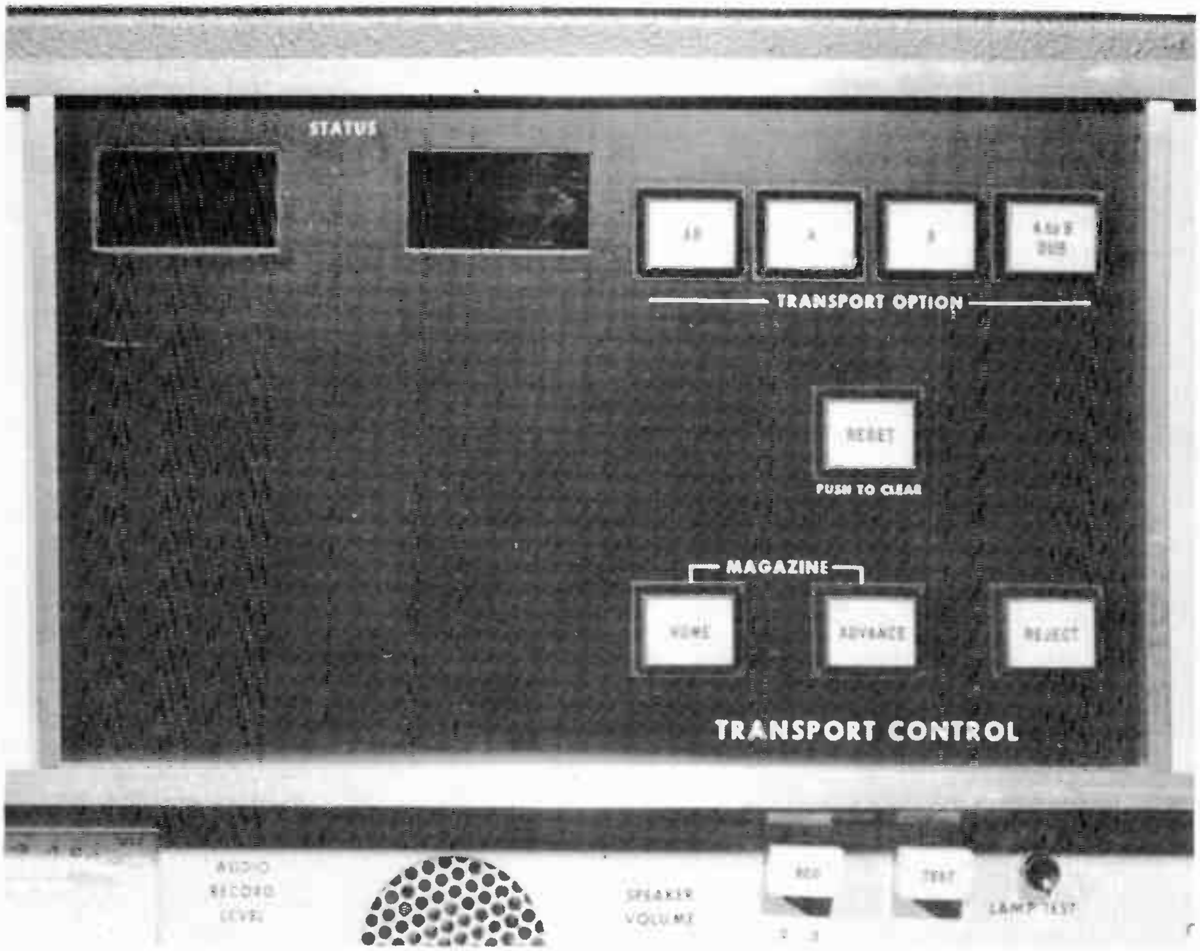

STATUS
TRANSPORT OPTION
RESET
PUSH TO CLEAR
MAGAZINE
TRANSPORT CONTROL

Fig. 14

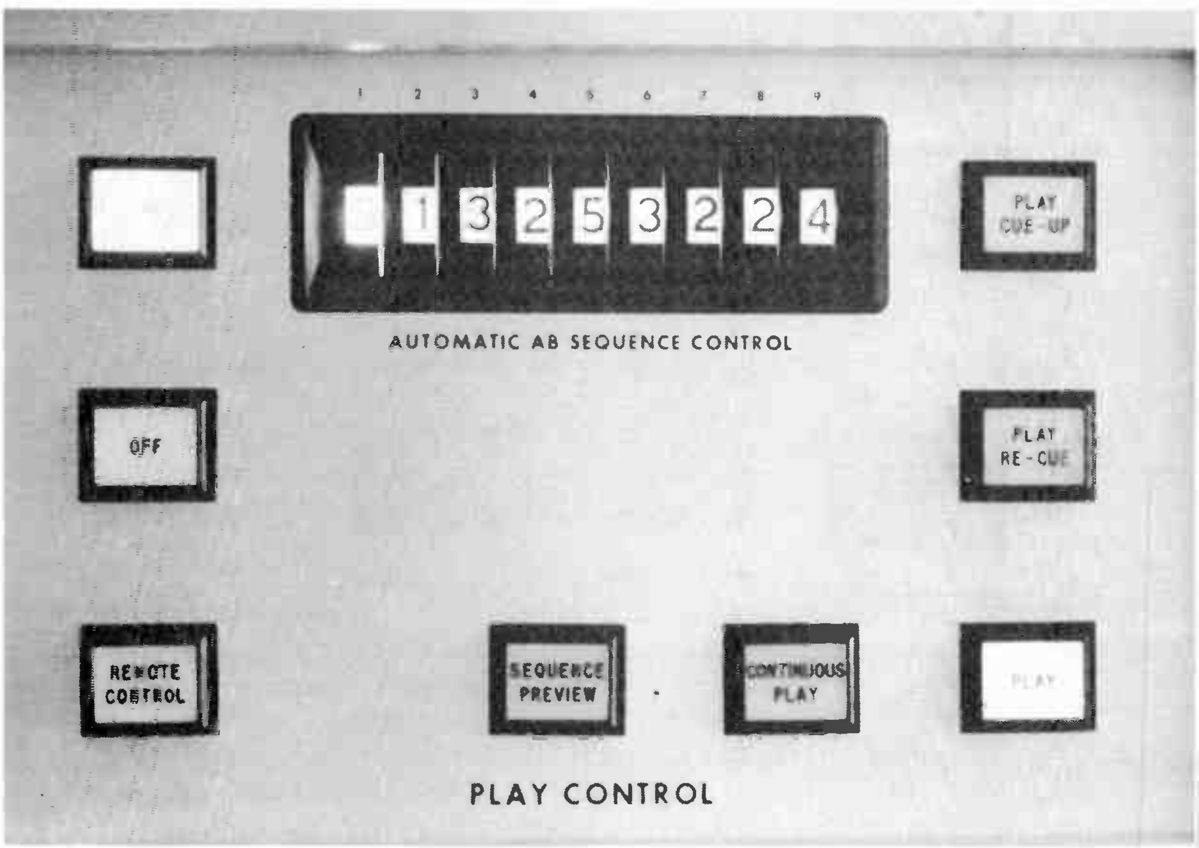

1 2 3 4 5 6 7 8 9
1 3 2 5 3 2 2 4
PLAY CUE-UP
AUTOMATIC AB SEQUENCE CONTROL
OFF
PLAY RE-CUE
SEQUENCE PREVIEW
CONTINUOUS PLAY
PLAY
PLAY CONTROL

Fig. 15

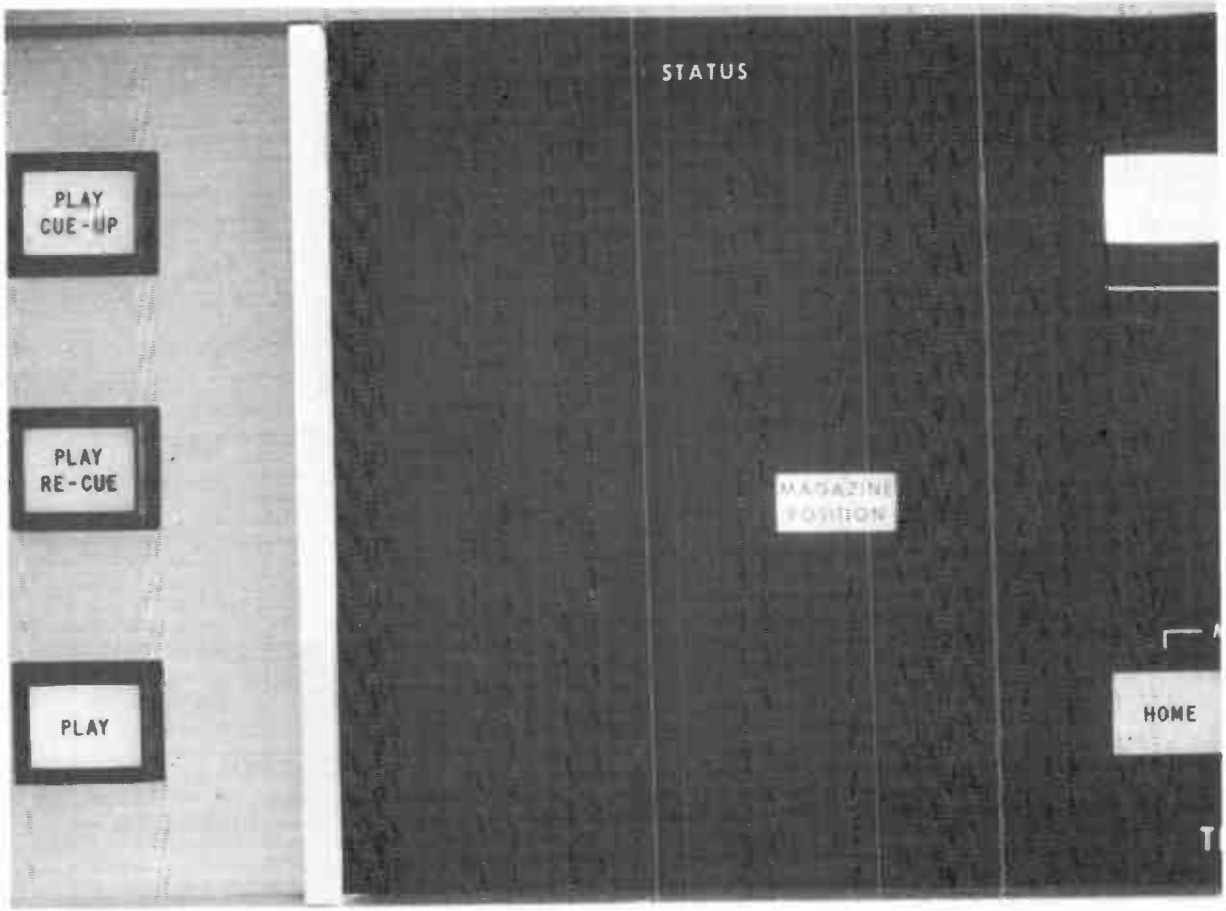

STATUS
PLAY
CUE-UP
PLAY
RE-CUE
PLAY
MAGAZINE
POSITION
HOME

Fig. 16

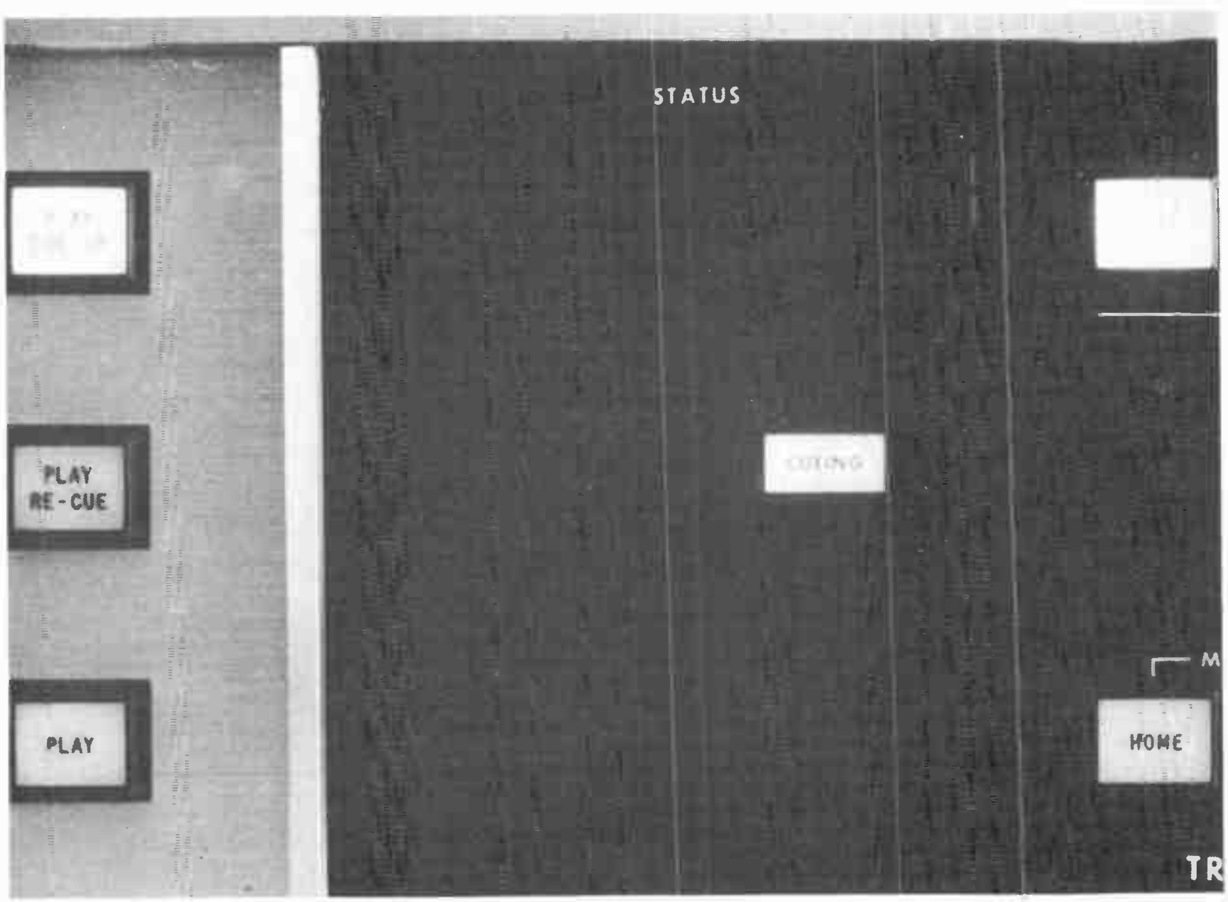

STATUS
PLAY
RE-CUE
PLAY
HOME

Fig. 17

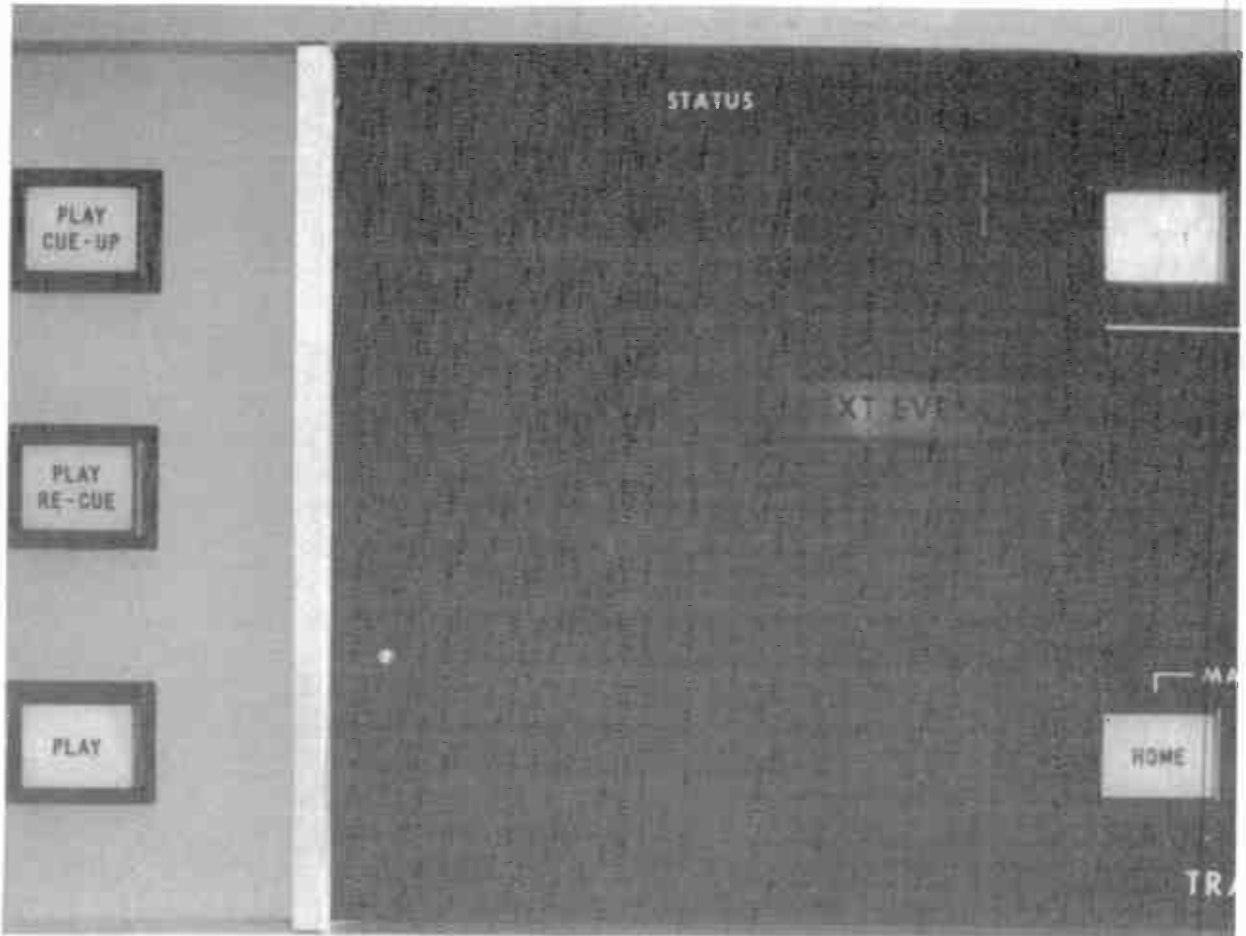

STATUS
PLAY
CUE-UP
PLAY
RE-CUE
PLAY
HOME

Fig. 18

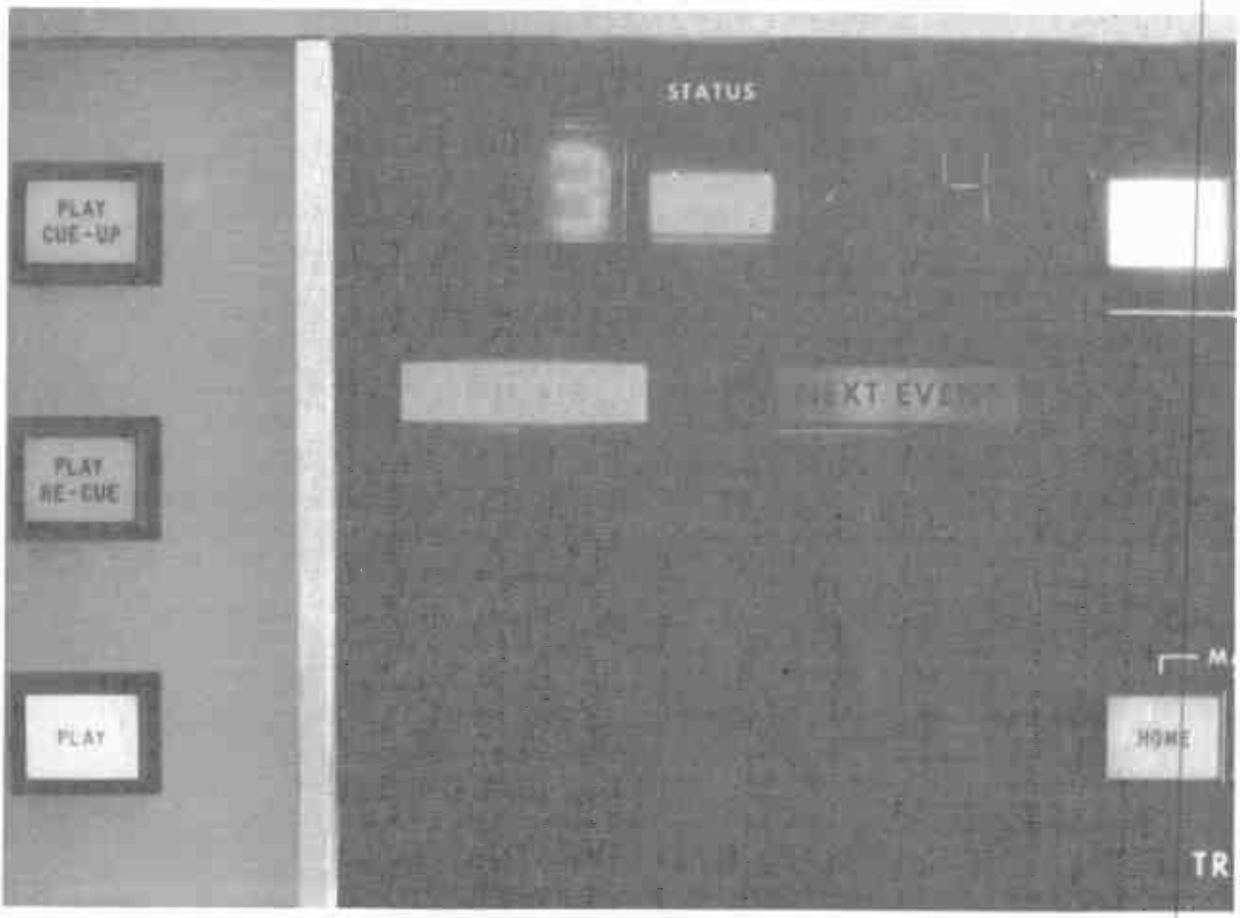
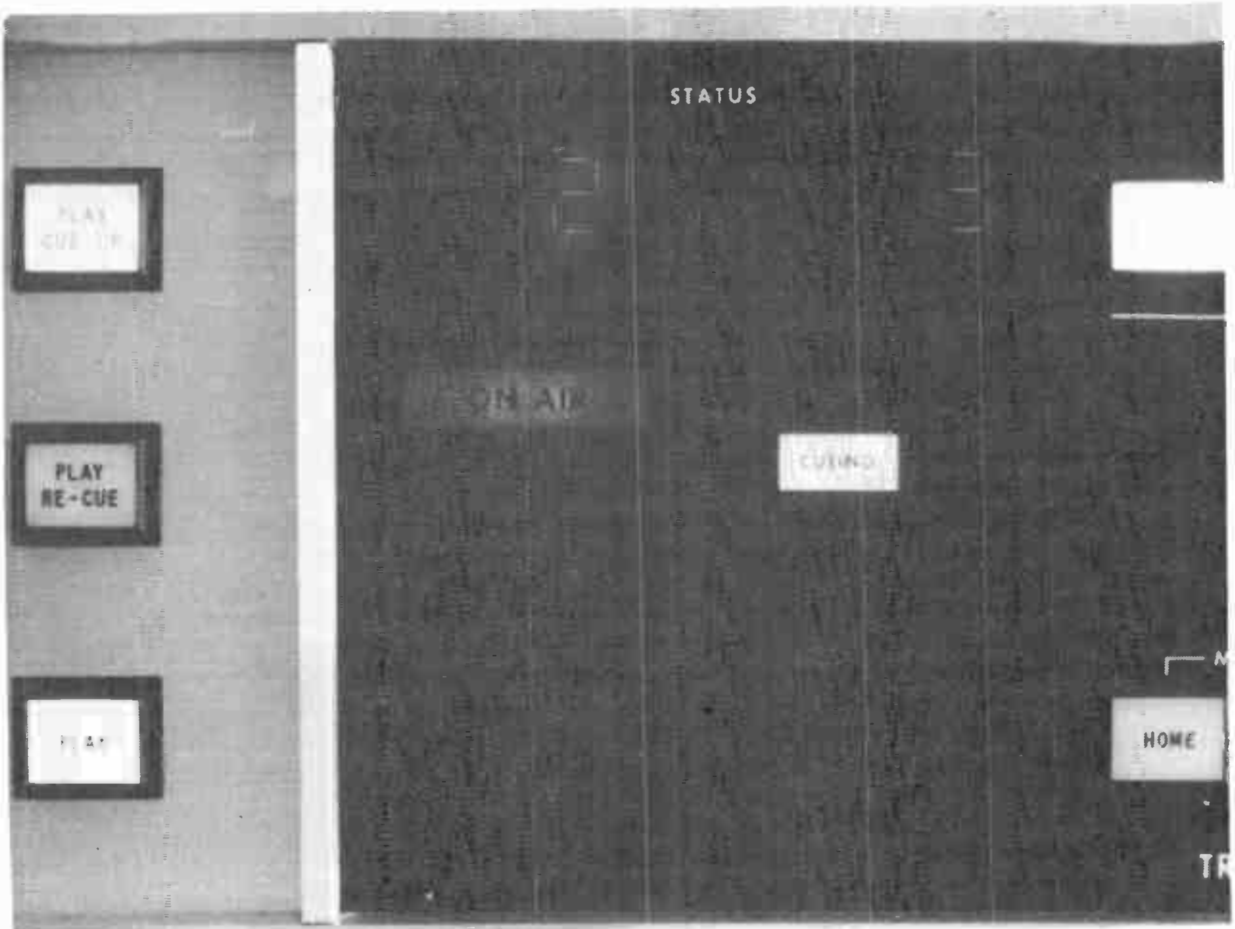
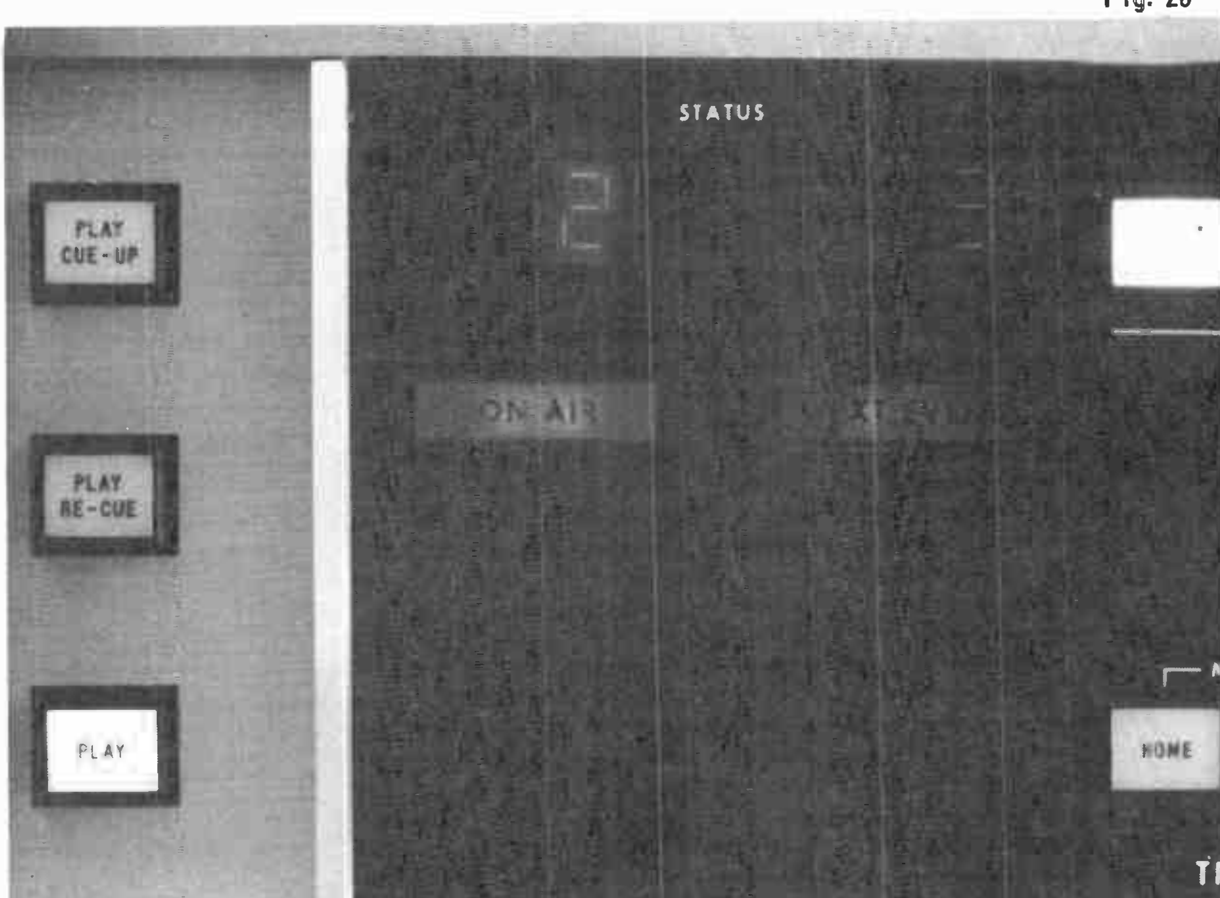
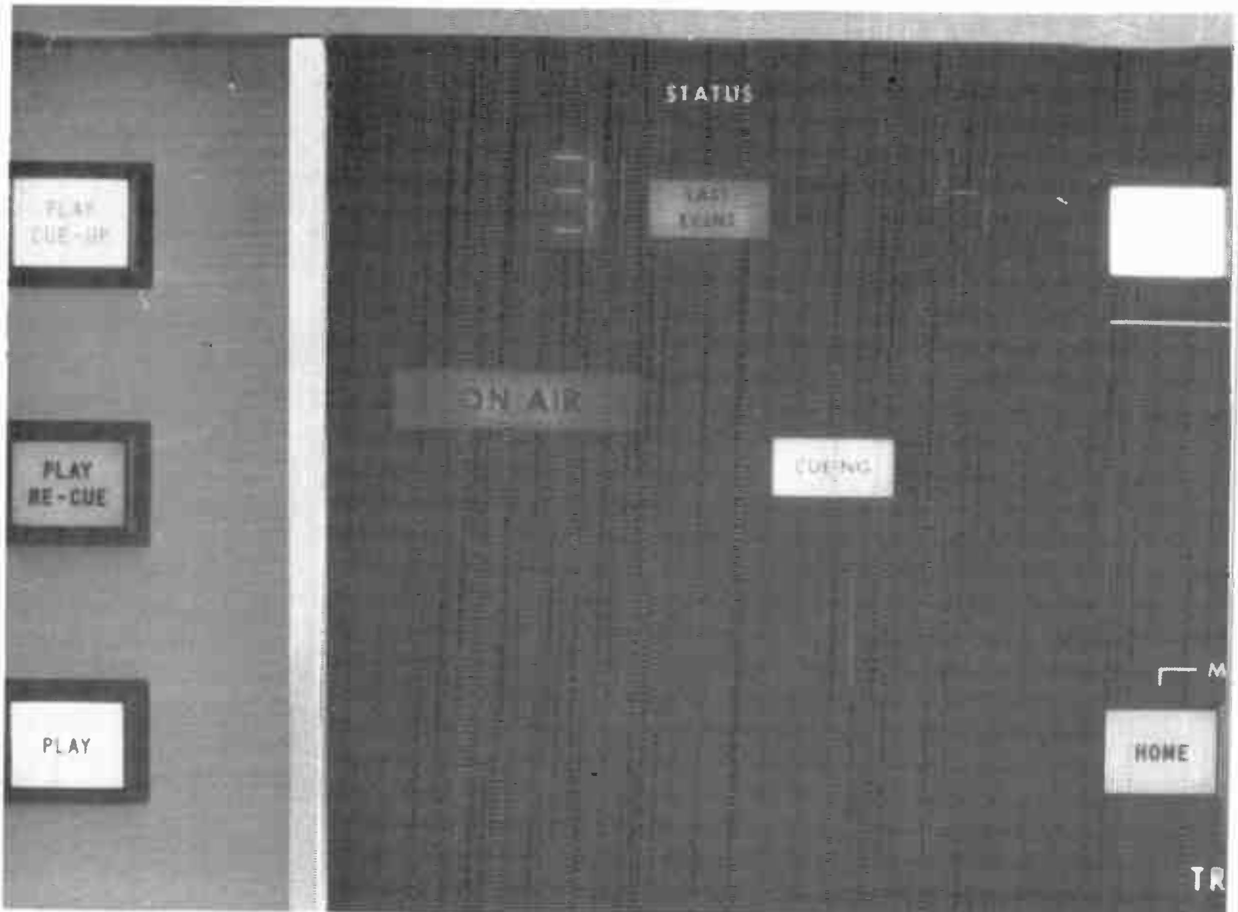
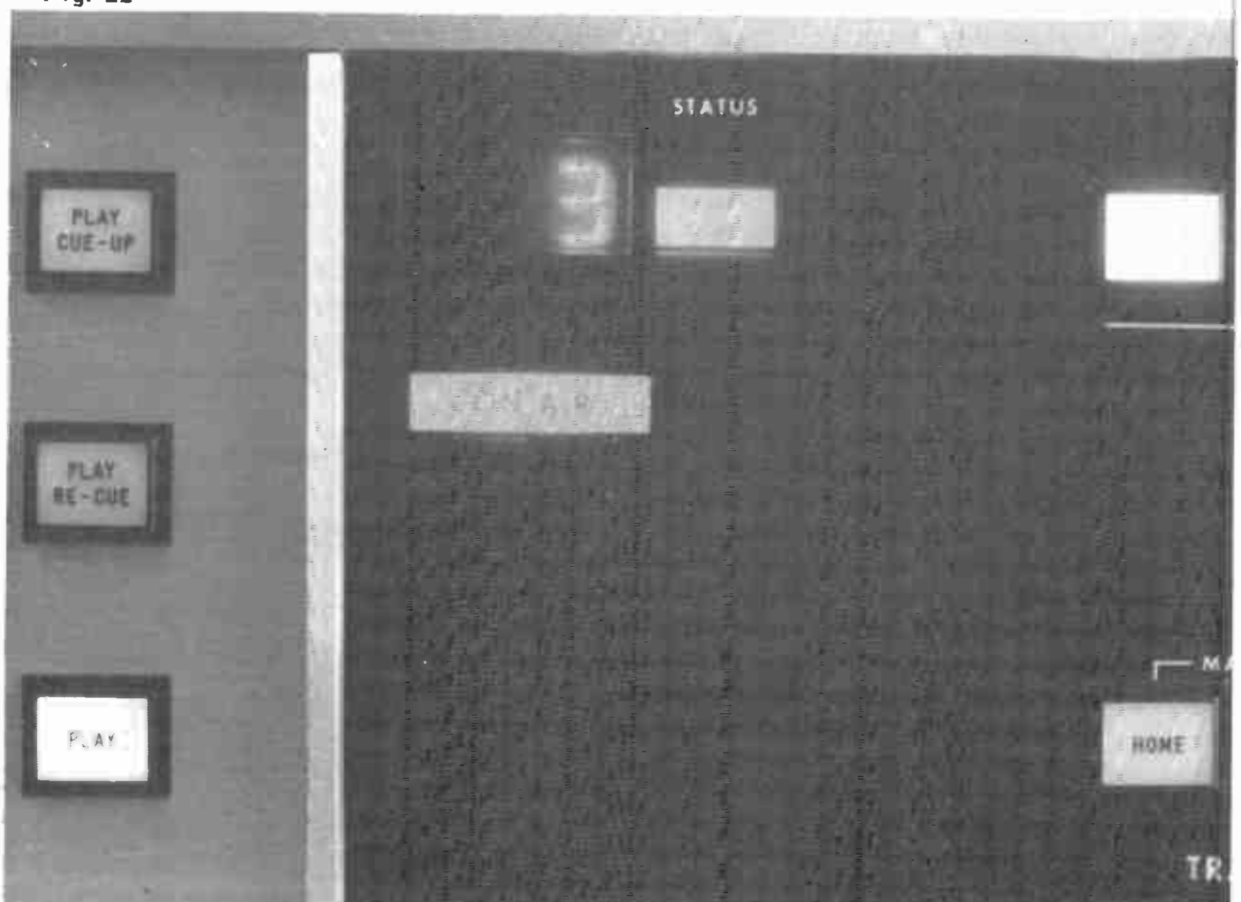

STATUS
PLAY
CUE-UP
PLAY
RE-CUE
PLAY
HOME

Fig. 19


STATUS
PLAY
RE-CUE
ON AIR
CUEING
HOME
Fig. 20


STATUS
PLAY
CUE-UP
PLAY
RE-CUE
PLAY
ON AIR
HOME
Fig. 21


STATUS
PLAY
CUE-UP
ON AIR
PLAY
RE-CUE
CUEING
PLAY
HOME
Fig. 22


STATUS
PLAY
CUE-UP
PLAY
RE-CUE
HOME
Fig. 23

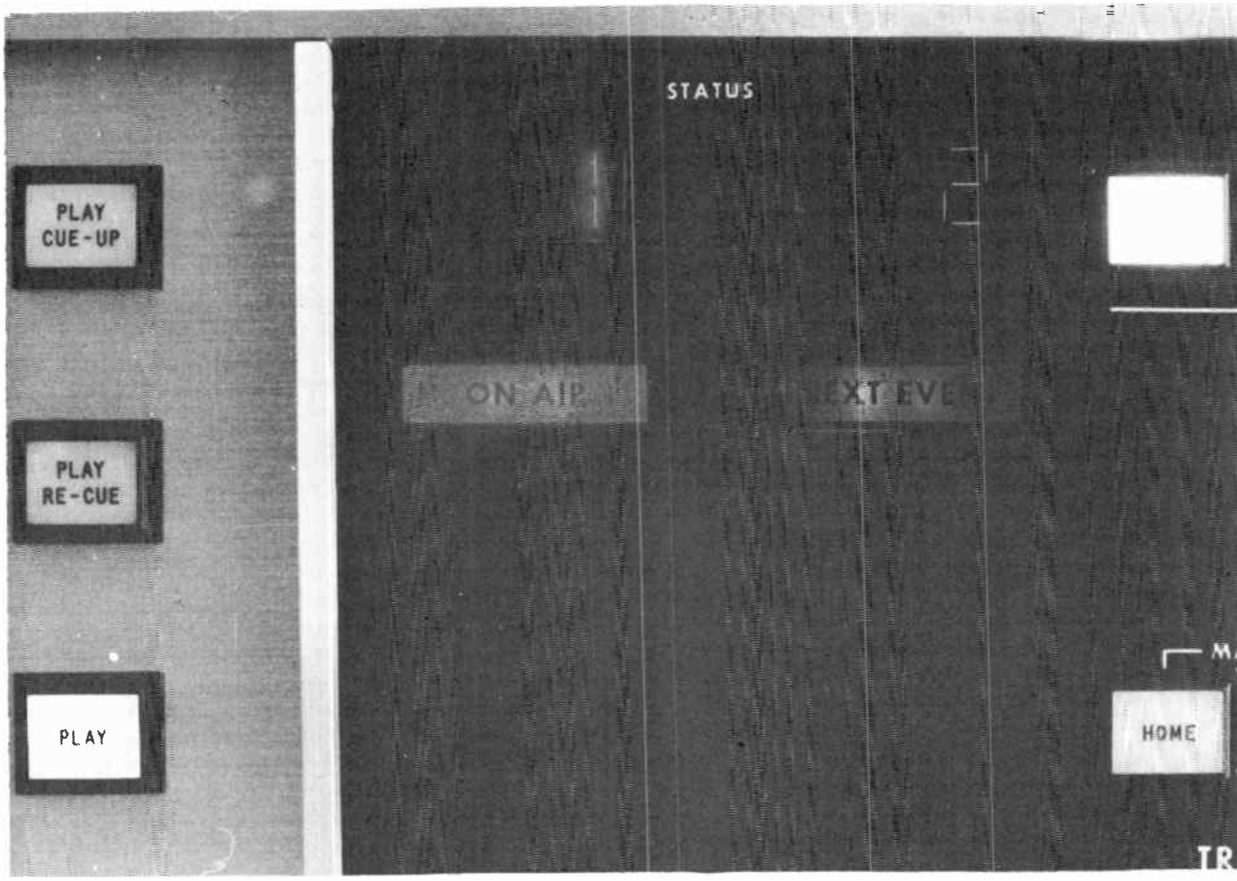


Fig. 24

I have chosen a sequence of three cartridges starting from the Home or #1 position. The automatic AB Sequence Control thumbwheel has been set and Automatic has been selected as indicated by the illuminated areas on the Play Control panel (Fig. 15). The Transport Control panel (Fig. 16) indicates the AB transport option has been selected and that the magazine is in position and ready to deliver the number 1 cartridge to the appropriate transport. A Play Cue-Up command (Fig. 17) has been issued (required only to start the first sequence, the remaining cartridges are loaded automatically in sequence) and the number 1 cartridge has been loaded and is now cueing. At the end of the Cue-Up cycle, the cartridge is ready to be put ON AIR and is so indicated as the NEXT EVENT (Fig. 18).

The magazine is first homed and the first cartridge is loaded and threaded into transport A. The machine advances and the second cartridge is loaded and threaded into transport B. The magazine returns to transport A to retrieve the first cartridge and then advance and load the third. The magazine then returns to transport A to retrieve the second cartridge and then advance and load the fourth and so on. The magazine is homed. Play Cue Up is pressed and cartridge 1 is loaded into transport A. The magazine automatically advances and loads 2 into B.

Now, in slow motion, the tape is extracted from the cartridge and is extended to form a triangle. It is then lowered into the headwheel panel and the threading arms are retracted. The tape is then rolled forward and is cued as the NEXT EVENT. At transport A, cartridge number 1 completes its cycle by prerolling 2 and then unloading. The magazine advances and loads 3. It then returns to B and waits for cartridge 2 to complete its cycle and unload.

Viewing the transport operation in slow motion, we see the automatic unthreading and unloading of the number 2 cartridge. The threading arms reform the triangle, the tape and cartridge are raised out of the tape path, and the tape is retracted into the cartridge. The carriage is lowered, the doors are closed, and the cartridge is unloaded into the magazine. The next cartridge is loaded and the transport operation is now shown in real time. The tape is automatically threaded and rolled forward to the cue point and is now ready as the NEXT EVENT.

In the meantime, the magazine returns to transport A and waits for the previous cartridge to complete its cycle. The cartridge unloads, the magazine advances and the next cartridge is loaded. The magazine then automatically returns to transport B and waits for the cartridge to complete its cycle and unload. The transport operation is again shown in real time as the tape is automatically unthreaded and retracted into the cartridge and the doors closed.

In summary, two fundamental innovations—automatic tape threading, and a compact system of specialized logic, made feasible by integrated circuits—have been combined to yield a totally automated tape-handling system, presented here as a solution to the increasing problem of handling short program segments accurately, reliably, and economically.

IF Modulation As Used In Solid-State VHF TV Transmitters

A. H. Bott
Gates Radio Co.
Quincy, Ill.

With the introduction of Gates new line of color television transmitters, the American broadcasting industry has available the first VHF equipment specifically developed and designed for color telecasting. The subjects...IF modulation, visual and aural exciter design, low power SBF, active group-delay compensation, power tube development, and solid-state control logic, reflect the advanced technology employed in these transmitters.

Employing Intermediate Frequency (IF) Modulation of the visual carrier, Gates' new series transmitters produce a color signal of a quality not possible with conventional transmitters. The new transmitters are also the very first FCC type-accepted with IF modulation for VHF TV service.

When planning started at Gates several years ago, engineers had to decide whether to use high- or low-level modulation. Furthermore, they had to determine whether or not to continue one step further and use IF modulation.

Before making this decision, considerable study was done on all systems. The greatest amount of information on the IF modulation system is available in European literature. However, in the last few years, several domestic and international manufacturers have attempted to introduce IF modulation in the United States. All these systems were imports. As a result of this study, mixed with the experience of a number of engineers, the following significant facts were isolated:

High-level modulation has two major weaknesses:

1. The video modulator in many of the older transmitters must supply video voltages up to several hundred volts into highly capacitive loads.

2. The modulated stage is grid modulated and, therefore, presents a varying load to its RF driver. Most shortcomings were not particularly significant in the black-and-white system where the signal content at high video frequencies is low and requirements for differential gain in amplitude did not exist.

Additional weaknesses are found in high- as well as low-level systems: the need for vestigial sideband filters at high power levels, and unsatisfactory system equalization. Some equalization schemes look like afterthoughts. This becomes more evident when considering the individual units of a video equalization system: a high-frequency equalizer, a low-frequency equalizer, an FCC equalizer, a notch diplexer equalizer, and an equalized low-pass filter. In the past, recommended systems of this sort required, in addition to the equalizers, distribution amplifiers and amplitude correctors to meet specifications.

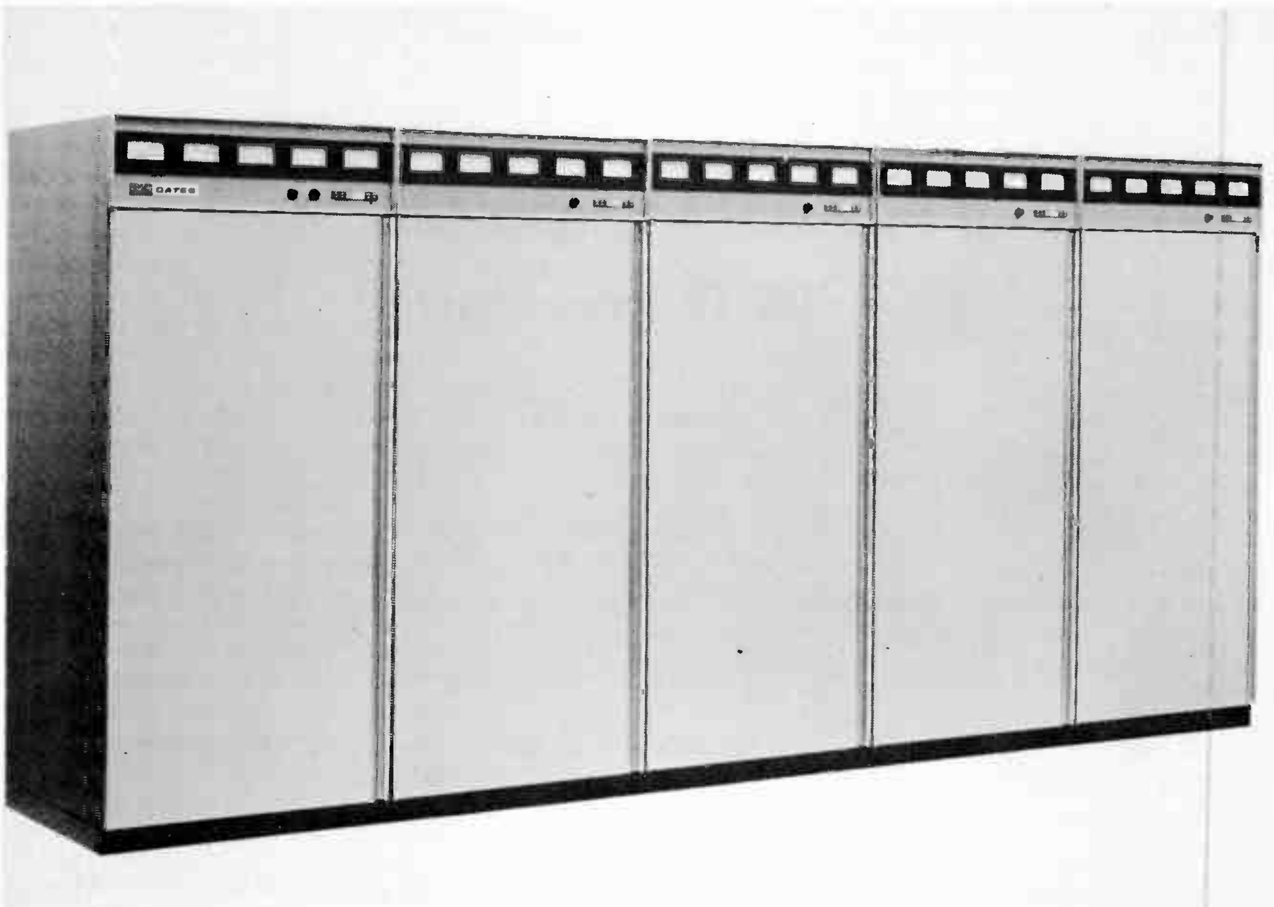


Fig. 1 A

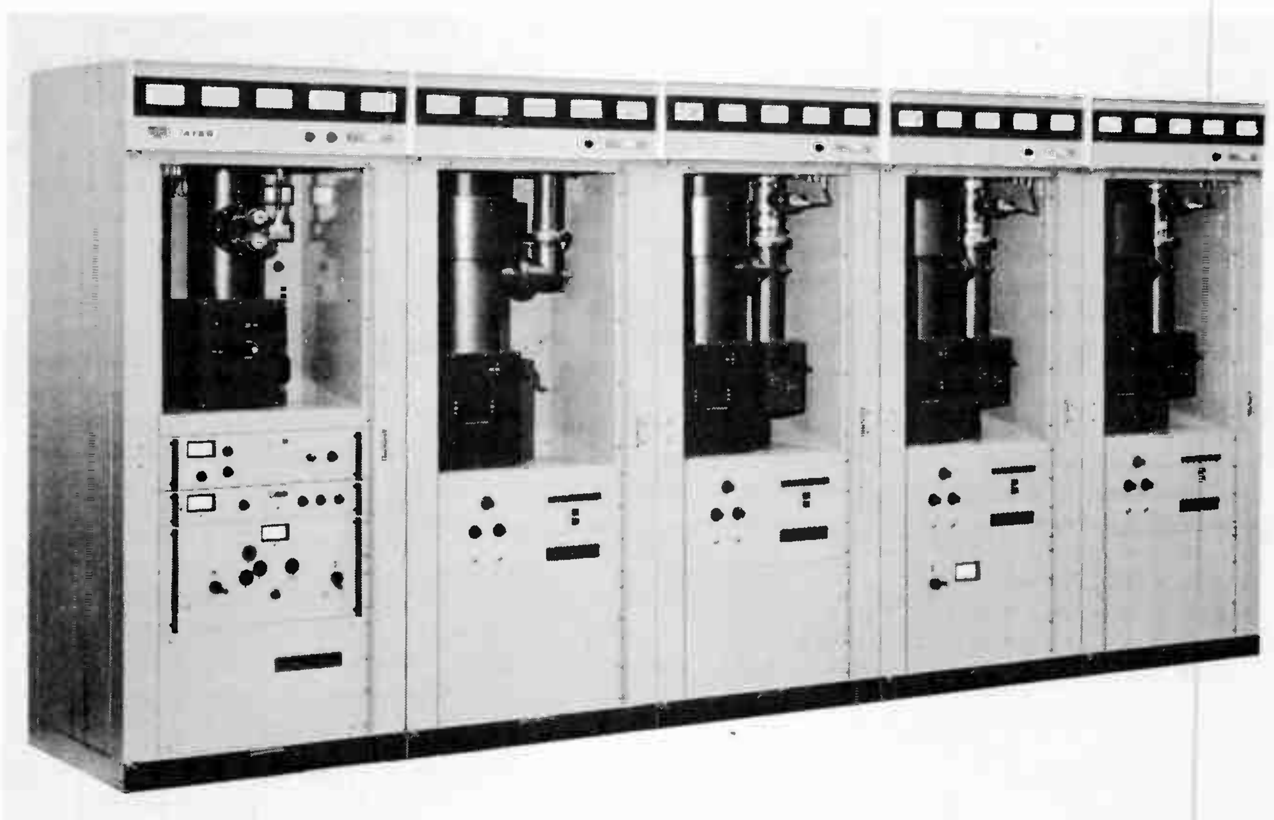


Fig. 1 B

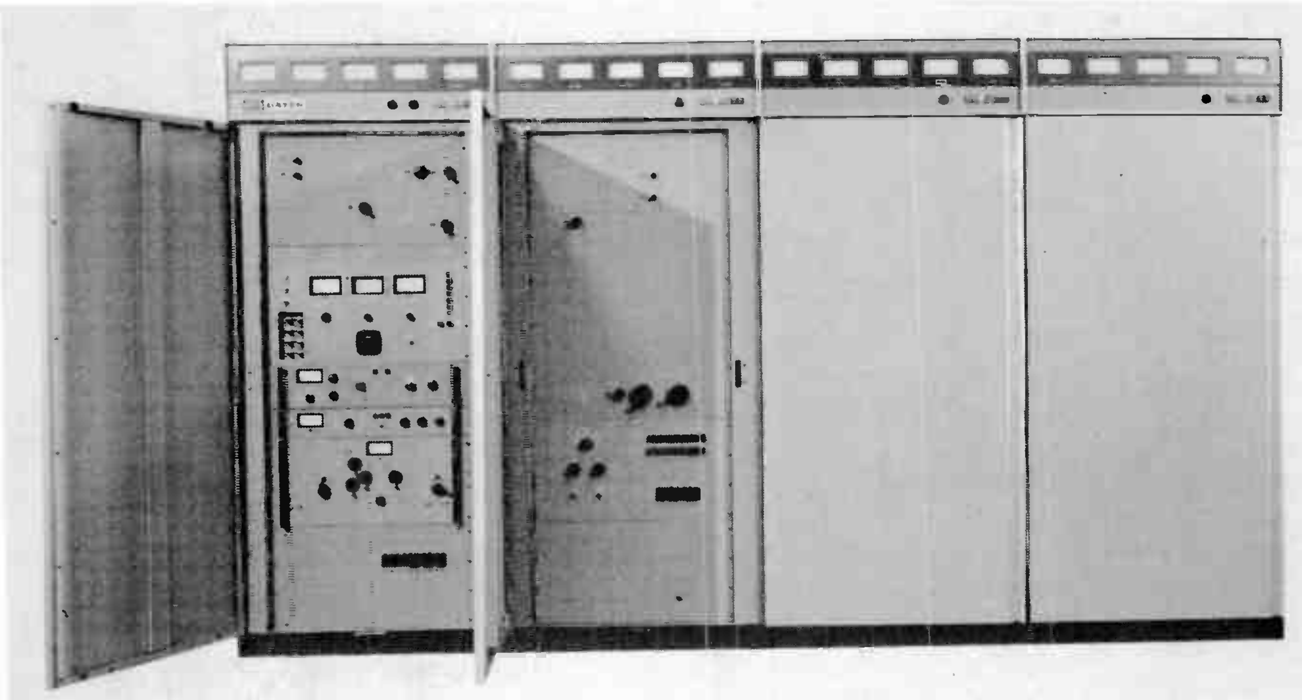


Fig. 2

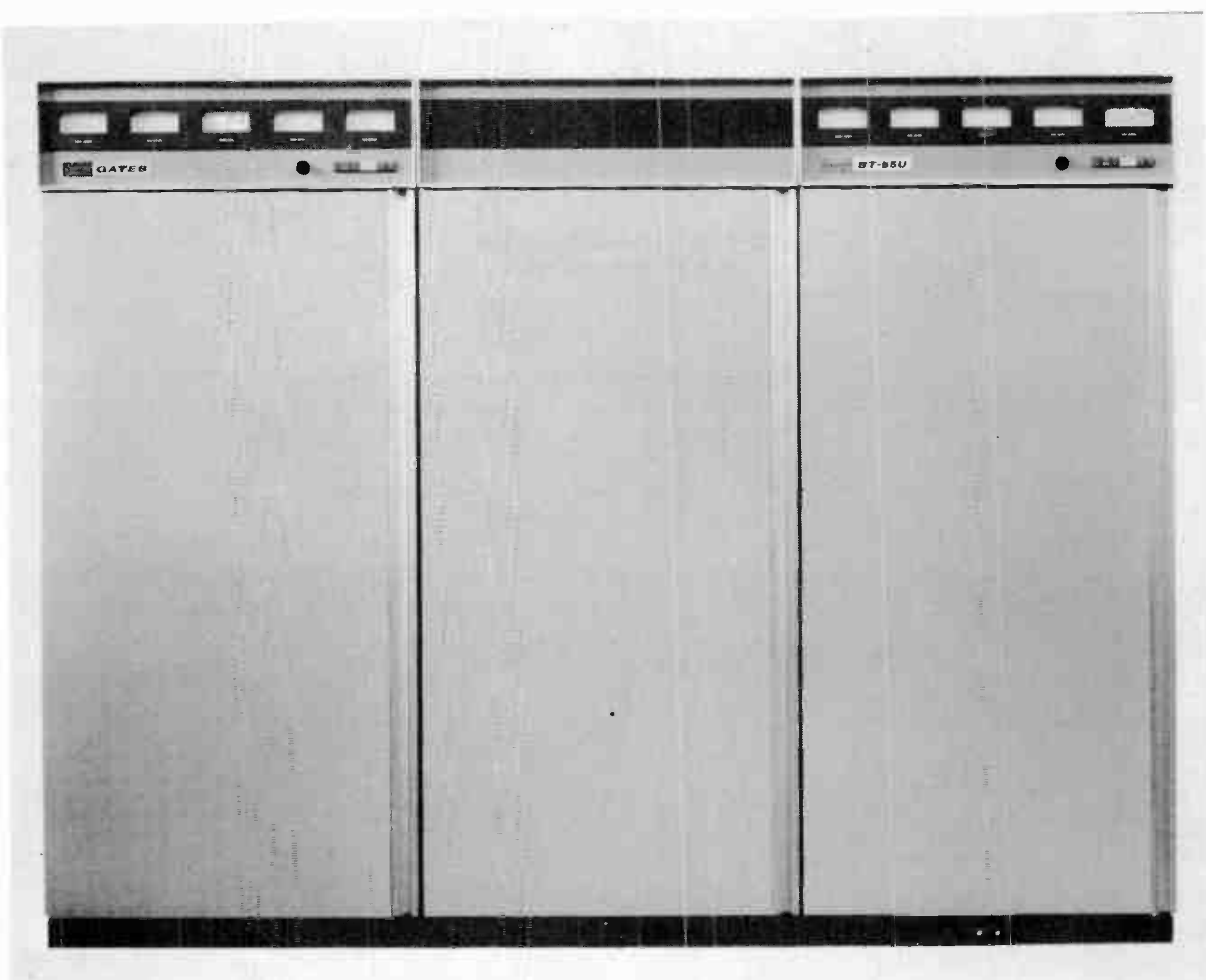


Fig. 3

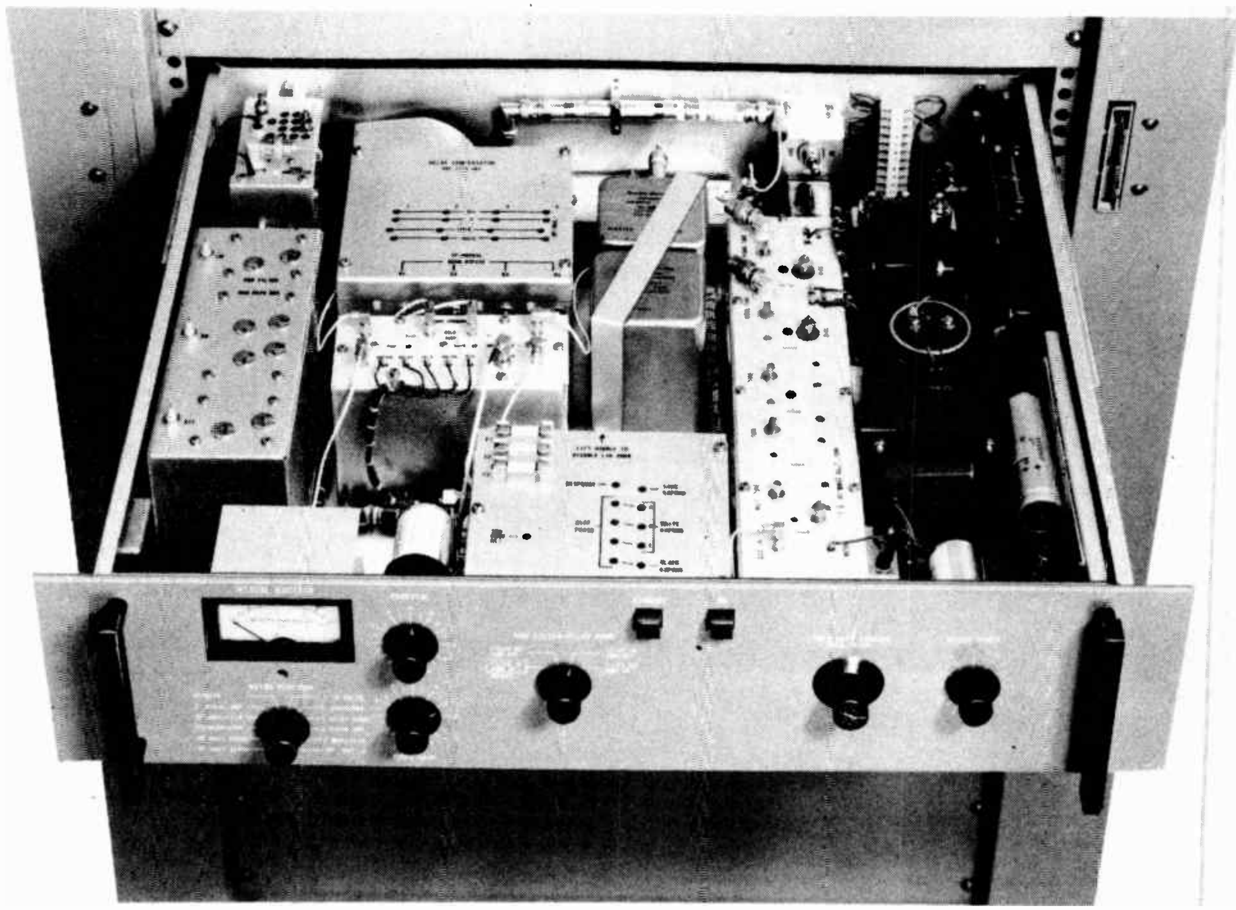


Fig. 4

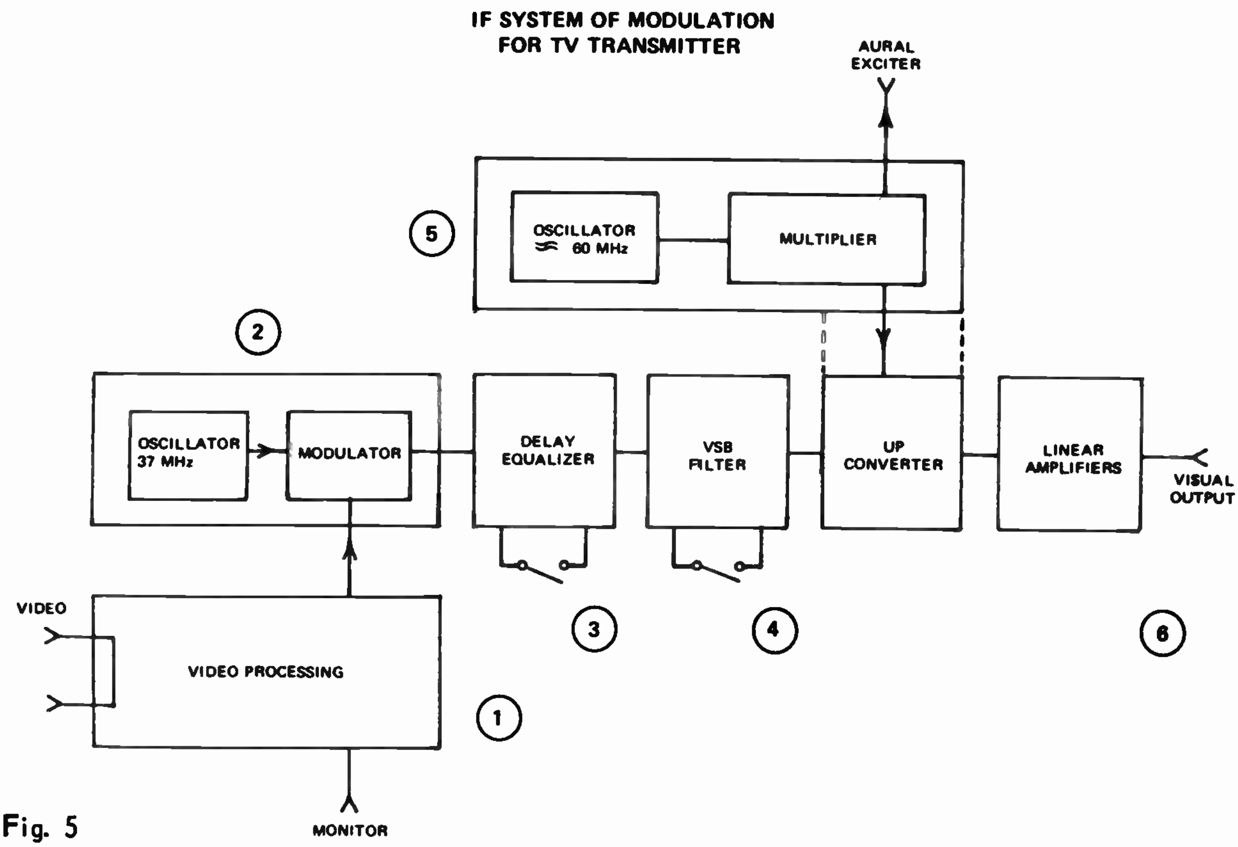

IF SYSTEM OF MODULATION
FOR TV TRANSMITTER
AURAL
EXCITER
5
OSCILLATOR
60 MHz
MULTIPLIER
2
OSCILLATOR
37 MHz
MODULATOR
DELAY
EQUALIZER
VSB
FILTER
UP
CONVERTER
LINEAR
AMPLIFIERS
VISUAL
OUTPUT
VIDEO
VIDEO PROCESSING
3
4
6
1
MONITOR

Fig. 5

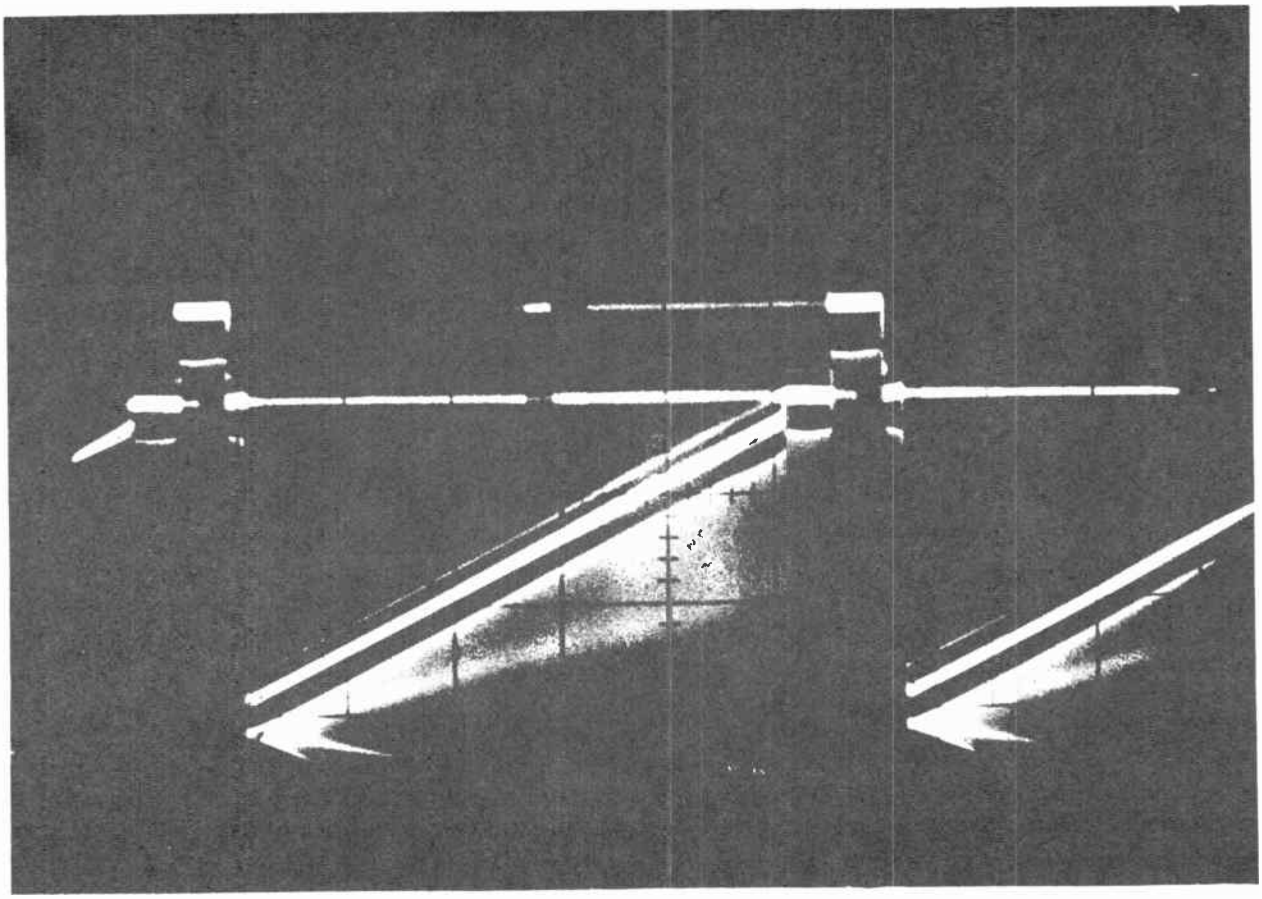


Fig. 6

How are these problems overcome by IF modulation? The modulation problem, mainly a shortcoming of the high-level system, is overcome by modulating a low-frequency carrier at low power levels. The modulated stage in Gates system, the first IF system completely and originally designed in this country, uses a ring modulator. This is an almost ideal device exhibiting very low linear distortion, outstanding modulation capability,and very low differential gain and phase discrepancies. Following the modulator, linear amplification will raise the power level. At this low level one can be wasteful with respect to efficiency to assure ultimate performance.

The deficiencies common to high- and low-level systems, in particular the need for a high power-vestigial sideband filter for video equalization, and an equalized video low-pass filter, are overcome in the IF system by employing a low-level IF vestigial sideband filter which is designed not only to shape the lower sideband response but also the higher sideband response. This eliminates the need for an equalized low-pass filter. Second, equalization is performed at IF levels, which is the same as performing the equalization on carrier. So it corrects a fault at the source. (Fig. 1 is a photo of the Gates BT-35H transmitter; Fig. 2, the BT-25L; Fig. 3, the BT-55U.)

IF modulation has become technically feasible through technological advancement in two areas: First, solid-state devices including hot carrier diodes, low-noise transistors, integrated circuits, etc., and, second, the availability of high-gain, highly linear power tubes especially designed for wideband application.

To more clearly define the system, Fig. 4 shows six significant modules: The first module is video processing. (Fig. 5 is a block diagram.) It employs solid-state devices and integrated circuits. It is protected against excessive voltages appearing on the video cable and will accept a standard sync, negative video signal to a loop-through input. It uses an extremely fast backporch clamp which will not interfere with the burst, and it provides linearity correction and a monitor output.

The second module is a ring modulator including its crystal-controlled 37-MHz carrier generator. The output from the ring modulator is an amplitude-modulated 37-MHz double sideband signal. Oscilloscope photos were taken at Gates of the output of this modulator, shown in Fig. 6. This picture was taken with a dual input oscilloscope showing a positive sync ramp signal (the heavy line) and purposely slightly offset in the vertical scale and the amplitude modulated 37-MHz carrier. The linearity can be judged by observing the constant displacement between the modulated envelope and the video input signal. This picture was taken without any filtering in the output of the modulator, evidenced by a small amount of harmonic content of the carrier (the shading of the area under the curve).

The next module is the delay equalizer consisting of three circuit boards individually switchable, each acts as one all-pass section except that its delay maximum, and the frequency of maximum delay, are continuously variable. The design of the equalizer boards will also allow a small degree of amplitude compensation.

The next module comprises the vestigial sideband filter. Sideband filter and delay equalizers can be switched in and out of the circuit in any possible combination. The design of the sideband filter at low IF frequencies leads to a considerably improved amplitude response, a sample of which is shown in Fig. 7. This picture was taken with an early model sideband filter and has since been considerably improved. Yet, it can be seen that the lower as well as the higher frequency slope of the sideband filter is well controlled. This is in contrast to older, high-power sideband filters which control only the lower sideband.

The next building block is No. 5 in Fig. 5. This unit is a mixer or up-converter which changes the IF frequency to the final frequency, wherever the final frequency may be. Up to this point, all exciters for VHF high-band or low-band transmitters as well as UHF transmitters are identical. It is obvious that considerable economies result from such a system which ultimately will benefit the user by offering better performance and greater reliability. The converter also utilizes a ring modulator very similar to the one employed as a modulator. It is obvious that any approach using conversion must aim to reduce spurious and unwanted frequencies to an absolute minimum. From this point of view alone, a ring modulator is the best choice. As a result of careful design in this area no frequencies, harmonically related orotherwise, have been found that do not exceed FCC requirements by at least 20 db.

The last building block is 6 in Fig. 5, into which all linear amplification is lumped, from the output of the mixer to the final operating power. In the exciter, about 30 db of gain is contained in a non-tuned wideband amplifier. An additional 10 db gain is added by a single-tuned linear amplifier, leading to a power output of 1 watt from the exciter.

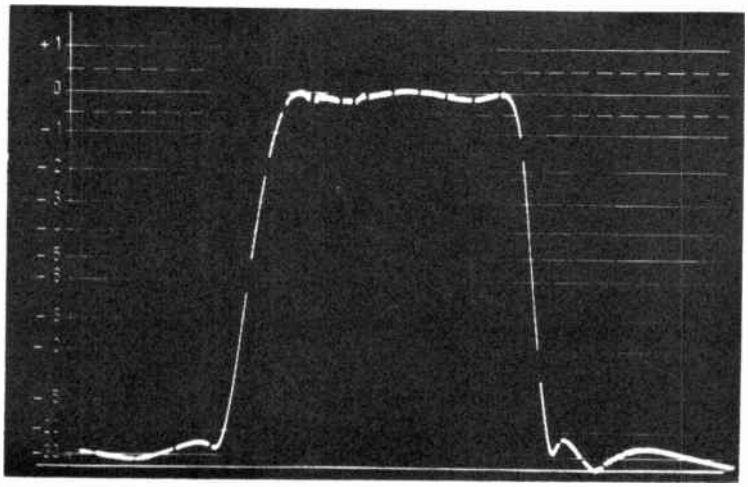


Fig. 7

Once the sideband filter is adjusted no further tuning is required in the exciter. The tuned circuit of the last amplifier is merely peaked for maximum power output since its overall bandwidth is in excess of 30 MHz. The output signal of the exciter, being on-carrier, can be used as a test signal for either transmitter or monitoring equipment. From here on, all amplifiers have 50-ohm inputs and outputs, and can be checked individually or cascaded.

The output signal of the exciter is of such quality that it becomes difficult to distinguish between the video input signal to the exciter and the demodulated output signal from a demodulator (assuming no receiver predistortion is used).

Following the exciter the only remaining task in an IF system is suitable amplification. This amplification must be performed with proper bandwidth and linearity if the quality of the exciter signal is to be maintained. Here, the high gain of new power tubes comes into play, permitting power levels of 35 KWor even 50 KW peak sync with only four stages, three of which are double tuned. It is interesting to compare this to existing high-level transmitters. Typically, a 25 KW peak sync transmitter requires two double-tuned stages, only one less than Gates' approach.

The advanced technology used in Gates' VHF television transmitters would not have been possible without the development of a whole new family of power amplifier tubes for VHF service. This group of tubes has excellent linearity and broad bandwidth, two essential design requirements for efficient operation in the VHF TV service.

First of all, the bandwidth capability of a tube is governed solely by its output capacity. Practical tube-manufacturing techniques determine that this output capacity is such that a plate impedance on the order of 500 to 1000 ohms is realized. Therefore, to get adequate power output at VHF frequencies, the tube must be of a high perveance type, having high current capability. Good VHF capability and practical working circuitry is also highly dependent on both input and output tube capacity.

Now, we have in fact the new family of ceramic tetrodes that require no design compromises. They have good linearity, broad bandwidth and high power output capabilities at VHF frequencies. The tubes employed in the Gates, television transmitters are these:

8122: Has a plate dissipation of 400 watts but is used as an intermediate power amplifier at a 100-watt level; it has full ratings to 500 MHz.

8792: Having a plate dissipation of 1.5 KW, it is used at a one-kilowatt level and at full ratings to 400 MHz.

8806: Dissipation is 12.5 KW. The power level used is 13 KW. Full ratings extend to 400 MHz.

8807: The operating level is 18 KW, with a plate dissipation of 15 KW. Ratings are full to 400 MHz.

Life expectancy of Type 8806 and 8807 tubes is predicted beyond 15,000 hours mean time to failure, with a peak life expectancy of 20,000 to 30,000 hours. This estimate is based on experience with the Type 8501 tube used in UHF service. All three types have similar cathode construction but the 8806 and 8807 have a greater cathode areas. This results in the cathode operating at a lower temperature and consequently increases tube life. Because the 8806 and 8807 are operating at VHF, not UHF, frequencies, there will also be less back bombardment of the cathode.

With Gates transmitters, only two types of cavities are required for any output power level, whether operating low-band or high-band. One type is high-level for

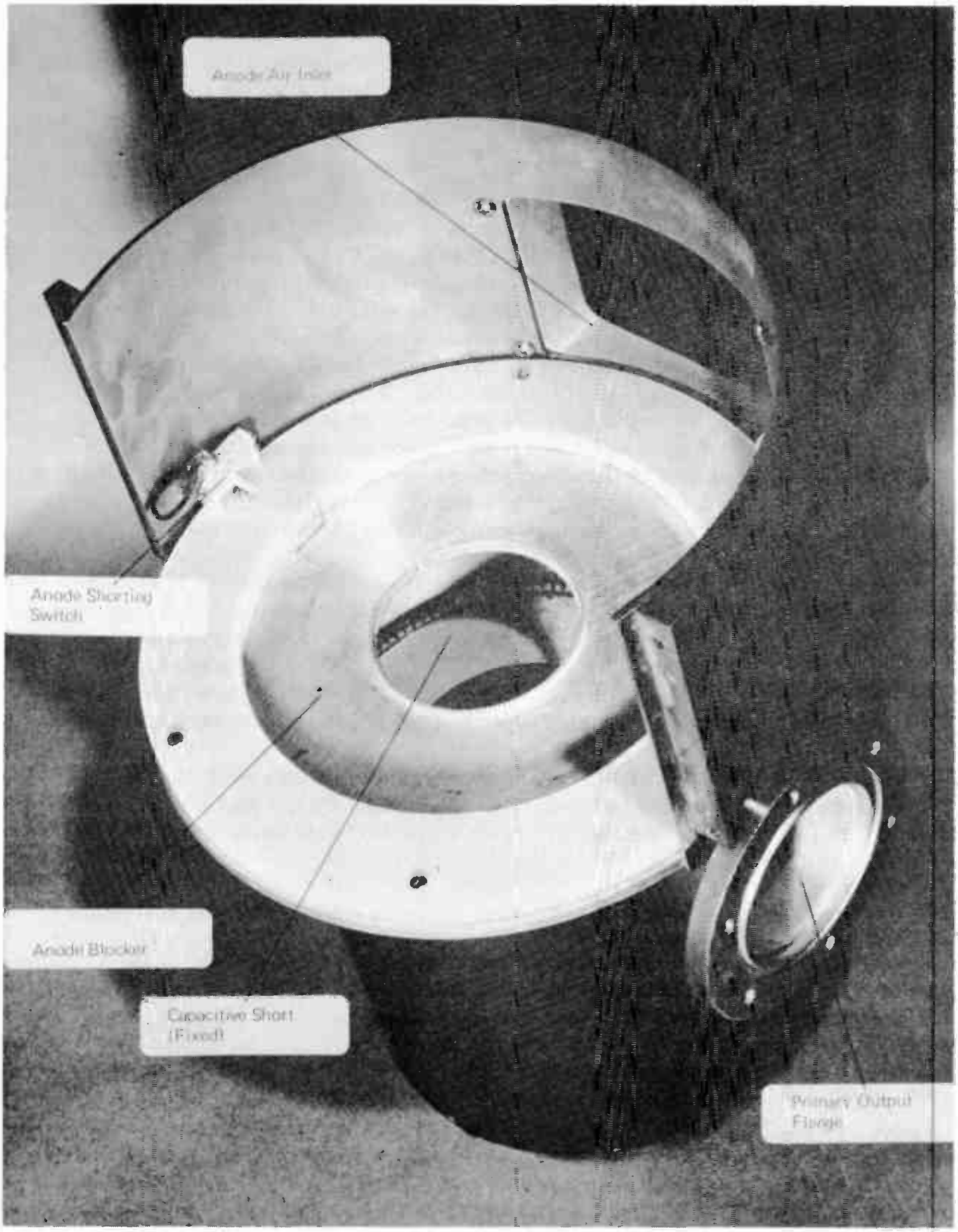


Fig. 8

outputs above 1.5 KW and accepts either the 8806 or 8807. (Fig. 8 is a picture of the VHF high-band cavity shell. Operation of the new ceramic tetrodes in the coaxial cavities is unneutralized, grounded control grid, ground screen grid. In the equivalent circuit of a high-level visual amplifier (Fig. 9) the circuitry to the right of the output coupling network is contained in the external output network. The input circuit is single-tuned with a very broad bandwidth, while the output is double-tuned with a primary and secondary circuit.

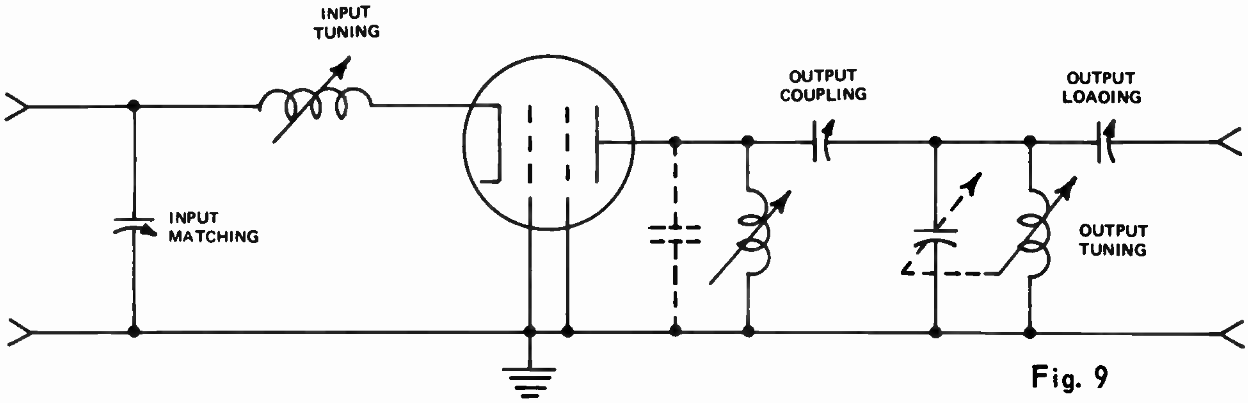


Fig. 9

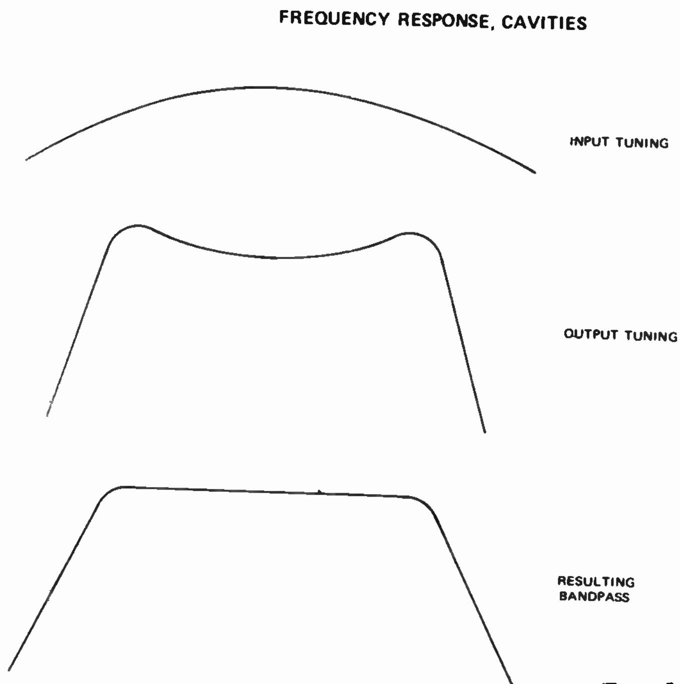


Fig. 10

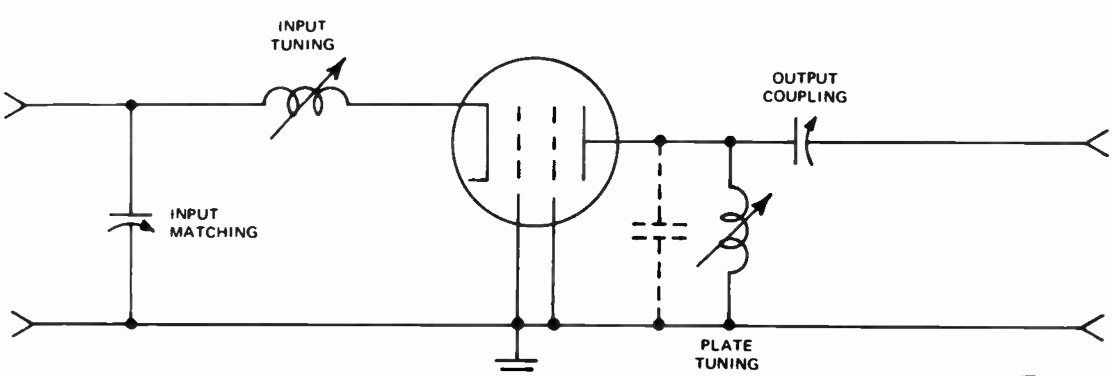


Fig. 11

EQUIVALENT CIRCUIT, CAVITY, LOW LEVEL

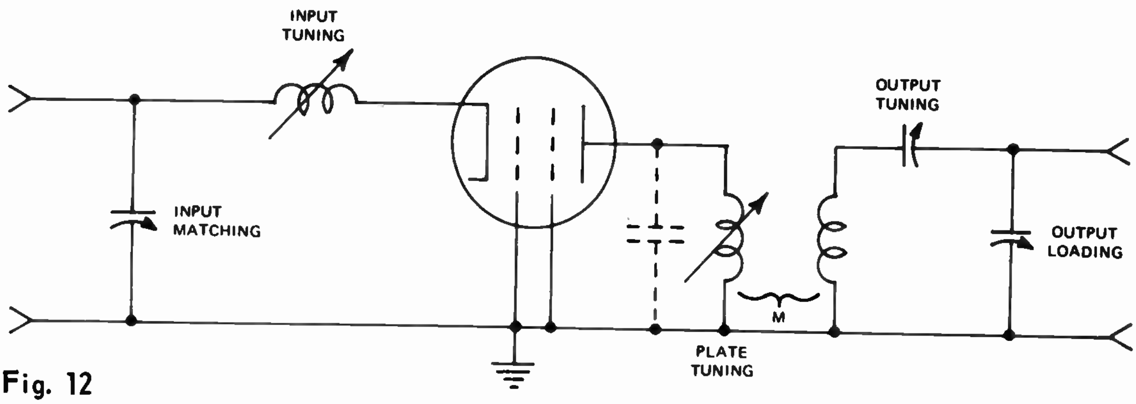


Fig. 12

TURN-ON BLOCK DIAGRAM

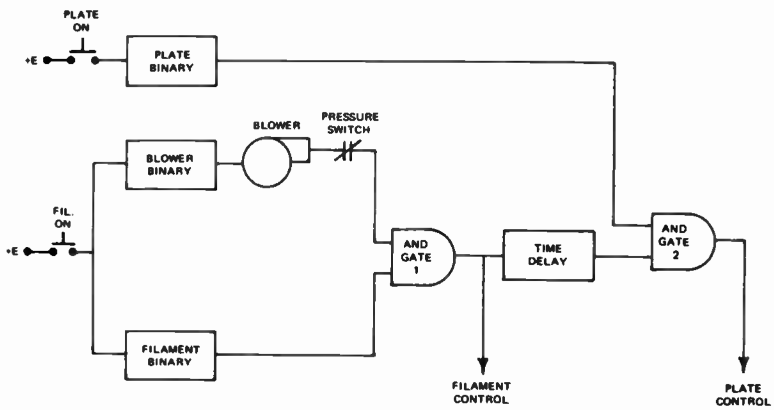


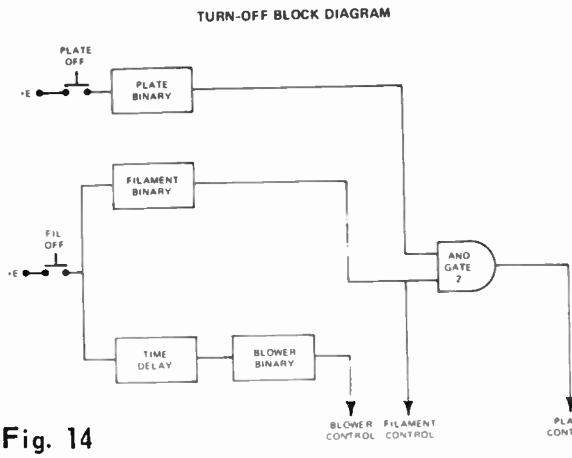
Fig. 13

Variable circuit coupling is interposed, allowing the output frequency response to resemble the familiar double-tuned response shape. Variable circuit coupling is used to determine the depth of the "valley." The end result is that the frequency response from cavity input to output is precisely the flat-topped, bandpass response, 6-MHz wide (Fig. 10).

In the equivalent circuit of the high-level cavity operated as an aural amplifier, (Fig. 11) the wideband visual output network has been removed. The low-level cavity (1,300 W) is shown in Fig. 12 and is used as an aural or visual amplifier employing the type 8792 tube. The Gates VHF television transmitters employ solid-state circuitry to control and indicate the status of all vital points in the system.

The prime objective in designing a solid-state control circuit was to eliminate the use of electro-mechanical relays in logic-performing functions. It was felt that relays used in this manner tend to be unreliable and troublesome to maintain. In addition, to perform the functions necessary in the control of a large system, a large number of relays are required, which in turn not only increases the chance of failure but increases the size of the control circuits as well. Some of the features of each control circuit include filament warm-up time-delay, air pressure interlocks, overload cycling, automatic reactivation with AC failures, and automatic high-voltage removal in any power amplifier which has had three overloads.

The four basic digital logic circuits elements employed are the AND gate, the OR gate, the binary and the monostable multivibrator. The two types of gates replace the usual series-wired relay contacts, while the binary replaces the usual latching relay. To illustrate the basic operation of these circuits, three operational sequences are described in Figs. 13 through 15.



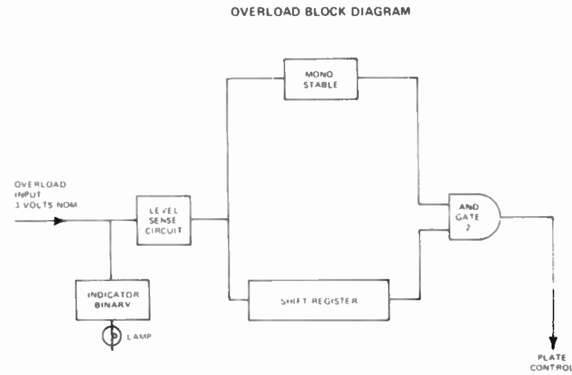


Fig. 14

Transmitter Turn-On: Fig. 13 illustrates the basic turn-on circuitry. A momentary input pulse, provided by the front panel filament-on pushbutton, changes the state of the filament and blower binaries. This action starts the blower and applies a positive logic level at one input of AND gate 1. When air pressure is adequate, a positive logic level is applied to the other input of the gate. With both inputs positive, the output of the gate goes positive, turning on the filaments and starting a time delay.

At anytime, the plate-on pushbutton can be depressed. The state of the plate binary changes immediately to the positive logic level. But if the time delay has not elapsed, anode voltage cannot be applied. If the plate-on pushbutton has been pushed and the time delay has elapsed, both inputs of AND gate 2 will be in the positive state and anode voltage will be applied.

The use of solid-state circuits for controlling Gates television transmitters have yielded a number of benefits to the customer. The first is increased reliability; no relays are used to perform logic functions. Second, reduction in the physical size of control circuits helps to decrease the total size of the system. Third, the simplification of inter-cabinet wiring makes initial system installation less difficult and, later, system maintenance much easier. Fourth, flexibility is enhanced. Fifth, future remote control is easily interfaced.

CBS Color Corrector for Encoded Video Signals

Frank Davidoff
Senior Engineer
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One of the most important characteristics of a color television program is its color balance. Color balance, as we all know, relates to the characteristic of the neutral gray which is obtained when the three color channels of television equipment have equal signal amplitudes. For a live program when pictures are obtained by television cameras, color balance is influenced by the scene illumination, the objects being televised, the spectral characteristics of the camera optical channels and the individual electrical channel adjustments. Generally, for a given studio and camera, the color balance is maintained by the electrical adjustments.

In the case of a film camera chain, the same factors exist as for the live camera. Here, the scene illumination and the object being televised correspond to the projector lamp and film, respectively. The color balance of the film is probably the major characteristic which may vary from program to program. Again, the color balance of the film camera is normally controlled by the electrical adjustments of the individual color channels.

In a third major source of color programs, the video tape recorder, there is no way to adjust color balance. The characteristics of the output signal are essentially those of the input signal and the color balance cannot be altered. The same situation becomes true for programs from both live and film cameras, for once the signals are encoded their color balance can no longer be modified.

In practical day-to-day programming there has been a definite need for a technique that permits modification of the color balance and other chroma characteristics of an encoded color signal. CBS has developed a new Color Corrector unit, which satisfies this need. This unit is simple, reliable and does not add noise to the program or degrade it in any other way. The unit can be used to make all segments of complex programs appear uniform and homogeneous, regardless of whether color differences in the segments have been caused by uncontrollable scene conditions, improperly adjusted equipment, or almost any other reason.

APPLICATIONS

Some of the applications for which the Color Corrector has already been found useful and others for which it is expected to be of great assistance are listed below:

1. News films frequently must be exposed under improper and uncontrollable lighting. Exposure conditions are often very far from ideal. These factors frequently result in wide variations in the color balance of television news film.

2. Frequently, in the production of a composite program, film and video tape segments which have originated at different locations and sources must be spliced together. With present practices it is almost inevitable that major color balance differences will frequently exist between such segments.

3. Outdoor programs, such as a golf match, frequently have scenes which are randomly exposed to sunshine or shadow. The color balances resulting from these two conditions are quite different. It is not practical to readjust cameras during the program to correct for these differences.

4. Films which have been exposed on different days will have noticeable differences in color balance, although the same film stock has been used in the same studio and exposed by the same camera.

5. The colorimetry characteristics of several television cameras may differ slightly. Color changes may be noticeable when switches are made between cameras during a given show.

COLOR CORRECTOR CONCEPTS

One basic concept of the CBS Color Corrector unit is that the program signal is not divided and processed. Instead, correction signals are derived from the program material and are then added back to it. This approach provides a stable zero correction condition and permits accurate calibration of the degree of correction introduced. It also permits a relatively simple circuit approach, not requiring a highly precise or highly stable design.

A second design concept is to provide the same type of black level and gain controls for the three color channels, as are found in a live or film camera chain. In addition to duplicating these functions, the Color Corrector provides the negative or complementary functions of each of the above controls. Additionally, several modes of operation are provided so that extremely versatile performance can be obtained for almost any situation.

Operation of the Color Corrector equipment is normally done by a skilled operator viewing the program signal on a properly adjusted picture monitor. He makes a subjective judgment of the picture characteristics and then adjust the controls to "paint" the picture he desires. In a manual mode of operation, the correction controls are left as adjusted and the corrected program leaves the unit for distribution. Alternatively, correction data in form of a digital code may be stored in an appropriate device and subsequently used for automatic correction of the program. In this latter mode, when a program is assembled from several segments, each of which requires a different correction, the entire process may be completely automated.

DESIGN PRINCIPLES

The Color Corrector unit modifies only the chroma components of the encoded program signal. No corrections or changes are made to the luminance. An analysis of luminance errors and their corrections must start with a fundamental question, "What caused the need to correct the signal?" Answers to this question will generally fall into two categories. One category will be the electrical misadjustments or malfunctions in the original transmission equipment or system. The

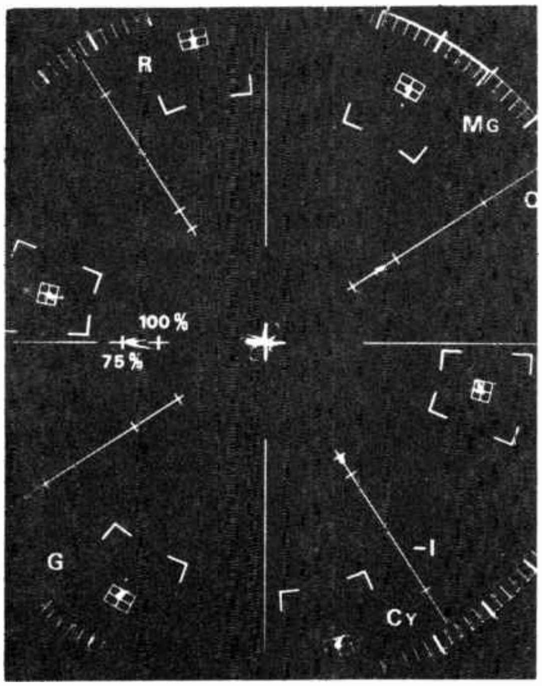


Fig. 1

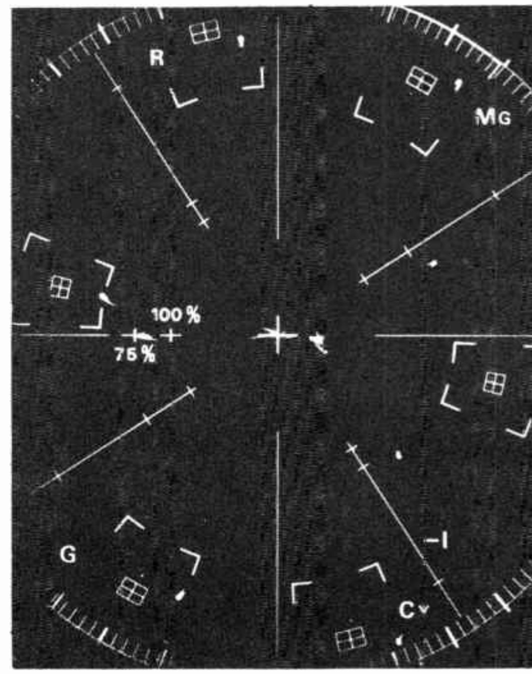


Fig. 2

second category will be abnormalities in the original scene which can produce displeasing effects even though equipment and transmission are ideal.

Consideration of the first group shows that the luminance correction required will be very dependent upon the cause of the original error. If the error was caused by misadjustment of a three-tube camera, then, theoretically, a luminance correction should be made whenever the chroma is corrected. If, however, the program signal originated from a four-tube camera, then no luminance modification would be called for. Similarly, some types of encoder misadjustments in the program origination will require chrominance changes without any change to the luminance component.

Errors in the second category depend almost wholly on subjective judgment. Since luminance corrections would be established quite separately from those of chrominance, there is little reason for automatically including a luminance component with a color correction. The above considerations have resulted in our decision not to include any luminance corrections in the present equipment.

The Color Corrector unit contains three black level controls, one for each of the primary colors. Black level correction of a color channel is obtained by merely adding to the program a sine wave of subcarrier having the proper amplitude and phase. This correction signal is added to all picture components of the program signal. To see the validity of this type of correction, consider the result of misadjustment of the black level control of a single color channel in a television camera. Misadjustment of this control will cause an undesired sine wave of subcarrier to be present on the program. The Color Corrector merely adds to the program a sine wave of the proper amplitude and phase to cancel the undesired subcarrier.

The Color Corrector equipment provides two modes of operation for black level, called "lin" and "log." These can be best explained by showing how a color-bar vector display is modified by a black level correction. Fig. 1 shows a normal color-bar vector display. In Fig. 2, we have added a blue-black level correction. Notice that all vectors have moved uniformly to the right in the blue direction. This is the "lin" mode, where every picture component has been given a uniform shift.

In pictures which originate from a typical live camera chain, the electrical signal in the channel amplifier generally passes through a gamma circuit which stretches black and compresses white. A black level error in the adjustment of this channel

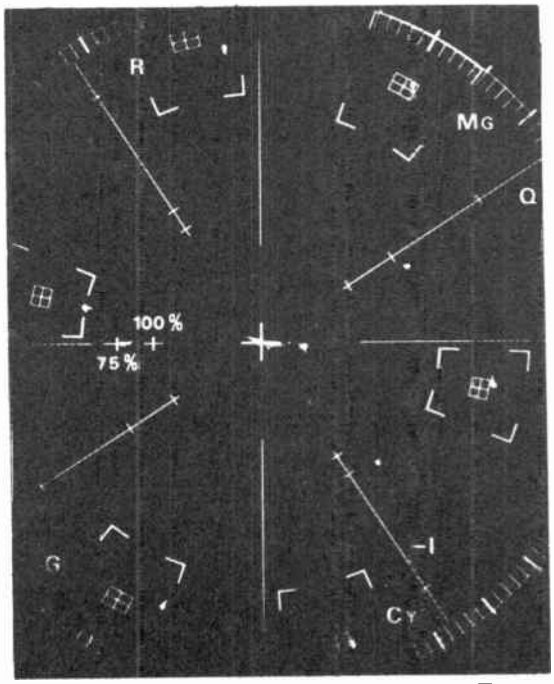


Fig. 3

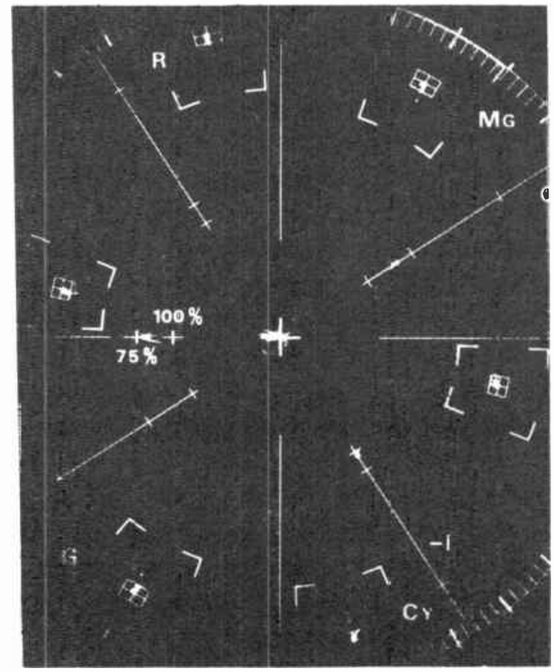


Fig. 4

would result in less subcarrier at the white level than at the black level. To correct this nonlinear type of error, the Color Corrector equipment contains a "log" mode of operation. The correction signal added by the black level control follows a logarithmic curve so that for that channel only, less error signal is introduced at highlights then at lowlights. This can be seen in Fig. 3 where the blue vector (a highlight) has moved less than the red and green vectors, and less than the zero point corresponding to black.

A color gain correction to an encoded video signal requires a different approach than that used for black level. A color gain correction is accomplished by adding to the program a signal in which the phase has the desired hue and the amplitude is proportional to the instantaneous amplitude of the hue component. To derive the required correction information, it is necessary to decode the program signal. The decoded channel output is then used to control modulation of a regenerated subcarrier. The modulator output is the desired correction signal. There is no need for great precision in decoding and remodulating. Since the correction signal is a second-order component, minor errors in its amplitude or phase are not important.

The Color Corrector equipment provides two modes of operation of the gain controls. The first mode is called "color balance"; in this mode the gain correction is proportional to the total program signal of the color channel. This means that both luminance and chroma components of the channel signal will influence a correction vector. In the other mode, called "colorimetry," the correction vector is proportional only to the chroma component of the channel signal. This means that any gray areas in the picture will not have any correction added to them; the original white balance is not altered. In other than gray areas, the correction will be proportional only to the chroma component and will not be influenced by the luminance component. The effect of these different modes on a color-bar signal may be seen on the next group of vector displays. Fig. 4 shows a normal color-bar display on a vectorscope. Fig. 5 shows a blue gain correction in the color balance mode. Notice that all the vectors which have a blue component are increased in amplitude. Also, notice two dots to the right of the center which indicate that a blue chroma component has been added to the previously neutral 75 and 100% white bars of the color-bar signal. Fig. 6 shows the same correction in the colorimetry position. Here the white bars have

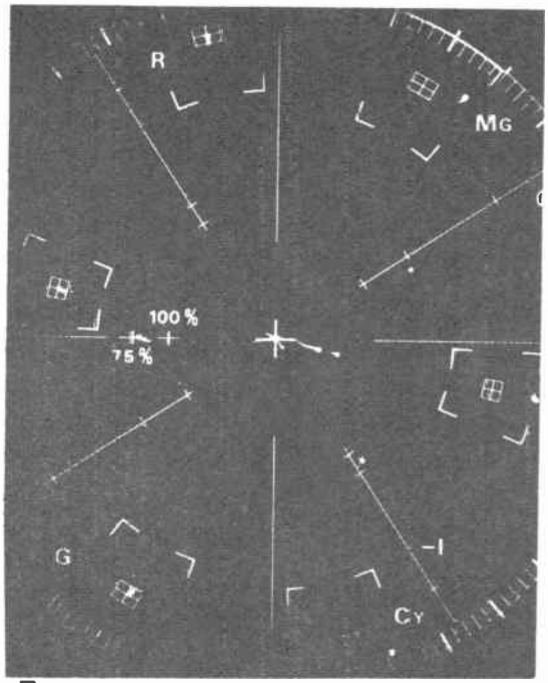


Fig. 5

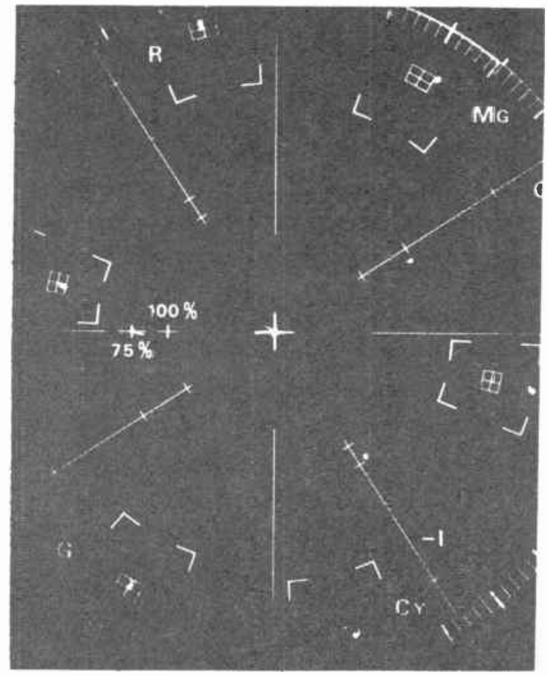


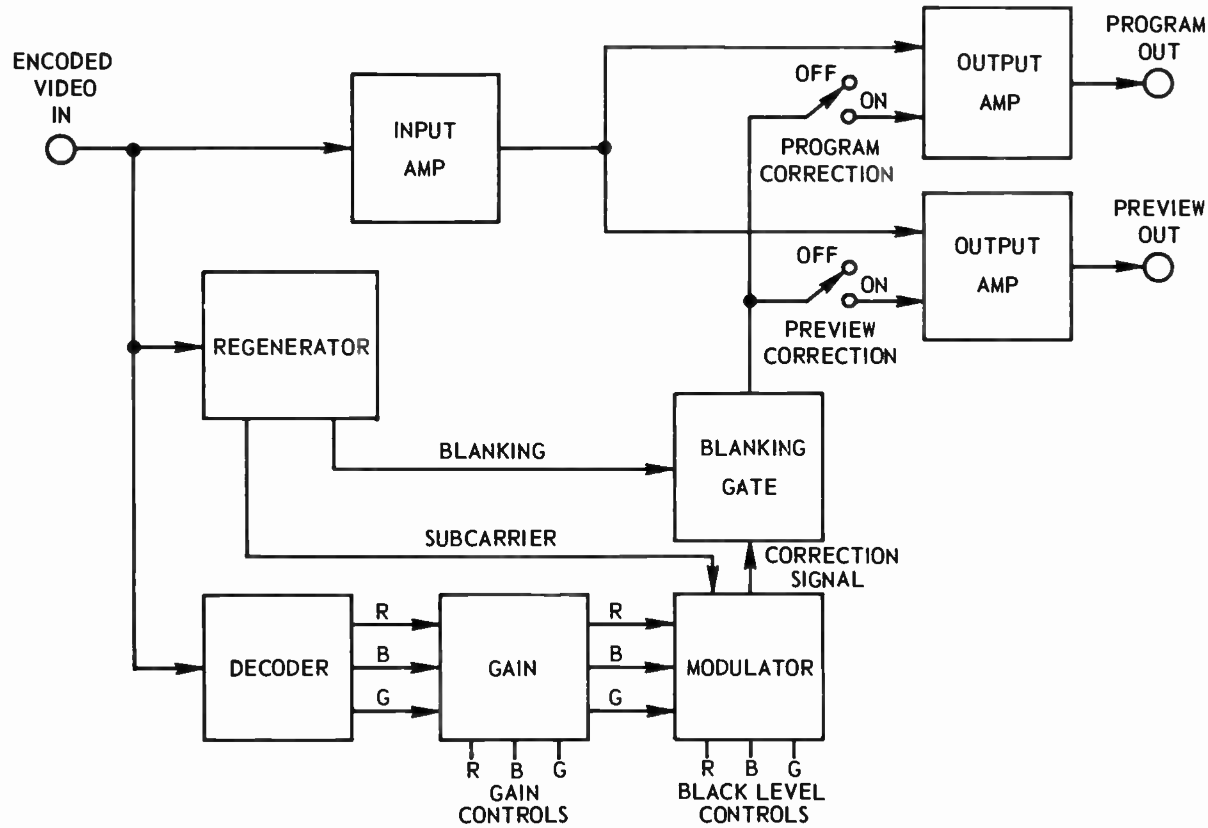
Fig. 6

not had any chroma added to them and there are no dots near the zero chroma point. The motion of the vectors with blue components is less, since the correction is proportional only to the chroma component.

The equipment also possesses a chroma gain control which may be used for minor adjustment of the chroma signal level. Another feature of the equipment are gamma correction controls which may be used in the color balance mode of operation. These controls permit the gamma characteristics of the red and green components to be adjusted with respect to that of the green signal.

Fig. 7 is a simplified block diagram of the CBS Color Corrector unit. An encoded video signal (upper left of the diagram) is applied via an input amplifier to two separate output amplifiers. One of these feeds the program line and other a preview line. The video signal input is also applied to a regenerator block where blanking and subcarrier signals are regenerated for internal use in the equipment. The video input also drives a decoder block which provides decoded red, blue and green channel outputs. These latter signals are applied to the gain block which consists of three independent gain control stages. These stages are arranged so that when the gain control is at mid position, there is zero output. Turning the gain control clockwise results in a positive signal component with an amplitude proportional to the amount of rotation. Turning the gain control counterclockwise puts out a negative signal component. In this way, it is possible to obtain both the desired channel signal or its complement. The red, blue and green channel signals, at a level set by the gain controls, enter the modulator block where they modulate the regenerated subcarrier to form a correction signal.

Black level correction is obtained by unbalancing the appropriate modulator to secure sine waves of the desired amplitude and phase. The individual gain and black level correction components are mixed together and leave the modulator as one correction signal output. The correction signal passes through a blanking gate so that no correction signal will be present during horizontal and vertical blanking. In this way, the sync pulses and color bursts of the program signal will be completely unaffected. The correction signal is then applied through two independent on-off switches to the program and preview output amplifiers. These switches are required for practical operation of the equipment.

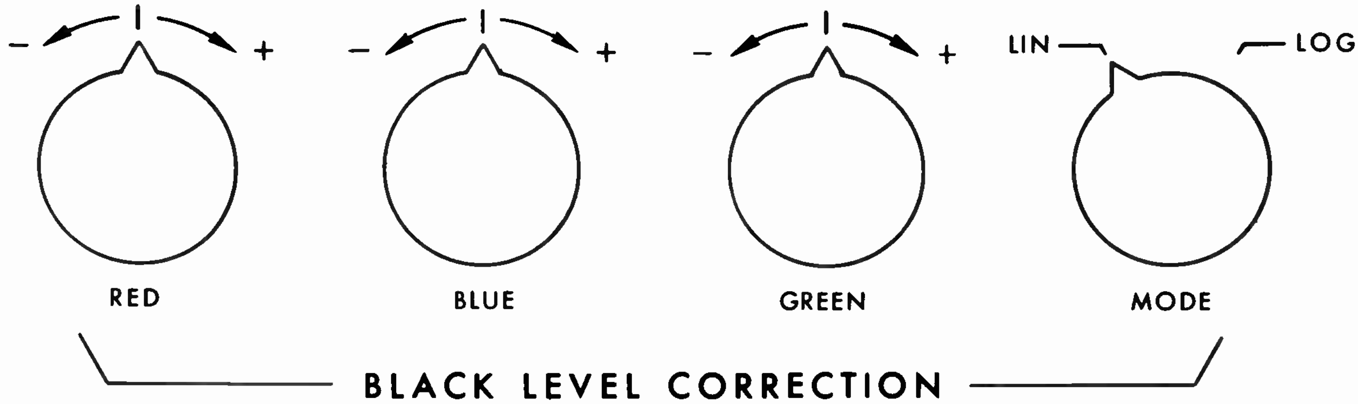


BLOCK DIAGRAM - CBS COLOR CORRECTOR

OPERATION

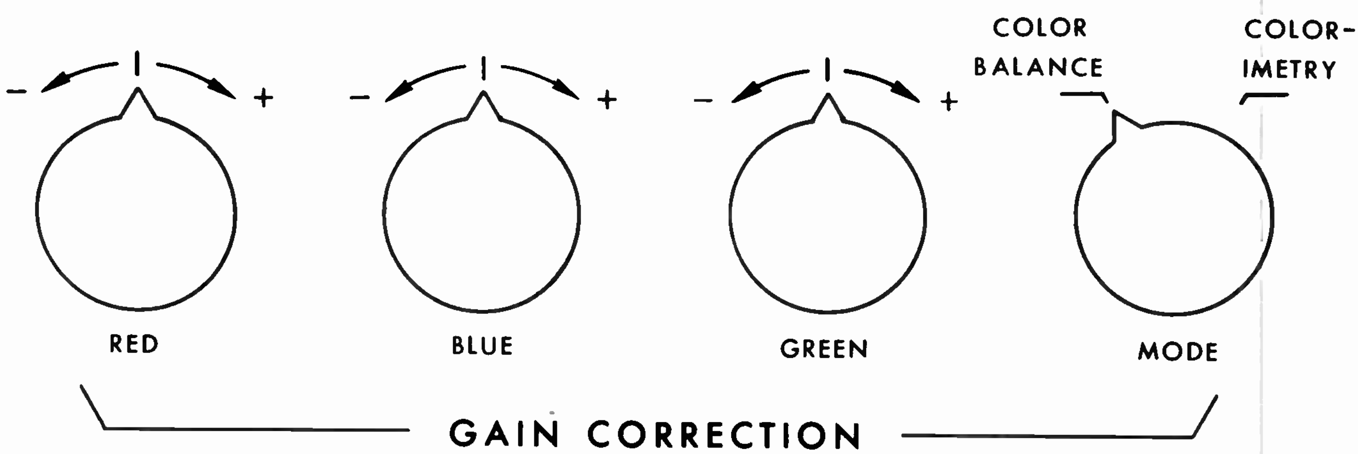
Operation of the Color Corrector equipment in a practical situation must almost always be done subjectively. Therefore, it is essential to have a standard, properly adjusted color picture monitor which will accurately display both the need for color corrections and the corrected pictures. The first choice an operator must make is to decide whether a picture needs black level or gain correction. This is not as easy a choice as it might seem, because the initial overall impression of a correction, to some extent seems the same, regardless of whether the black level or gain control has been used. However, a study of different areas of the picture will generally show whether a uniform change in lowlights or highlights is required, thus calling for black level, or whether a gain change, which would affect the highlights much more than the lowlights, is required. The operator must then decide which correction mode to use and again the picture details must be studied to make this decision.

Fig. 8 is a functional diagram of the black level correction controls available to the operator. Notice that three zero-center controls labelled red, blue and green are provided. The center position provides zero correction. Turning the red control clockwise in the plus direction adds a black level correction whose amplitude is proportional to the rotation of the control. Turning the control in the counterclockwise or minus direction would add a minus red or cyan black level correction. We have found that operators vary the black level controls to suit their subjective judgment and then switch between the lin and log modes to see which they prefer. Having decided on the mode, they will generally readjust the black level controls to some extent.



FUNCTIONAL DIAGRAM
BLACK LEVEL CONTROLS

Fig. 8



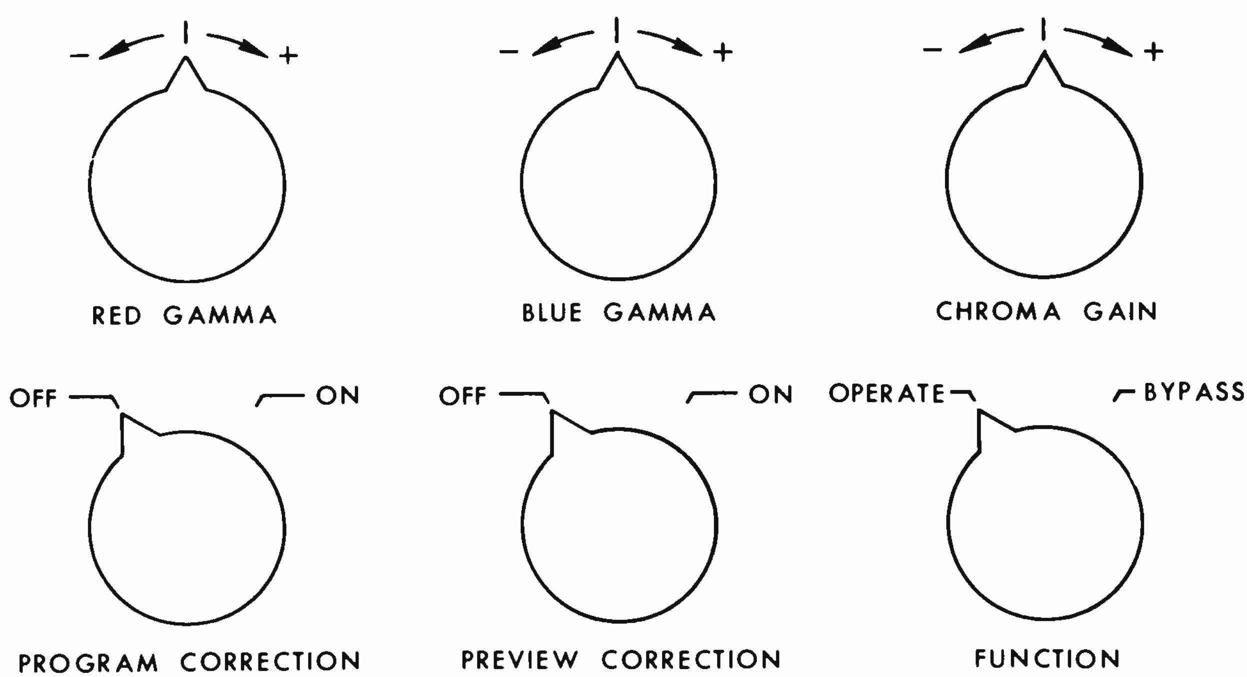
FUNCTIONAL DIAGRAM

Fig. 9

GAIN CONTROLS

Fig. 9 is a functional diagram of the gain correction controls available to the operator. Again, the three red, blue and green knobs are zero-center controls and function in a manner similar to the black level controls previously described. The choice of operating mode depends very greatly on the nature of the program signal errors. If the gray areas of the program are not truly neutral, then the color balance mode is preferred, since this will correct the gray-scale balance. However, if the signal does have proper grays, the Colorimetry mode may be more appropriate. One example of the use of the Colorimetry mode would be to compensate for the slight colorimetric differences, which may exist among a group of cameras in a studio.

Fig. 10 is a functional diagram showing various other controls. The gamma tracking and chroma gain controls operate only in the color balance gain control mode, but will be useful in many situations. The controls in the lower row marked "program correction off-on" and "preview correction off-on" are very important operating controls. It is almost always desired to preview a corrected picture before it is applied to the program line. With these controls, an operator puts the program correction switch in the off position and the preview correction switch in the on position. The correction controls are now adjusted to obtain a satisfactory picture on the preview picture monitor. The operator can at any time obtain an A-B comparison of the corrected versus the uncorrected picture by operating his preview correction control between the on and off positions. When the correction to the picture is satisfactory, it may then be added to the program line by placing the program correction switch to the on position. The correction is added to or deleted from the program without any transients or disturbances.



FUNCTIONAL DIAGRAM - MISCELLANEOUS CONTROLS

Fig. 10

After the various black level and gain controls have been adjusted for a particular correction, they may be left in this position and immediate use may be made of the corrected program. An alternative mode of operation is to transmit data defining the setting of the controls via auxiliary equipment to a storage device. At any subsequent time, the stored data may be sent back to the color corrector equipment so that the correction will be added automatically. With this technique it will be possible to automate the correction of many different program segments without any time interval between them, using the previously established subjective judgments which have been stored in the memory device.

Another type of operation may be called instantaneous correction. This situation occurs when remote programs must be distributed in real time and it is not possible to either preview or store the signal. In this case, corrections must be decided on and made instantaneously. This type of operation is practical with a skilled operator who knows the limits and effects of the various controls. Corrections must be introduced gradually so that no abrupt discontinuities will be observed by the television viewer.

The CBS Color Corrector is a new device which allows color differences in encoded television signals to be corrected or modified. This equipment can theoretically correct many different types of color variations. However, it has been found that, subjectively, it can improve almost any type of program having a color deficiency. The probable explanation is that most television scenes have one center of interest. If a viewer is satisfied with the color characteristics of this center of interest, he will very frequently accept or adapt to other areas which may be distorted. It is expected that this new Color Corrector equipment will be a major step in achieving the goal of uniform and pleasing color television pictures at the home receiver.

The Color Corrector was developed as a joint project of the CBS Television Network and CBS Laboratories Divisions. We would like to acknowledge the major contributions made by Renville H. McMann of CBS Laboratories, co-inventor of this device, and Clyde Smith also of CBS Laboratories, who designed the production version.

The Role of the Video Tape Recorder In Automated & Computer-Controlled Operations

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Automation in various degrees is very much a fact of life in broadcasting today, and any designer of equipment for the broadcasting industry must understand why automation is attractive and how equipment is to be used in an automated environment. First, why is it attractive? One major factor enhancing automation is the shortage of skilled personnel. Even though the designer of an automation system must have exceptional skills, people who operate the system can be less skilled than ordinarily would be required to perform the tasks, and few such people are required.

In this last statement lies the meat of the problem confronting the designer of equipment. Because fewer skilled people are available in an automated environment, equipment must be very reliable, be very simple to load and operate, require little set up or very simple set up, it must be as automatic as possible within its self, and, of course, it must interface readily with computer equipment. Additionally, the new equipment must overcome the shortcomings of older equipment it replaces.

These were precisely the goals we set for ourselves as we set out to design two new television tape systems, the AVR-1 reel-to-reel recorder and the ACR-25 cassette recorder. I'd like to discuss with you how we met the goals and what this means in operational flexibility. The two units were planned as a total system, and this should be obvious as we examine them.

Let us bear firmly in mind the fact that magnetic tape has been a miracle agent for television, and that with few exceptions it is technically of a very high quality. Let us also be honest and admit that several technical problems as well as several operational problems do exist on present recorders. Let's look first at the technical problems and this will lead us into the operational ones.

With the exception of the VR-3000 portable recorder, no reel-to-reel quadruplex recorder employs a constant tape tension system. In this highly sophisticated television age this lack causes interchangeability problems which manifest themselves as hue shift and saturation errors. This lack, therefore, was one of the technical problems we set out to solve. After all, our goal is to require no adjustment of controls by an operator, and one way to accomplish this is to make perfect recordings.

Tension control can best be accomplished through the use of vacuum columns to isolate the reels from the tape path and then by controlling carefully the reel drive motors. We have a great deal of experience with this sort of tape handling in our Videofile systems and our computer transports. We have made liberal use of this experience, and you will notice that both the AVR-1 and ACR-25 use vacuum systems. The ACR-25 goes one step farther and uses vacuum to draw tape from the cassette and thread the transport. Vacuum is also used to hold the tape against the capstan in both units, thus doing away with pinch rollers and attendant guiding problems. Tension is held constant within a few percent.

A printed-circuit capstan motor is used along with high torque reel motors so the tape may be accelerated briskly. Because of the isolating effects of the vacuum columns the tape near the video and audio heads is accelerated very quickly, and the reels catch up a fraction of a second later. As a result, we get an added bonus of quick starts. In the ready mode, both the AVR-1 and ACR-25 will be fully synchronously locked in 200 milliseconds. The advantages and opportunities here are obvious.

Control track problems are all too common on present equipment because of poor set up or maintenance, so here again we made every effort on the AVR-1 and ACR-25 to fulfill our basic goal that the recorders made perfect recordings and be able to play back anything. Monitoring, while recording of the control track with a built-in scope, allows easy level adjustment of the record amplifier. Tracking on playback is automatic, and in fact for emergency use a control track is not even needed. A penalty in lock up time (up to three seconds) is paid, but a tape that presently cannot be salvaged can be played with ease on an AVR-1. One less reason for having a highly skilled operator with each VTR!

Another similar area where errors can occur is the matter of high-band, low-band standards selection on playback. The manual controls are there if you prefer to drive your own Rolls Royce, but automatic sensors can select the proper playback standard in a fraction of a second. Another reason a skilled operator is not needed.

The other automatic features we now take for granted; Amtec, Colortec, Auto-Chroma, and Velocity Compensator are still in the AVR-1 and ACR-25, but in much improved form. The entire time-base stabilization and processing operation is now accomplished in a single system we call the "video buffer." The buffer uses entirely new techniques for stabilization in which binarily arranged delay lines are switched in and out of the signal path, thereby allowing a correction range of plus or minus 32 microseconds. There is not a single control on this entire unit. No need for a skilled operator here! Bearing in mind the plus or minus 32 microsecond correction capability of the buffer, it should be obvious that an intersync servo is not needed. A simple tone wheel servo holds the pk-pk head wheel error to under two microseconds.

Video processing consists of adding new sync and burst, for there is only one mode of operation, fully synchronous! This fact, together with the wide correction range of the buffer and the ability to move the tape near the heads quickly, allows us to solve a long standing operational problem of how to handle wild switches. During a non-synchronous switch the head rephases rapidly, and the tape is quickly positioned correctly longitudinally. On playback the same thing occurs within 200 milliseconds with no interruption to sync because new sync is always added. A circuit is provided for fading the output signal to black during the momentary disruption of video. No receiver or monitor rolls will be caused by the wild switch.

A battle has waged for some time over the merits of band-by-band versus line-by-line auto-chroma devices. No one argues their necessity, just how best to do it. Both ways have merit and compliment each other, so we have used both methods to achieve all the advantages of both. Velocity compensation is achieved by simpler techniques than now used, but performance and reliability of the newer unit are still as high as ever. With both auto-chroma and velocity compensator installed, there is certainly one more reason a skilled operator is not needed.

Now to the matter of set-up. Even if the operator is not highly skilled, we firmly believe he should be able to set the machine up quickly and accurately without the need for outside test equipment. Video heads can be optimized easily with the now familiar VHO, which incidentally was developed on this project and was an early fall out to the VR-2000 and VR-1200. For audio optimization, built-in test oscillators, meters, and scope are provided so that level and equalization can be set quickly and accurately.

When the Mark XX video head was designed, one of the requirements laid down was that it must be designed for automatic threading of tape. Accordingly, the vacuum guide was made to retract completely out of the way, and the Mark XX head is used on both the AVR-1 and the automatic loading ACR-25.

We must admit that earlier tape recorders grew over the years by the addition of new accessories and that controls were not always conveniently grouped. They are all in one convenient area on the AVR-1. Every adjustment is available from the front of the console, and this includes air and vacuum controls.

The controls are uniquely designed for use with automation. All adjustable controls are merely potentiometers connected across plus 12 volts. The adjustable arm supplies a DC control voltage to the circuit being adjusted. Grounding of the control wire adjusts the amplifier to unity gain or to a standard position. No signal circuits are brought to the control panels; therefore, the panels may be easily remoted up to distances of two hundred feet. Additionally, the use of DC control allows easy interface with computers through the use of digital-to-analog converters. The controls can be set by a pre-programmed computer to correct deficiencies in a tape, thus saving hurried, last minute adjustments. Yet another advantage is that by use of a time-shared digital system, along with suitable A-to-D and D-to-A converters, the controls can be operated over conventional telephone lines of any length. A VTR in Hollywood can be adjusted from New York.

So far what has been discussed is common to both the AVR-1 and ACR-25, but now let's look specifically at the ACR-25. One of the fundamentals of automation is that planned events be set up off-line out of real time and that the sometimes complex events can be performed later precisely as planned and that they be carried out flawlessly. A station break with its usually complicated switching sequences of several commercials and station ID's is a perfect place to employ automation. Present automation systems do the job smoothly, but they still can tie up a number of film units and VTR's for a single break.

The ACR-25 cassette VTR was designed especially to relieve this problem. Twenty-five cassettes, each capable of playing for up to six minutes, can be loaded and played continuously in a completely random fashion. The ACR-25 has a cycle time for shorter time cassettes of ten seconds, so this means twenty-five ten second spots can be played continuously without interruption. This remarkably low cycle time is accomplished by liberal use of air and vacuum systems to remove tape from the cassette, for threading, and for tension control of the tape during play modes.

Here is a machine designed from the ground up for an automated environment, yet let me hasten to add that it can be manually controlled or programmed to operate automatically and form an island of automation within a sea of manual operation. The automatic features common to the AVR-1 and ACR-25 make operator attention minimal, and there should be little if any need for lengthy leaders on commercials and other tapes so that the machines can be manually tweaked up.

There is a paradox in automation, yet it need not be unduly troublesome if it is recognized and planned for. As automatic features are added to a device, the system becomes more complex. If a failure does occur, troubleshooting is likely to require a very high level of skill. Several things can be done, fortunately to alleviate the situation. Basic design of the system should be sound so that reliability is very high. Integrated circuits, if properly used, can be of great help, for by their very nature of being more readily available in digital form, they have forced us to change our design concepts completely. Analog circuits, such as a frequency discriminator with all of its DC drift problem, can now be replaced with digital circuits in many cases. Our frequency discriminator is now a counter which simply counts how many cycles we are off frequency. On both the AVR-1 and ACR-25, IC's have been used extensively and wisely.

Tests points abound, and it is relatively easy by use of built-in monitoring and a lab scope to isolate the fault down to a plug-in module or a group of modules. Once this point is reached by the use of relatively unskilled technicians, the faulty modules can be removed and serviced by the few skilled and well equipped men available. Spare modules can be used to keep equipment running while faulty modules are repaired.

Not too many are vitally interested in the international aspects of the AVR-1, but for those of you who are interested, let me stress that the equipment was designed for maximum performance on the much more difficult international 625/50 PAL color system. Switching to 625 PAL or SECAM can be accomplished by pushing a button. By adjusting links on a transformer, operation can be had on power line voltages from 105 to 250 volts, 50 or 60 Hz.

There it is. There is our approach to the automated environment of today where we must all adapt to new methods and learn new techniques or face the prospect of being obsolete relics by the time we are forty. We have tried to design for the times, and I think that in general we have been succesful. I think the equipment I have discussed is a practical, reliable extension of the state-of-the-art.

An Engineering Approach To Studio Lighting

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With the advent of color television in the late 1950s, a whole new area of television was opened. This area was studio lighting. From the early days of black-and-white television until the late 1950s, studio lighting was more or less thought of as a necessary evil that was required to get an acceptable picture on the screen. As color television became more and more widespread, it was found that the early methods of lighting were inadequate for the newly established requirements of color television. For the first time, a new term "Kelvin temperature" became part of the vocabulary of television lighting. Lighting levels also changed and for the most part were multiplied 2 to 5 times their former levels to get an acceptable picture.

As color became more widespread, the lighting requirements became more and more complex and required much more time and effort than was previously thought necessary. The importance of a qualified lighting director became very apparent as color television programming became more and more production oriented.

In many non-network television stations, a lighting director was not on the staff, so the responsibility for studio lighting was given to the chief engineer. This paper is designed for this type of station where a full-time lighting director is not on the staff. By breaking the various laws of lighting down into engineering terms and using basic geometry and mathematics, engineering personnel will be able to do the routine day-to-day lighting that is required. This paper is not intended to make anyone into a lighting director, but it is intended to give sufficient information so that an engineer can know the basic lighting techniques.

TYPES OF FIXTURES

There are basically six special types of light that are required to light the average television set. Each one of these special lights is discussed in detail.

Key Light

The key light or spotlight is the main apparent source of illumination on your set. It is the job of this light to make your subject or subjects stand out from the background. It is this light that highlights or "keys" the subject and draws viewer attention to the subject. A key light must have the following characteristics in order to be an effective key light.

1. Control: Since this is the main apparent source of illumination, the output of this light must be controllable so that unwanted spill light can be avoided by the use of barn doors. The barn door is an accessory that is slipped onto the front of the spotlight that can be used to control this unwanted spill. For most television applications, a set of barn doors would have four leafs or shutters allowing the light beam to be controlled in all four directions.

2. Soft edge: The key light should ideally have a soft edge. By soft edge, it is meant that the light pattern of the unit does not have an abrupt cut-off but tends instead to disappear gradually around the edge of the pattern. This is important because on many sets more than one key light is used and if the units had a hard edge or a distinct cut-off, the overlap would be readily apparent.

3. Harsh shadow: Since it is the key light's main function to highlight the subject, the light must by definition be a harsh light which will key and highlight certain features of the subject. Harsh shadow is a term used to describe the shadow that this light throws on the background.

4. Focusing: A key light must be capable of adjusting its beam from wide to narrow with a corresponding change in foot-candle level so that the exact coverage and/or intensity can be realized without the necessity of moving the fixture. The quality of the light output from the unit should not appreciably change when going from wide to narrow beam coverage. In other words, the light should still exhibit the controllable feature, soft edge feature, and harsh shadow feature, no matter in what focus position the unit is used.

One of the single most important characteristics of the key light is its control. No matter how efficient a fixture may be, if the light is not completely controllable, it is almost totally useless. Take, for example, boom shadow problems. If the key light was not controllable, boom shadow could become a major problem in set lighting. The most versatile fixture for key lighting is the quartz iodine Fresnel spotlight. These units are available in sizes from a 6-inch 750-watt unit up to a 20-inch 10,000-watt unit. The exact size and wattage of the fixture depends upon the individual station's requirements.

Back Light

Another very important fixture in the television studio is the back light. The back light is a fixture that is often not properly applied or overlooked completely. The main function of the back light is to separate the individual subjects from the background and give them depth and dimension. Without the use of a properly applied back light, the television picture has a very flat, dull appearance. The back light has the following characteristics:

1. Control: The back light must be every bit as controllable as the key light. This control is very important in keeping the back light flare out of the camera lens. The exact position of the back light and how it is used is discussed in another section of this paper.

2. Soft edge: As in the key light, the back light fixture must exhibit a soft edge for the previously mentioned reasons.

3. Harsh shadow: Again, the same note applied to shadow factor on the back light as does the key light.

4. Focusing: The focusing feature in many ways is more important in the back light than in the key light. This is true because of the variety of subjects that must be properly backlit. For example, a subject with dark hair must be backlit differently than a subject with light or blonde hair.

As in the case of the key light, the universally used fixture in studios is the Fresnel spotlight. As a rule, the intensity of back lighting required is 1/2 to 1/3 of the intensity of your key light. Therefore, the size of the back light is normally smaller than that of the key light. Most back lights range in size from 750-watt 6-inch units to 2,000-watt 12-inch units, with the 8-inch 1,000-watt unit being the most widely used.

Base Lighting

Base lighting is the third type of light that is required to light a television set. It is the job of the base light to establish the ambient light level on a television set. It is this ambient or base level that brings up the entire set area to a usable intensity. The base light has the following characteristics:

1. Non-controllable: Due to the fact that the base light should cover a very large area as evenly as possible, the unit should have a very large apparent source. Because of this large apparent source, the light is very uncontrollable by design. As a rule, the more uncontrollable the light, the better its quality for smoothness.

2. Soft edge: Since a number of base lights are normally required for set lighting, the units must exhibit a very soft edge so that these multiple lights can be easily blended.

3. Soft shadow: A base light must, by design and application, be a very soft source of illumination. In contrast to the key light with its harsh shadow, the base light should produce very soft shadows which do not detract from the picture and cause background shadows. The shadows cast by the base light should be undistinguishable on the background.

4. Focusing: The ideal base light is a unit that can have its coverage as well as intensity continuously adjustable by merely turning a small lever or crank. This allows the user maximum flexibility and ease in setting up his lighting levels.

The scoop is the most widely used form of base lighting. Scoops using quartz lamps are currently available in wattages from 500 to 2,000 watts. These units are from 14-inches to 18-inches in diameter and are generally available in both a focusing and non-focusing versions.

Fill Light

A fill light is used in studio lighting to mask the "mistakes" created by the individual doing the lighting. It is the job of the fill light to cover up and fill the shadows created by the key light. In addition, the fill light can be used to improve the subject's appearance by use of soft, direct lighting. The characteristics of the fill light are identical to that of the base light and, in fact, the terms fill and base are used interchangeably. A fill light properly positioned can also serve to act as a base light and, conversely, a properly applied base light can also be used as a fill light. Again, the most commonly used fixture for fill lighting is the scoop.

The four lights previously discussed and mentioned make up the bulk of the units required to properly light a television set. As can be seen, only two basic fixtures, the Fresnel spotlight and the scoop (flood light) are required to light a set. In order to completely describe all of the lighting required, we must discuss set- Cyclorama-lighting and effect lighting.

Set Lights

Set lights are fixtures that are designed primarily to bring up the background levels to blend in with the overall set or mood. These lights are very specialized fixtures which are designed to smoothly light a wall or backdrop. Cyclorama lights, on the other hand, are lights that are designed to light a background curtain or cyc. With the use of gelatine and other plastic materials, the Cyclorama curtains can be "colored" through the use of these special Cyclorama lights previously described. These units can be wired and controlled to produce 2, 3 or 4 individual colors on the curtain. With the use of dimmers, these colors can be blended to give any one of many possible shades and tints.

EFFECTS LIGHTING

Effects lighting mainly concerns itself with shining a pattern or design on the background to add variety or interest to the picture. The light normally used for this pattern projection is a Leko, or ellipsoidal spotlight.

FIXTURE LOCATIONS

Now that the various types of studio fixtures have been discussed in detail, how do we apply them? For most basic lighting requirements, the triangular approach is used. If the back light is directly behind the subject and the camera directly facing the subject, the key light is placed to one side of the subject and the base/fill light is placed an equal distance to the other side of the subject. If a line is drawn from each light toward the subject, they would intersect at the subject and form a 3-legged open triangle.

There is no steadfast rule as to which side the key light is on; that is left up to the individual doing the lighting. In some instances, the subject may be more easily lit from one side or the other.

In order to be effective, the back light should be 45° to 60° above the horizon behind the subject. In this way, any unwanted shadows created by the back light will fall out of the camera area. The subject should be at least three feet from this back wall for proper separation of the light. By having the light at this high angle, direct radiation into the camera is substantially reduced.

The key light, on the other hand, should be 45° above the horizon. This angle was chosen for two reasons: By using 45°, the subject can look straight ahead at the camera without the direct radiation of the light into his eyes; and secondly, the light is not so high that it creates unwanted shadows under the nose and chin. The base/fill light is normally from eye level to a maximum of 30° above the horizon. This lower angle is required to ensure that the shadows created by the key light are adequately filled by this base light. In many applications, a pantograph or scissors hanger is used with the fill light so that its exact vertical height can be set upon application. Many studios use some sort of base/fill light on movable stands so that low-level fill lighting can easily be accomplished.

The lighting levels that are required are set up by the particular camera that you are using. The ratio of the various lights is important to your overall picture quality. For a starting point, if your base and fill light is given a numerical value of 1, your key light could have a value anywhere from 2 to 3 with your back light having a value of from 1-1/2 to 2. In other words, with a base light of 100 f.c., the key light should be set for 300 f.c. and the back light for 150 f.c. The exact ratio depends upon experience, subject matter, and the effects desired. It must be emphasized that these rules are only for starting purposes.

So far, our discussion has concerned the most basic type of setup which is the one camera, one subject set. As more subjects and cameras are added, so are the lighting requirements increased. Generally speaking, each subject should have his own key light and back light. In addition, there are many instances when the subject must be key lit and back lit from two separate lights because of multiple camera angles. Again, the basic triangle method of lighting can be utilized.

With the advent of color television, the term "Kelvin temperature" has appeared in our vocabulary. What is Kelvin temperature? Is it as critical as some people say? Why not use longer life, lower Kelvin temperature lamps in place of higher Kelvin temperature, short life lamps? By definition, Kelvin temperature is the actual absolute temperature at which the filament of the lamp is burning. 3200° Kelvin (abbreviated °K) means that the tungsten filament is actually heated to a centigrade temperature approximately 3000°. This corresponding temperature produces a certain "temperature" of light. The higher the Kelvin temperature, the bluer (cooler) the light; the lower the Kelvin temperature, the redder (warmer) the light. By coolness and warmness, light color quality and not centigrade temperature is understood.

Modern color cameras are normally designed to be used with 3200°K lamps. The cameras can be re-balanced for any Kelvin temperature within reason. The reason that 3200°K is used is the fact that this Kelvin temperature is a good balance between high output and long life.

Kelvin temperature is analogous to amplifier class of operation; the higher the Kelvin the higher the lumen output (efficiency), the lower the Kelvin temperature, the lower the lumen output (efficiency). For example, a 1,000-watt 3200°K lamp will put out 27,000 lumens, whereas the same lamp designed for 3,000°K will put out 21,000 lumens, a decrease in lamp output of 22%. Even though both lamps will draw 1,000 watts of AC power and produce 1,000 watts of thermal heat, the 3200°K lamp being more efficient will give you 22% more foot candle under identical circumstances. Most cameras on the market today will tolerate a Kelvin shift of 100° without a noticeable shift in quality.

Since Kelvin temperature is so important to color television, why use dimming systems which control not only the intensity of light but the Kelvin temperature as well? There are many reasons that dimmers are desirable for color television. The first reason is that with the use of dimmers, effects lighting such as fade-outs and subtle background changes can be easily be realized. In addition, Cyclorama coloring can easily be changed through the use of dimming. If the key and fill lights are kept more or less at their full setting, much can be done with the background and set illumination without altering the overall quality of the picture.

In summary, it must be stated that lighting techniques evolve from a series of experiments and applications. The "rules" discussed are only intended to be a starting point.

JCIC Ad Hoc Committee on Color TV
A Status Report

K. Blair Benson, Chairman

In September 1968, under the auspices of EIA, IEEE, NAB, and SMPTE, the Ad Hoc Color Television Study Committee was organized to investigate the objectionable variations in hue and saturation encountered on the home receiver, and to pinpoint the system elements contributing to the problem. At this time last year at the NAB Engineering Conference in Washington, organization of the Committee, and the various avenues of investigation being initiated was outlined. During the ensuing twelve months studies have been, and are continuing to be conducted, into all phases of broadcasting from televising of the original scene or film, through the recording and reproduction equipment, the transmission system, the transmitter and propagation path, and lastly the home receiver.

These detailed investigations are being carried out by a series of subcommittees, whose findings then serve as the basis for recommendations of further, in-depth study and action by standing committees of the four sponsoring organizations; in cases where an appropriate committee has not been in existence, a recommendation has been made for assignment of a special committee for the necessary coverage of the subject.

I would like to review the progress which has been made by the Ad Hoc subcommittee, and by committees under the sponsoring societies and associations. Of the latter, the very important work of the Electronic Industries Association's Broadcast Television System Committee will be reported on as a part of this presentation by the Chairman, Mr. B. D. Loughlin. However, before introducing Mr. Loughlin, first I will cover progress in the other activities under way.

COLORIMETRY STUDY

Under the chairmanship of Mr. E. P. Bertero of the NBC Television Network Engineering Department, a study has been conducted of the effect upon picture reproduction by variations in colorimetry component characteristics. Using a relatively complex mathematical model, a computer analysis was conducted of the color television system performance, and the resultant color fidelity of reproduction under varying conditions of scene lighting temperature, camera signal matrixing, receiver phosphors, and receiver adjustment.

A work of the subcommittee has been completed and reported in a paper presented at the SMPTE Winter Television Conference in Atlanta by Messrs. DeMarsh and Pinney of Eastman Kodak. Since their paper is published in the SMPTE Journal, I will not go into the detailed findings. Nevertheless, it is important to note that the mathematical system could be used by equipment manufacturers and broadcasters to design and to evaluate cameras. For example, the component characteristics from practical camera designs can be compared with the ideal "aim" system to determine the magnitude of hue and saturation errors in terms of "Just Noticeable Difference" units. The analysis techniques and data have been turned over to an SMPTE

Committee, also under Mr. Bertero, for development of procedures which can be used by operating personnel to assure the day-to-day uniformity of color rendition.

TRANSMISSION STUDY

Equally important has been the findings in a transmission field test held in Chicago in April. Data was gathered from test signal transmissions over three transmitters to eight antennas and tuners, two at each of four different receiving locations. Analysis of the data is only partially completed; an interim report on the results was given at the IEEE meeting in Washington on September 19 by Mr. Morrison of RCA, Chairman of the Subcommittee which conducted the tests. Suffice it to say for this report that the portion of the television system from master control to the antenna terminals of home receivers makes a significant contribution to observed changes in hue and saturation. Undoubtedly, for one the need for more elaborate and rigorous test and maintenance procedures is indicated. A full and final report, and recommendations of the Transmission Subcommittee, is scheduled to be completed later this month (April 1970).

VIDEO SIGNAL PROCESSING

Processing or stabilizing amplifiers provide a means for varying hue by adjusting the burst-to-chroma phase relationship, and saturation by adjusting the luma-to-chroma level ratio. In addition, regeneration of the burst can introduce changes in signal characteristics which in turn can result in variations in color decoding. Thus, improper use of such amplifiers can introduce significant errors in color reproduction. The problem has been referred to NAB which in turn set up a committee under Mr. R. L. Pointer of ABC to study the use of processing amplifiers and develop a set of recommended practices for their proper operation. To date, measurements have been completed on roughly 40% of the different types of processing amplifiers in general use today. The work of this committee is being undertaken in close co-ordination with EIA/BTS.

VIDEO TAPE EQUIPMENT

The performance of video tape recording equipment with variations in synchronizing signal characteristics is under study by a subcommittee of the SMPTE Video Tape Committee. Extensive measurements have been completed and are presently being reviewed by the VTR Committee. The preliminary data has been turned over to EIA/BTS for their review relative to signal specifications. A report and recommendations, if any are warranted, is expected from the VTR Committee in April (1970).

COLOR MONITOR AND RECEIVER COLOR BALANCE

The SMPTE has adopted D6500 as a Recommended Practice for the balance of control room color monitors. However, how to arrive at this adjustment has been a major stumbling block. A subcommittee of the SMPTE Television Committee is being organized with the charge to make recommendations for the means and methods of adjusting color monitors.

On the receiver front, Mr. D. Zwick of Eastman Kodak is arranging a display of color reproduction at various color temperatures. The aim is to demonstrate whether there is an advantage of D6500 balance over the 9300 K commonly used for the home receiver.

In the film area, two projects presently in the planning and organization stage will be of interest. The problem of variations in color film commercials, a specialized area of outstanding importance has been taken up by an industry group representing broadcasters, film laboratories, a film manufacturer, and advertising agencies. The direction of the effort is to prepare an instructive symposium to explain production, photographic processing, and color evaluation guidelines for those concerned with all phases of production for commercials. Presentations are planned to give explanations and graphic demonstrations of specified problems and how to correct them.

The presentation will be primarily visual involving 35mm film, 16mm film, slides, and video tape material. Explanations will be given by recognized experts, knowledgeablein all facets, in a manner which will avoid any highly technical interpretation.

Each half-day long presentation will be conducted for small groups, in the order of thirty people; thus each person will be able to see clearly every detail of the presentation. Hopefully the program can be repeated several times initially in New York, Chicago, Los Angeles and Toronto. The intent of the entire symposium is that the attendees can leave the presentation convinced that poor quality of color film commercials appearing on the television system can be avoided and they have been provided with the know-how necessary to assure a high degree of technical quality and uniformity.

Assistance in the setup and operation of telecine equipment for optimum reproduction of color film is being offered by Eastman Kodak. Field engineers, equipped with film and slide test material and color monitor calibrators, will be available on invitation to visit television stations in the U.S. and Canada and work with their engineering staffs in standardizing setup techniques.

Before closing I would like to commend the members of the Ad Hoc Committee as well as those of the other committees assisting in the study for their valuable and enthusiastic participation. In a year and a half, their efforts have prompted the initiation of a variety of in-depth studies, covering the full gamut of television system elements; and of equal importance, it has created an increased awareness of the problems by the industry and an impetus toward undertaking appropriate corrective actions. In short, concerted efforts promise to bring about a significant improvement in color quality for the home viewer.

Broadcast TV Systems Committee (BTS) Activities Report

B.D. Loughlin, Chairman

Early last year the JCIC Ad Hoc Color Television Study Committee asked the Broadcast Television Systems Committee of EIA to consider whether any changes in signal specifications were appropriate in order to assure better color uniformity. This was prompted by previous data collected by a JCIC Subcommittee which indicated that if signal parameters were varied between certain extremes of tolerances permitted within the FCC specifications, undesirable changes in color reproduction can result.

BTS has been very active studying many facets of this question over the past year. Some of the items under consideration include: the advisability of tightening up tolerances on sync and burst timing specifications; the possible need to specify a standard monitor and standard demodulator; and the possible need to update specifications regarding gamma, primaries, and reference white. But the problem considered to be of urgent priority is: How to assure during program transmission that the chrominance-to-luminance ratio is correct, and that the burst has the right phase and amplitude compared to chroma. According to present specifications, the tolerances on chroma-to-luma ratio and on the burst-to-chroma phase are defined on color bars which are not present during program transmission. Also the burst-to-chroma amplitude ratio, which is important for equipment using automatic chroma control, is defined in such a manner that if parameters do vary between permitted extremes, a wide variation in saturation is possible.

Early last year, BTS recognized a solution to this urgent problem by having an ever present color reference signal during the vertical interval. A subcommittee was set up to prepare a suitable specification for such a signal, and the proposed Vertical Interval Reference signal specification was circulated last summer (1969) to the JCIC Ad Hoc Committee for preliminary comments. As a result of feedback, particularly from the networks, a BTS subcommittee was re-established, this time with expanded membership including representatives from the three major U.S. networks, the CBC, and NAB to propose suitable modifications in format of the VIR signal so as to permit an early evaluation in preliminary network tests. A signal format for preliminary testing has been agreed to, and a signal generator, designed with adequate flexibility to permit a trial of variations in the proposed format, has been constructed and demonstrated.

One form of reference signal—specifically, the one currently planned to be used in starting field tests—is shown in Fig. 1. It contains chroma, luma, and black references. The signal is proposed for line 20 during the vertical interval on both fields, but tests on one field only are also planned. A chroma bar is superimposed on a 70-IRE unit level which has been chosen to be representative of skin-tone luminance. The bottom of the chroma bar is compared with the adjacent 50-IRE unit luma reference to confirm the chroma-to-luma ratio. The chroma reference is of the same phase and amplitude as the nominal burst and, therefore, can provide a ready reference for specifying the burst and for confirming that regenerated bursts from processing amplifiers are a proper reference for the phase and amplitude of chrominance. Additionally, it is currently considered necessary to include either a black or gray reference level in order to further confirm that the signal has been properly handled

A PROPOSED VIR SIGNAL

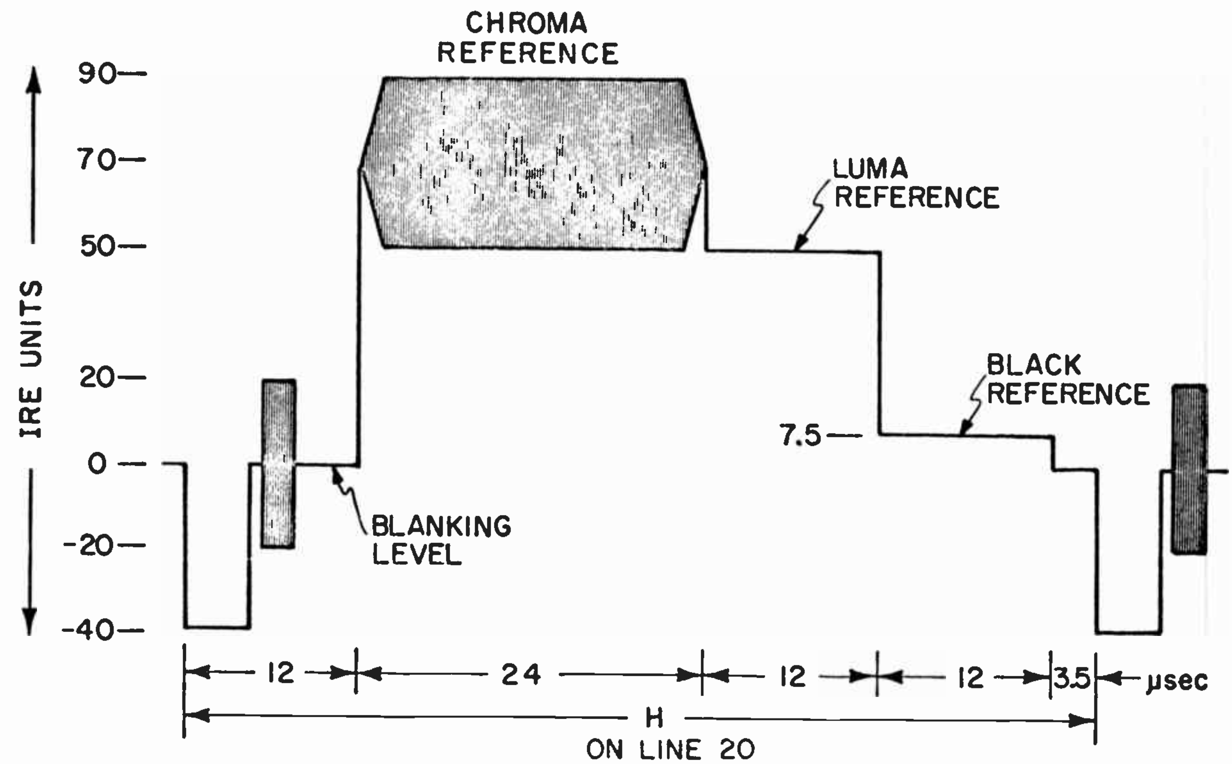

Fig. 1

by stabilizing and processing amplifiers.

It should be pointed out that success of the VIR signal implies that line 20 is treated like picture in passing through processing and stabilizing amplifiers. In some cases this may require a readjustment in processing amplifiers, specifically, a shortening of the blanking period so that line 20 is not treated as vertical blanking.

Each bar in the reference signal is wide enough to provide good visibility, freedom from edge transition and adequate energy for possible automatic correction equipment. In-plant tests using the vertical interval reference are already either in process or are planned at the central plants of the three major U.S. networks. These preliminary tests are proceeding by circulating the one existing VIR signal generator. Local on-the-air and also over-the-network tests are currently being planned by the BTS Field Test Subcommittee, under Eric Leyton as Chairman. Phase 1 of the field test will be local on-the-air tests which are planned to take place before this Spring. Phase 2 will be over-the-network tests which are planned to take place this summer (1970).

Further information and details of these tests will be circulated in the near future, including: time of tests, precise signal format, etc. Your cooperation will be requested by observing the VIR signal at various points in the TV system and by recording your observations. But before all of the details become available, we wanted to take this opportunity to notify NAB members ahead of time of the tests, and we hope you will plan to cooperate in these preliminary field tests.

Solving the Operational Problems of Live Color Cameras

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Color television cameras today are showing up at more places than ever before. The demands by the public, as well as the desire and necessity of the broadcaster to deliver live events, has increased the incidence of remote color telecasts greatly. With the increase has come an awareness by the viewer, as well as the broadcaster, of some real operating problems. It is my intent to discuss some of these inadequacies and to illustrate how they can be improved by a combination of operating techniques and modern engineering.

To begin, I will lead with a problem common to both studio and remote telecasts; that of color match between cameras. Because of variations in the pickup tubes and optics, the inherent color match between cameras is not always perfect. Even though high-quality, tight-tolerance optical components are used, the pickup tube variations make the odds on a close match less than a sure thing. For those camera users who strive for perfection, the past practice has been to gray-scale balance and then have a video operator "paint" the cameras in, using gain-type controls while observing a "color girl" or other reference, until the skin tones look good (in his estimation) and seem to match from camera to camera. Actually, what is achieved by this method is a fair match on flesh tones with no assurance of a match for other colors. A far better method, and one that has received much notoriety lately, is the use of three-channel color masking.

Unlike the single channel "red masking" or "red enhancement" often used to improve the deficiency in red response of the lead oxide pickup tube, this technique operates on all three color channels. It is possible, with this scheme, to apply different amounts of correction to different colors and achieve an overall improvement in color fidelity and, at the same time, leave gray-scale balance completely unaffected. By applying this masking, in conjunction with some type of known color reference of suitable design, it is possible to achieve an outstanding color match between cameras.

To better understand how this masking works, let's take a look at the mathematical expression for a masked green channel (see Fig. 1). In this expression the R, B, and G represent the red, blue and green signals uncorrected as they come from the camera; a and b are the masking coefficients and correspond to two of the controls on the masker unit and G' is the green output after masking. Now, on an all-white picture (Fig. 2) the values of R, B and G are all one, which corresponds to 100 IRE units of signal and the difference signals (G-R) and (G-B) go to zero. The masked green output G' is thus equal to the uncorrected green input G. Similar expressions apply to the red and blue channels (Fig. 3) and, as can be seen, these difference signals also go to zero on white, leaving the outputs unaffected. Therefore, since no correction is applied on white to any of the three signals, the white balance is preserved. Since this same argument applies to all the gray values between white and black, the gray scale balance is also preserved.

$$G' = G + a\,(G - R) + b\,(G - B)$$

WHERE R, B, and G are uncorrected camera signals

a and b are the masking coefficients

G' is the green output after masking

Fig. 1

$$G' = G + a\,(G - R) + b\,(G - B)$$

ON WHITE $R = 1$

$B = 1$

$G = 1$

SO $(G - R) = 0$

$(G - B) = 0$

THEREFORE

$$G' = G + a\,(0) + b\,(0)$$

OR $G' = G$

Fig. 2

$$R' = R + c\,(R - B) + d\,(R - G)$$

$$B' = B + e\,(B - G) + f\,(B - R)$$

ON WHITE $R = 1$
$B = 1$
$G = 1$

SO $(R - B) = 0$ $(R - G) = 0$
$(B - G) = 0$ $(B - R) = 0$

THEREFORE

$$R' = R$$

$$B' = B$$

Fig. 3

$$R' = R + c\,(R - B) + d\,(R - G)$$

$$R' = 75 + 0.1\,(75 - 10) + 0.1\,(75 - 15)$$

$$R' = 75 + 6.5 + 6.0$$

$$R' = 87.5$$

Fig. 4

$$G' = G + a\,(G - R) + b\,(G - B)$$

$$G' = 15 + 0.1\,(15 - 75) + 0.1\,(15 - 10)$$

$$G' = 15 - 6.0 + 0.5$$

$$G' = 9.5$$

Fig. 5

$$B' = B + e\,(B - G) + f\,(B - R)$$

$$B' = 10 + 0.1\,(10 - 15) + 0.1\,(10 - 75)$$

$$B' = 10 - 0.5 - 6.5$$

$$B' = 3$$

Fig. 6

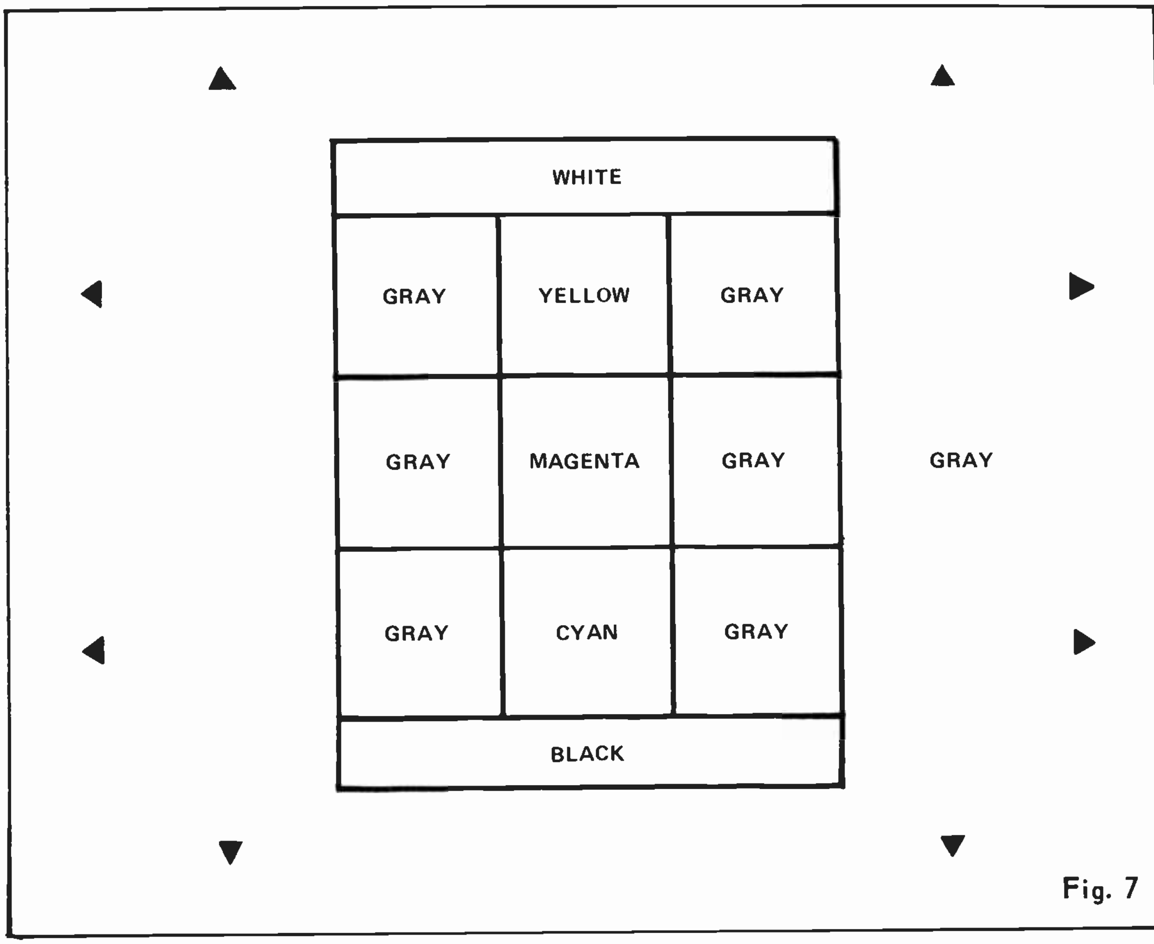


Fig. 7

Now, suppose the camera is viewing an orange-colored object. Let's see what happens in the masking process. For purposes of explanation, the orange in question has a red signal level of 75 IRE units, a green signal level of 15 IRE units and a blue signal level of 10 IRE units. Also, assume the masking coefficients are all set at 0.10 or 10 percent. In the red channel (Fig. 4) the result of masking is to increase the red signal from 75 IRE units to 87.5 IRE units. In the green channel (Fig. 5), the result is to decrease the green signal from 15 IRE units to 9.5 IRE units and, in the blue channel (Fig. 6), the result is to decrease the blue signal from 10 to 3 IRE units. In this case, two of the signals were decreased and one was increased. On other colors, the results will be different and depend on the amounts of red, blue and green that are in the subject material and how the masking coefficient controls are set.

The question may now arise as to how to properly set the six masking coefficient controls. Just a moment ago, I mentioned using a known color reference to achieve a good color match between cameras. The reference I was hinting at is a color chip chart (Fig. 7). This chart is designed for use with our new live color camera and it enables the operator to completely set up the masking amplifier without the use of a vectorscope or other external test gear. All that is required is the monochrome picture monitor which is built into the camera control unit. The design of the chart makes this simple procedure possible. As you can see, it contains the three color chips: yellow, cyan and magenta, but in addition there are 6 gray chips. These chips are built-in reference values and correspond to the correct signal levels that the three color channels of a camera should have on these three test colors. That is, by knowing the spectral response of the color chips, we have calculated the signal levels that the red, blue and green channels should have for each of these color chips.

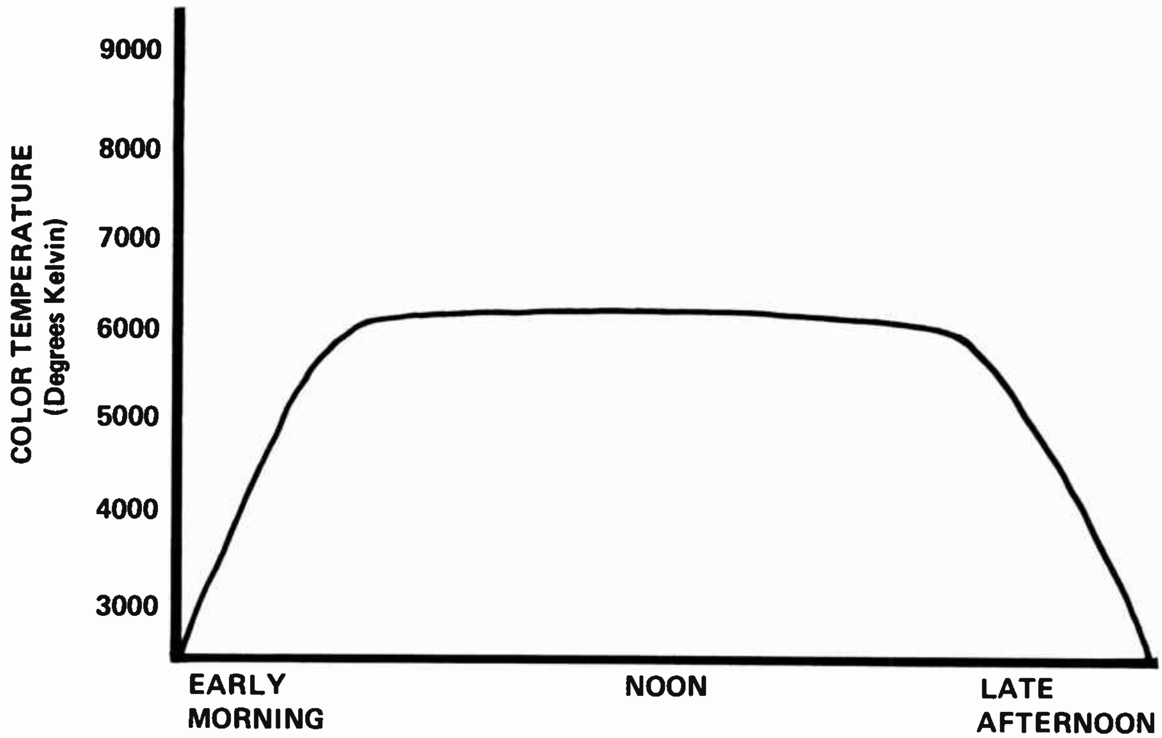


Fig. 8

COLOR TEMPERATURE – VS – TIME OF DAY

By observing the masked outputs of the color channels, the masking controls can then be set to make the signal levels equal the calculated values. These calculated values are represented by the gray chips. Matching the gray values of the color chips to the correct gray chips will, therefore, result in the camera having the calculated signal levels. What better way to match gray values than on a monochrome picture monitor? A look at the masked outputs of the color channels on the picture monitor will tell at a glance when the gray values are equal.

Using this procedure, the optimum masking coefficients for each particular camera will be obtained, since variations in tubes and optics are taken into account. Then, if all cameras are setup in this manner, all will have the best obtainable color fidelity and outstanding color match will result.

Another set of problems that has been complicating the life of the color camera operator are the extremes of lighting conditions. Although these extremes are usually confined to remote broadcasts where there is often little control of lighting, some pretty terrible things can also happen in the studio, as I will point out.

Probably one of the most frequent lighting problems on remotes is not enough foot-candles. In an indoor area which is not too large, this might not be a problem if enough light fixtures and power are available. But at night in a football stadium or baseball park, the situation is a bit more serious. Unfortunately, there is little the camera operator can do but open the iris and gain and hope the signal-to-noise is not too bad and the video level is not too low. This problem, in other words, is one for the camera manufacturer to work on; and we have. Our new camera, for example, incorporates preamplifiers with improved signal-to-noise characteristics, as well as some additional noise reduction techniques. This improvement in noise, along with up to 12 db of switchable reserve gain, results in high-quality, full-level pictures at light levels as low as 15 foot-candles. Performance like this, besides solving some of your existing problems, might also suggest some new possibilities for color remotes.

Still another lighting problem, this one found usually on outdoor daytime pickups, is color temperature variation. To gain a little insight into this problem, let's take a look at some figures (Fig. 8). On a typical clear, sunny day the color temperature of the light can vary from about 3000 degrees in the early morning to around 6500 degrees at high sun, and then back down to about 3000 degrees near sunset. On a partly cloudy day, when the clouds periodically interrupt the sun, the color temperature may jump from four or five thousand to as high as nine thousand. These variations act on the color camera to cause large fluctuations in the signal levels of the color channels and thereby disrupt the white balance. For example (Fig. 9), here is a camera white-balanced on 3200-degree light and subjected to color temperature changes up to 8000 degrees. As can be seen, the red signal level decreases by more than two-to-one and the blue signal increases by nearly two and a half to one. In this example, you will notice that the green level changes very little. This is because of the spectral shape of the green channel and because the luminance channel is used for the level reference for these measurements. That is, as the color temperature changes, the luminance signal level is kept at 100 percent by adjusting the iris. Doing this removes effects caused by intensity variations of the light. However, in order to operate with changing color temperatures, these signal level variations need to be minimized. This is accomplished by inserting color correction filters into the light path. If the filters are carefully selected, it doesn't take many to do a good job. We have found that five color-correction filters can hold the signal variations to less than 10 percent over the temperature range from about 3000 degrees to about 9000 degrees. Then, by using the built-in "paint pots," the remaining errors can be trimmed out and excellent white balance is maintained.

Color temperature problems can also be found in places illuminated with some of the newer lamps like mercury vapor, multi-vapor, deluxe white, and Lucalox. Fortunately, with these same filters and a little painting, excellent results have been obtained.

Finally there is a problem associated with lighting that has been tolerated by camera users for years. This is the inability of cameras to handle large contrast ratios which occur frequently and in many ways. One situation can occur when the object of interest in a scene is illuminated by several light levels which are greatly different. For example, a football field where part of the action is in direct sunlight and part is in shadows. The highlights in the sunlit area may be five or six times brighter than those in the shadows. If the camera exposure is set for the sunlit portion, then the shadow portion is so dark that most of the detail is lost. If the exposure is set for the shadow area, then the detail in the sunlit area is lost due to white clipping. The usual solution is to set the exposure high enough to get some of the detail in the shadows but not so high that excessive white clipping occurs on the sunlit portion; a poor compromise at best.

Another difficulty which occurs frequently involves skin tones and clothing. In this situation, the camera is viewing a person who is wearing some type of garment which has very high reflectance, relative to his skin. If the video operator exposes the camera so the skin tones look about right, then the clothing will be into the white clippers and detail in the clothing will be lost. But in this case, the operator usually

COLOR TEMPERATURE (Degrees Kelvin)	NORMALIZED SIGNAL LEVELS (Percent)		
	RED	GREEN	BLUE
3200	100	100	100
3600	88	102	123
4400	72	102	157
5400	61	100	191
6000	57	100	206
8000	47	96	243

Fig. 9

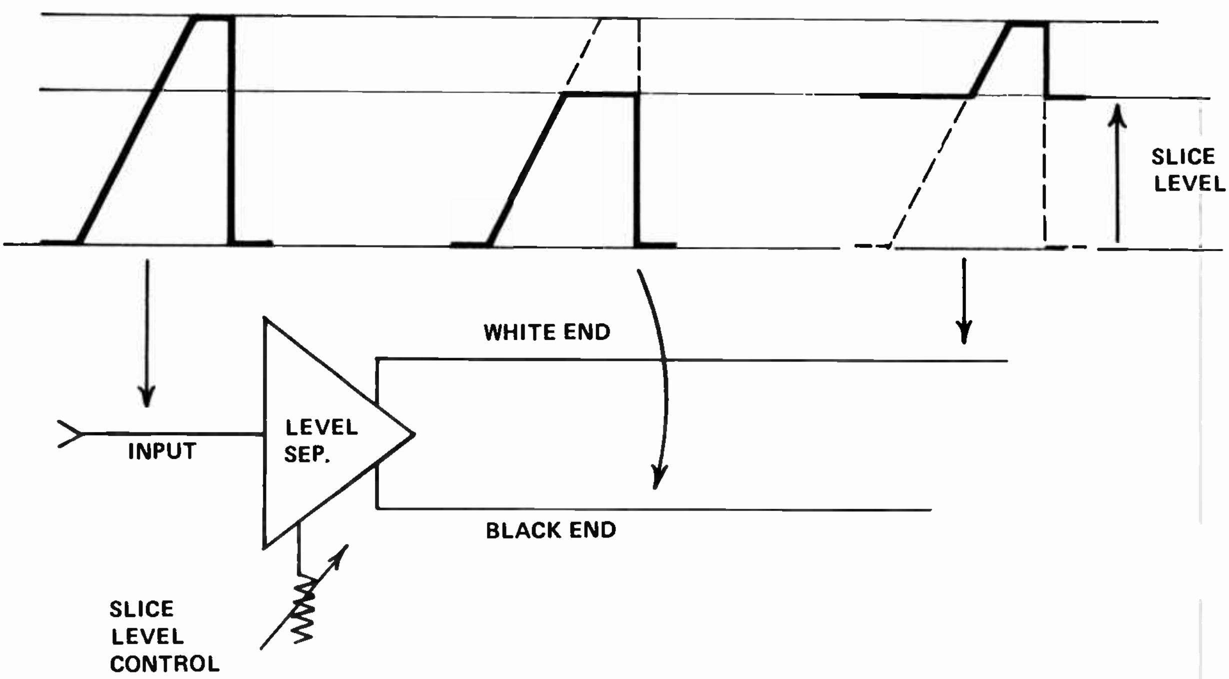


Fig. 10

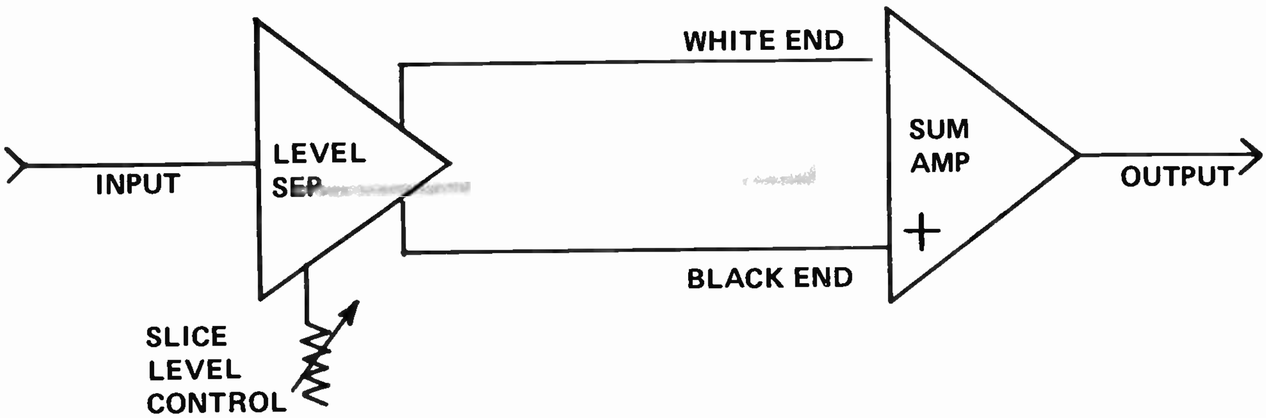

WHITE END
INPUT
LEVEL
SEP.
SUM
AMP
+
OUTPUT
BLACK END
SLICE
LEVEL
CONTROL

Fig. 11

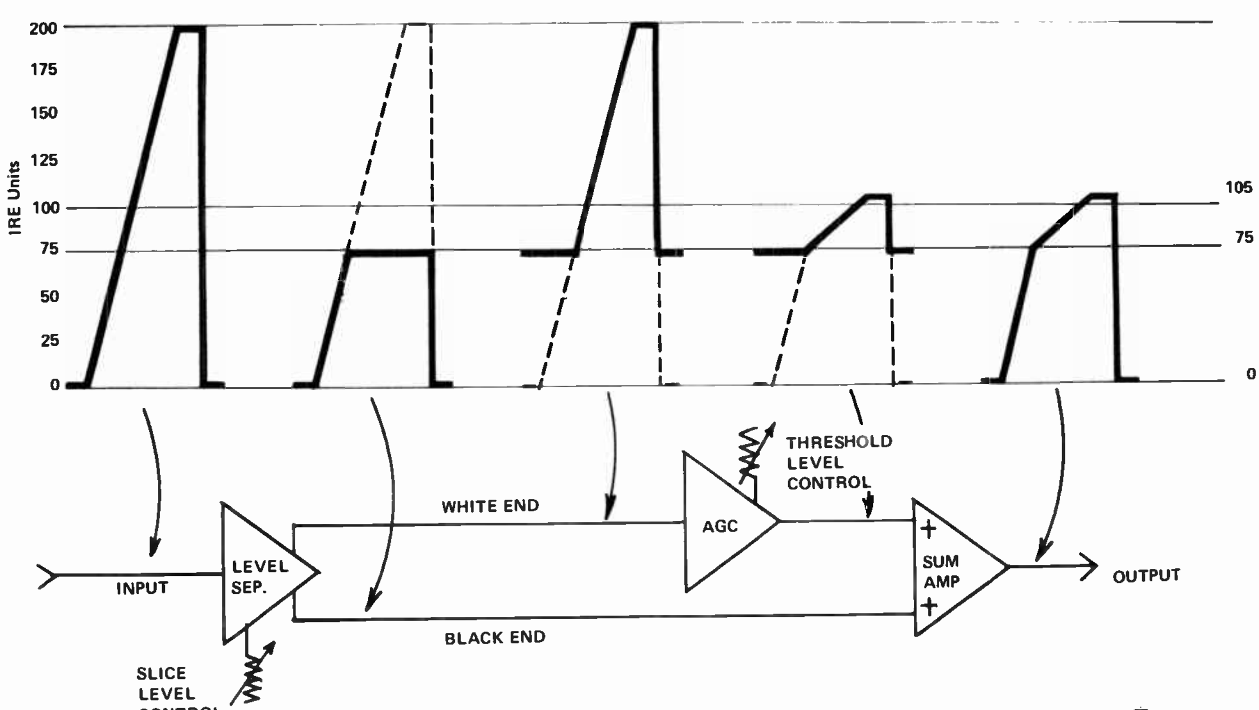

200
175
150
125
100
75
50
25
0
IRE Units
105
75
0
THRESHOLD
LEVEL
CONTROL
WHITE END
AGC
+
SUM
AMP
+
INPUT
LEVEL
SEP.
OUTPUT
BLACK END
SLICE
LEVEL
CONTROL

Fig. 12

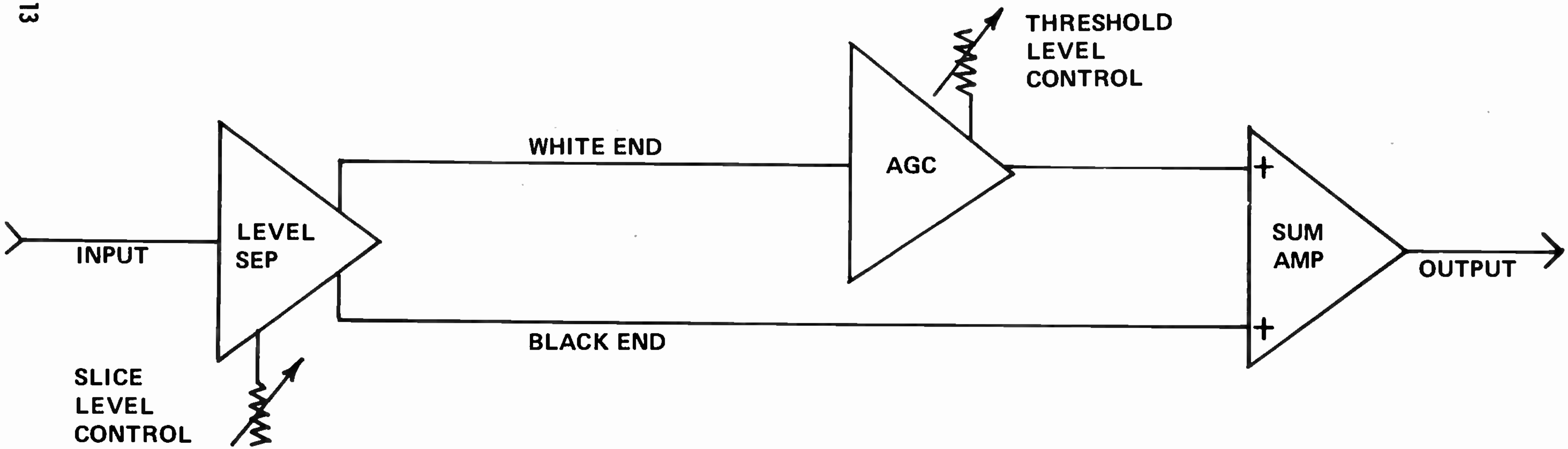

THRESHOLD
LEVEL
CONTROL
WHITE END
AGC
INPUT
LEVEL
SEP
SUM
AMP
OUTPUT
+
+
BLACK END
SLICE
LEVEL
CONTROL

Fig. 13

has little choice, since reducing the exposure will foul up the skin tones. He's stuck with white clipping the clothing. If the garment in question happened to be an expensive dress a star had obtained "just for the show," you can bet somebody will have some excuses to make.

These, then, are two examples of scenes with contrast ratios much too high for most color cameras to handle. I said most color cameras because now General Electric has one that will. It is the PE-400 with a newly developed automatic gain control system incorporated in each of the camera's four channels. The circuit is called Auto-Trast gain control and is outstanding because of its unique ability to handle the high contrast ratios while still retaining highlight details. The circuit can make scenes like those I just described as easy to handle as a well-lit chip chart. On the football field, for example, the exposure can be set for the shadow area and detail in the sunlit area will not be white clipped away. Or, with the bright clothing problem, the camera exposure can be set high enough to get good skin tones without fear of white clipping.

Let's look now at some waveforms and simplified block diagrams of the Auto-Trast gain control circuit (Fig.10). The input video signal is first fed to a level separator. Here it is divided into two components which, for clarity, I will call simply the white-end signal and the black-end signal. The level at which the separation takes place is called the "slice level" and is adjustable by the "slice level" control. It can be set for any level between 20 and 100 IRE units. If, for example, the control is set to 75 IRE units then only that portion of the input signal which is above 75 IRE units will come out of the white-end output. The remainder of the signal, all that below 75 IRE units, will come out of the black-end output (Fig.11). Now after separation, the black-end signal merely goes to a summing amplifier where the white-end signal will be re-added after it is processed (Fig.12). The white-end signal goes next to an automatic gain control circuit. This circuit operates like a conventional AGC. As long as the input signal to the AGC is below a certain level (called the threshold level) the AGC has a gain of one and the signal is unaltered. If the input signal increases above the threshold level, the gain of the circuit is reduced, proportionate to the increase, and the peak of the output signal is held to the threshold level. In this circuit, the threshold level is adjustable and can be set to any value between 90 and 130 IRE units. The output of the AGC circuit feeds the summing amplifier where the two signals are recombined.

Now, let's see how the circuit actually works (Fig.13). Assume the slice level is set at 75 IRE units, the threshold level at 105 IRE units, and there is a 100 IRE unit input signal. As you can see, the black-end signal is just that portion of the input signal below 75 IRE units and the white-end signal is that portion above 75 IRE units. The output of the AGC circuit is identical to its input since the signal does not reach the 105 IRE unit threshold level and no gain reduction is required. The summing amplifier output is, therefore, the same as the input signal, since nothing has been done but separation and recombination.

Suppose now, that the input signal doubles to 200 IRE units (Fig.14). As before, the separator output signals are just the portions of the input signal above and below the 75 IRE unit slice level. But, in this case, the AGC output is different. Since the input signal is well above the 105 IRE unit threshold level, the AGC has operated and reduced the signal level at its output so the peak is at 105 IRE units. Now, this reduced signal is recombined with black-end signal in the summing amplifier to form the output signal. As you can see, the input and the output signals are identical below 75 IRE units. Only the portion above 75 IRE units is distorted. This is an important point since herein lies the ability to AGC a scene without upsetting flesh tones. With these same control settings, take the example cited earlier of a girl wearing a highly reflective dress. The exposure can now be set so the girl's skin tones look

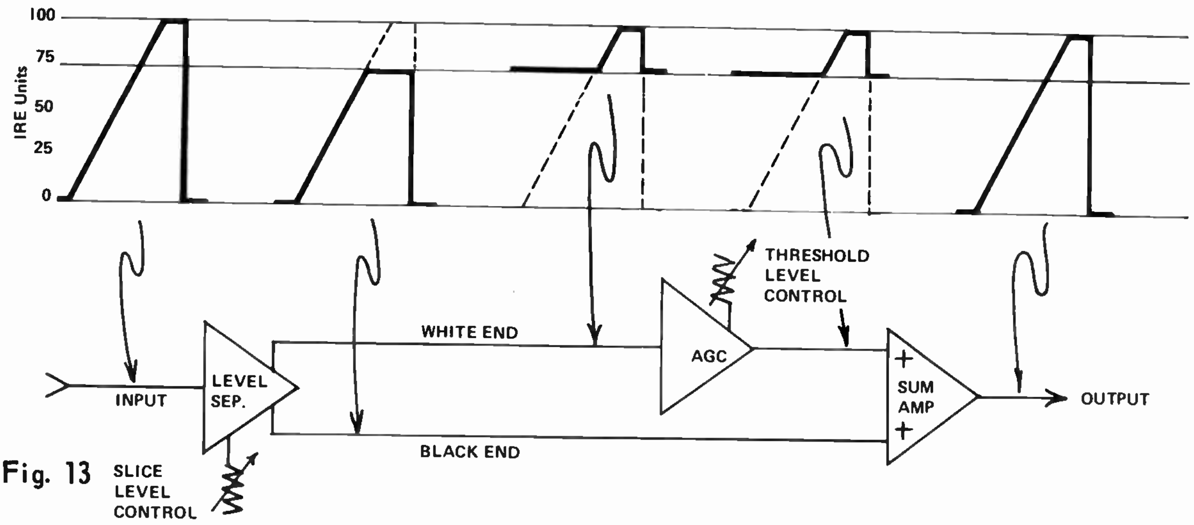


Fig. 13

right without white clipping the detail from the dress. This is so because the girl's skin will fall in the area below 75 IRE units and will not be affected by the AGC. The dress, on the other hand, will fall in the area above 75 IRE units and will be compressed into the area from 75 to 105 IRE units. The detail in the dress is, therefore, preserved, since no clipping occurs, while proper exposure for the flesh tones is achieved. The football field problem can also be improved considerably by using the Auto-Trast gain control circuit. With it, the exposure can be set to be more nearly correct for the shadowed portion of the field without white clipping the sunlit areas. The detail in the sunlight will be compressed and the result will be a much less abrupt transition between area of shadow and sunlight. These are just two examples of high contrast scenes which can be improved by the use of the Auto-Trast circuit. I'm sure that everyday camera users can think of many more.

These, then, are some operating problems with some solutions. To recap, we have seen how three-channel masking, adjusted while using a reference color test chart, can result in optimum color fidelity from each camera and excellent match between cameras; that good low-light-level performance requires low-noise preamplifiers and other noise reduction techniques; that in order to operate under conditions of varying color temperature, color correction filters and some gain trimming are necessary; and finally; that to make good color pictures on high contrast scenes, the General Electric Auto-Trast gain control circuit now becomes the new tool of the industry.

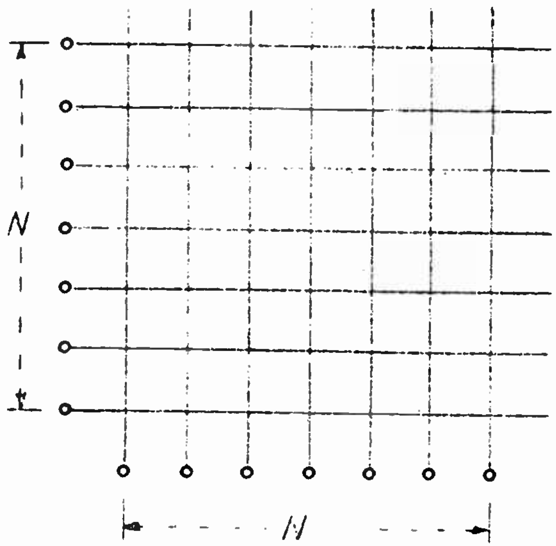
A Modular Digital-Controlled Routing Switcher

M. Berry
American Broadcasting Co.

The development and design of the ABC/Grass Valley Audio/Video/Machine Control Routing Switcher has been guided by two primary considerations. High performance in the form of minimal degradation of audio and video signals routed from two hundred sources to two hundred destinations, and easy maintainability in the form of a high mean time between failure and extreme system simplicity. The large size and expandability requirement of the system, from an initial 100 X 60 to a 200 X 200 configuration, without any down time, made the guidelines extremely restrictive as to the ultimate form of the switcher. There are an extremely large number of details associated with the design of a modern switcher that meets these stringent requirements. This paper deals with some of the considerations that led to the ultimate design, as well as a discussion of a number of user-oriented characteristics and some interesting control and mechanical developments.

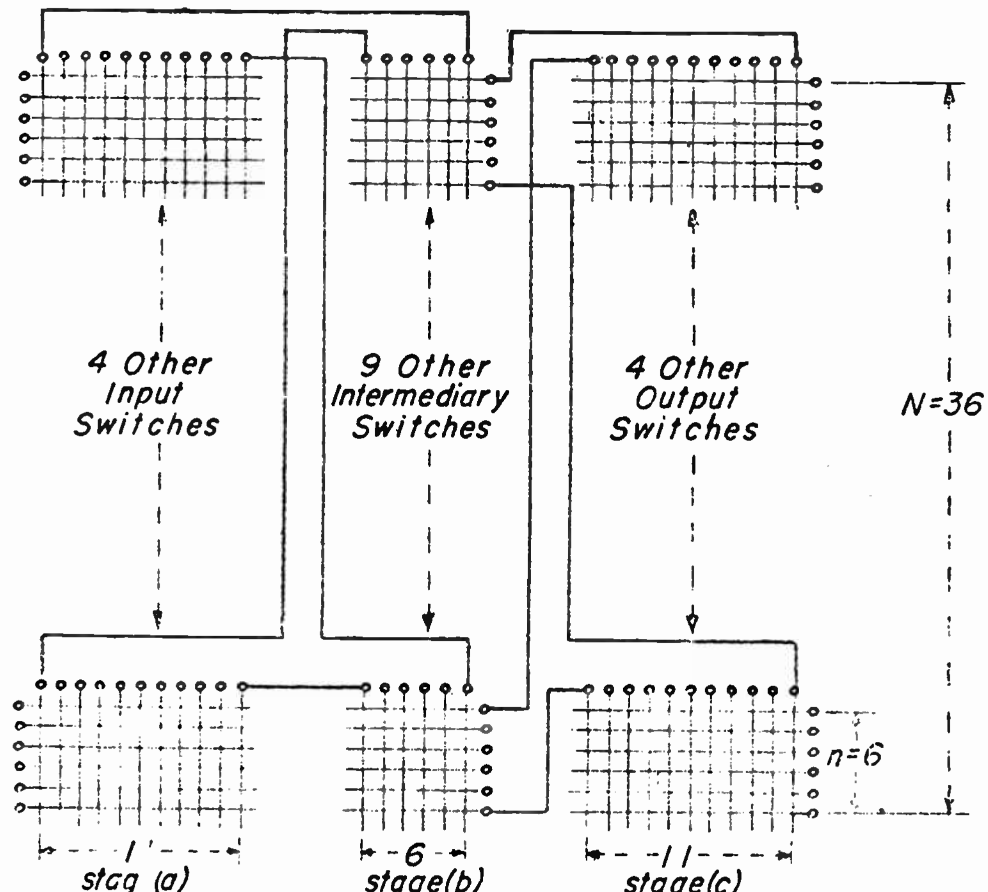
The number of crosspoints associated with a switcher of this size becomes monumental and certainly inspires careful consideration of crosspoint-reducing methods such as that reported by Bell Laboratories (C. Clos, A Study of Non-Blocking Switching Networks, Bell System Technical Journal; March, 1953) and others. A straightforward square matrix in the 200 X 200 size requires over 40,000 each of audio, video, and machine control crosspoints. A three-stage matrix as described by the Bell Laboratories article would only utilize approximately 17,000 crosspoints of each type. Fig. 1 shows the square matrix on the left which requires at least N^2 crosspoints. The qualification of "at least" comes from the methods required to reduce crosstalk from all sources to the single destination. Generally, this requires one additional crosspoint for each ten in the case of video. The same figure shows a simplification of a 36 X 36 switcher in the form of a three-stage matrix. In addition to the smaller number of crosspoints than the N^2 required on the left, we can see another interesting characteristic. Whereas in the square matrix there is only one path from a source to a destination, there are eleven paths involving thirty-three crosspoints potentially available for one source to reach one destination in the three-stage matrix. This presents a dilemma. On the one hand, failure of one crosspoint can be rapidly bypassed by switching to an alternate path without having to locate the fault. On the other hand, the control logic required to manipulate these paths becomes quite complex. In a specific study of our 200 X 200 configuration, although the 17,000 crosspoints required by the three-stage array is 40% of the square array, the rack space grew to 60% of the square array. In addition, the more complex routing of the three-stage array made it necessary to provide a dispatcher panel for control of the paths utilized and a typewriter readout for maintenance.

Fig. 1



Number of crosspoints = N^2

SQUARE ARRAY



Number of crosspoints = $6N^{3/2} - 3N$

(1188 Crosspoints when $N = 36$ vs $N^2 = 1296$)

THREE-STAGE SWITCHING ARRAY

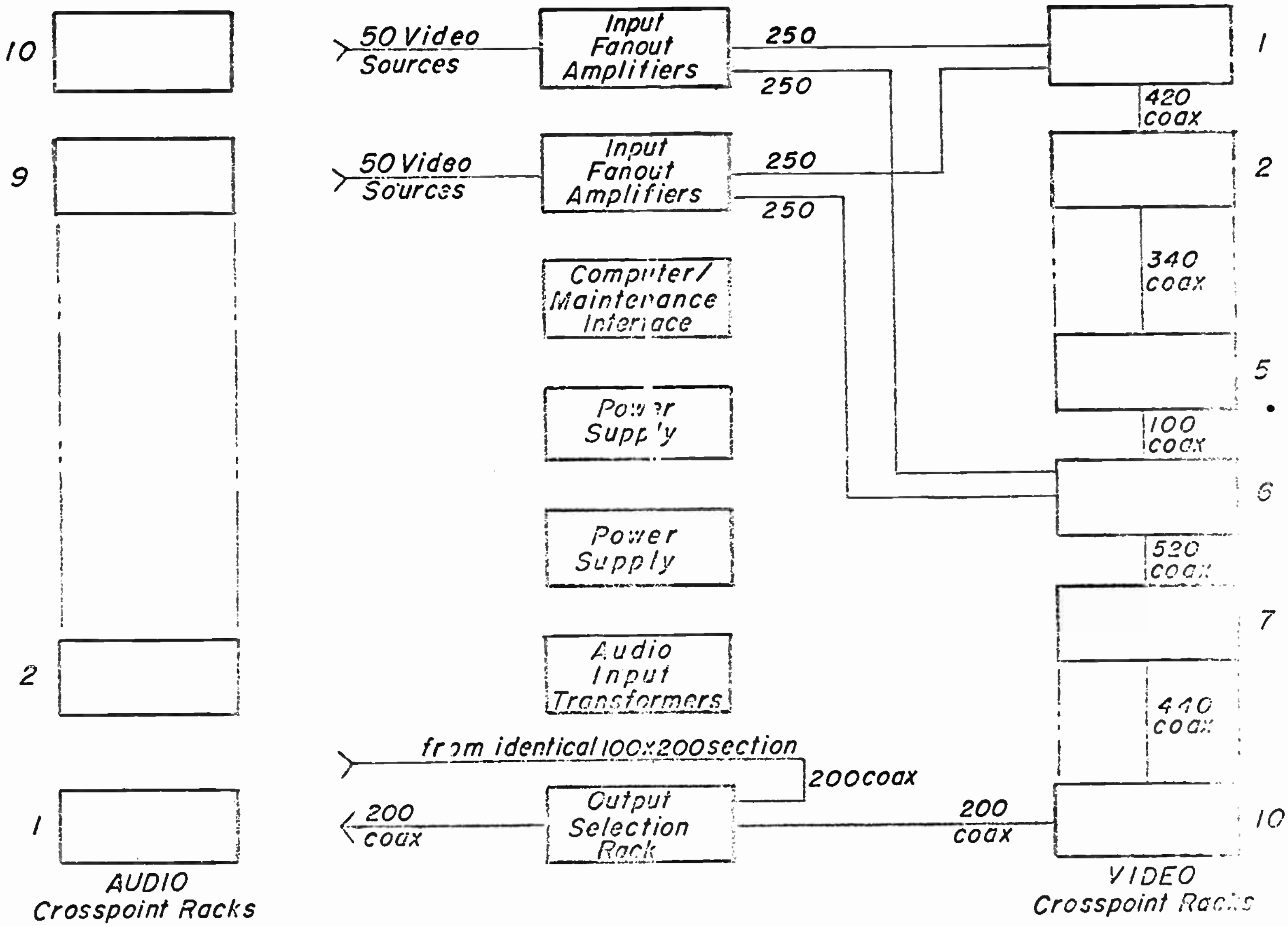

50 Video Sources
Input Fanout Amplifiers
250
250
50 Video Sources
Input Fanout Amplifiers
250
250
Computer/ Maintenance Interface
Power Supply
Power Supply
Audio Input Transformers
from identical 100x200 section
200 coax
200 coax
Output Selection Rack
200 coax
420 coax
340 coax
100 coax
520 coax
440 coax
1
2
5
6
7
10
VIDEO Crosspoint Racks
10
9
2
1
AUDIO Crosspoint Racks

Fig. 2

It was decided to proceed with the square array for this switcher because of the inherent simplicity of the concept which manifested itself in decreased control complexity, elimination of any specialized operator requirement, rapid isolation of trouble in case of failure, and easier expansion of the system without downtime.

The routing switcher hardware has been organized on the basis of the destination to which each of the source signals is routed. This type of layout lends itself to rapid fault location and module replacement with a minimum danger of disturbing an operating "on-air" module that might also contain the defective circuitry of a destination that has reported trouble. Each destination has its exclusive 10 X 1 crosspoint modules, output amplifier module and destination control module. It does share a video fanout amplifier with other destinations, but a monitoring system has been provided which gives the maintenance man the facility to isolate trouble to this amplifier or absolve it without having to resort to disturbing the module itself. This will be described in more detail later.

Layout of the 26 racks of a 100 X 200 section of the switcher exclusive of machine control is shown in Fig. 2. (Machine controls are supplied with studio feeds only. Physical restraints determined their location separate from the audio/video section.) An identical configuration would be required for the addition of 100 sources except for the output selection rack which is common. The video path length from each source to every destination is kept constant. In the first phase of the ABC switcher (100 X 60) only the first three audio and video crosspoint racks are required in addition to the fanout, power supply and control racks. Expansion of the number of destinations to 200 will require the addition of one audio and one video crosspoint rack for each increase of twenty destinations or part thereof.. Destinations can be added one at a time by installing the card rack for ten destinations in one half of the rack but adding only the modules, one set at a time, for the destinations to be added. The inputs are already available from the fanout racks. There is no disturbance of the racks already in use and, therefore, there is no downtime.

HUMAN ENGINEERING

We have already indicated that the switching system will have 26 racks of electronics in each of two parts in the 200 X 200 size. How do you assure yourself that the television production system, operating as it does, on a 24-hour basis with the switcher as its heart will not get bottlenecked by switcher downtime due to any reasonable series of catastrophic failures, maintenance or need for adjustment?

The approach that has been taken has already been touched upon. The system has been designed to be destination-oriented. By this we mean that each user or destination has an essentially unique path from input to output. He shares only two portions of electronic circuitry with other users. The input fanout amplifier and the power supply that feeds ten destinations are the only points of electrical commonality and we will show how this has been handled. There is no conceivable failure that can occur in the twenty crosspoint boards, two output amplifiers and control module associated with each destination that can affect the signals, audio, video and control of any other destination. Equally important is the fact that a maintenance man who might be working on one destination can insert a defective module into the assembly associated with the destination that might be in trouble without concern that he might adversely affect another user.

Destination orientation was accomplished by designing all switches and control modules to contain only a single output. In this case, the audio and video switch modules are ten in by one out and the output amplifier and control module involves a single output only.

The power supply common to 20 destinations is protected in three ways. The 20 destinations are fed from two power supplies in parallel. Failure of either one will sound an alarm, but there will be no effect on the switcher performance as each power supply can handle the entire load. Secondly, each half of the dual power supply is connected to a separate AC power source. Failure of either line would not affect the switcher as previously mentioned. A third protective element in the power supply system is the provision of an individual regulator for each destination's power. Consequently, a short circuit on the load side will be isolated by the regulator located on the output amplifier module of the individual destination.

The only common signal link in the entire switcher is the input fanout amplifier. If this amplifier fails, all destinations that have selected this source lose their inputs. We have provided an operational monitoring facility to be described that permits rapid troubleshooting of this possibility. By this method, there is never a requirement for a maintenance man to have to handle the fanout amplifier to ascertain its proper performance.

The magnitude of the switcher in its ultimate size makes even the navigation among the 50 racks somewhat time consuming. This is especially true when one looks forward to maintenance procedures. The philosophy behind the maintenance facility, both for emergency and routine procedures led us to:

1. Provide sufficient flexibility to permit the isolation of trouble to a module without leaving a central monitor location.

2. Eliminate all front panel test points, controls, and indicators.

3. Provide a monitor switcher that did not have any electronics between points to be monitored and the monitor itself.

4. Provide a monitor switching control that is independent of the routing switcher control.

5. Provide test jigs for complete set up of each module in the maintenance shop.

All of these items obviate the need for troubleshooting within the physical confines of the switcher itself.

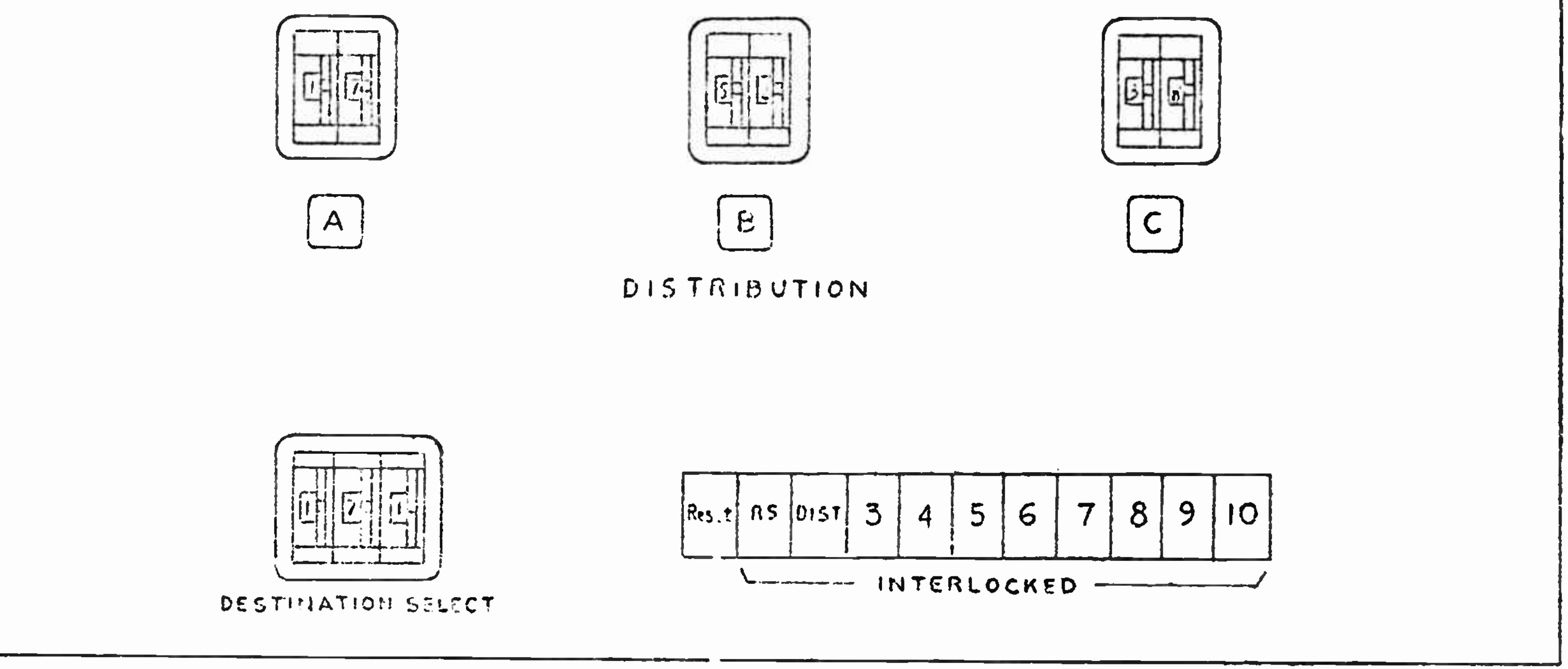
The centralized maintenance control area is shown in Figs. 3A and 3B. It can be described by using its features to troubleshoot the switcher. Assume a trouble report from destination 12. Source 71 is not being received, although the digital readout at the destination displays 71. The maintenance technician goes to the Routing Switcher Maintenance Control and proceeds as follows: (A simplified functional diagram, Fig. 4 will help us follow this procedure.)

1. He dials source 71 and observes it on his input monitor, thereby assuring himself that the signal is getting to the Routing Switcher. (The A section controls the routing switcher sources. The B and C sections control the same source monitor feeds connected to other locations.)

2. He then keys source 71 into the maintenance source select (one output of the switcher set aside for maintenance) via his own keyboard. A satisfactory signal at the output shows that the input fanout amplifier is normal.

3. This step tests the destination control module. Destination 12 is dialed into the destination interrogate input of the control panel which connects the digital cross-

Fig. 3 A


A
B
C
DISTRIBUTION
DESTINATION SELECT
Res.t
RS
DIST
3
4
5
6
7
8
9
10
INTERLOCKED

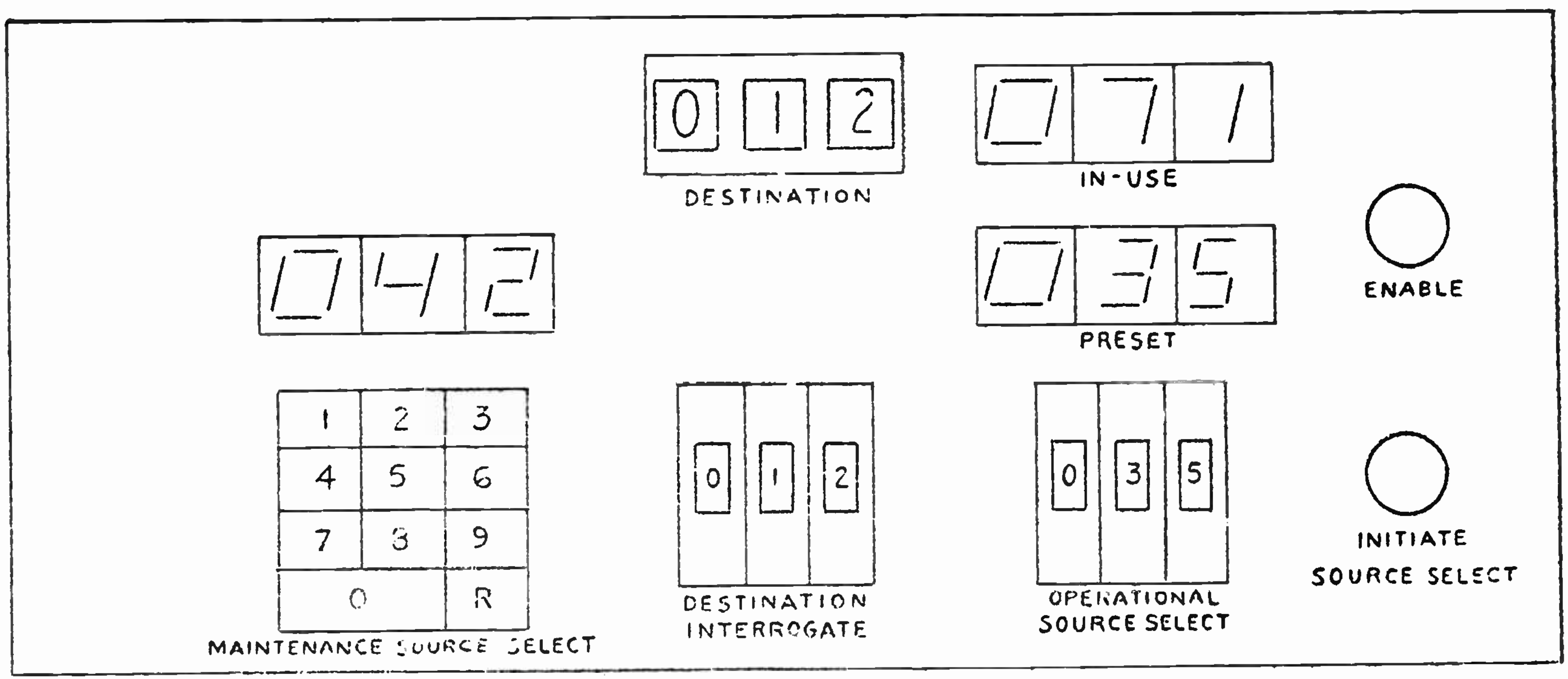

012
DESTINATION
071
IN-USE
042
035
PRESET
ENABLE
1 2 3
4 5 6
7 8 9
0 R
MAINTENANCE SOURCE SELECT
0 1 2
DESTINATION
INTERROGATE
0 3 5
OPERATIONAL
SOURCE SELECT
INITIATE
SOURCE SELECT

Fig. 3B

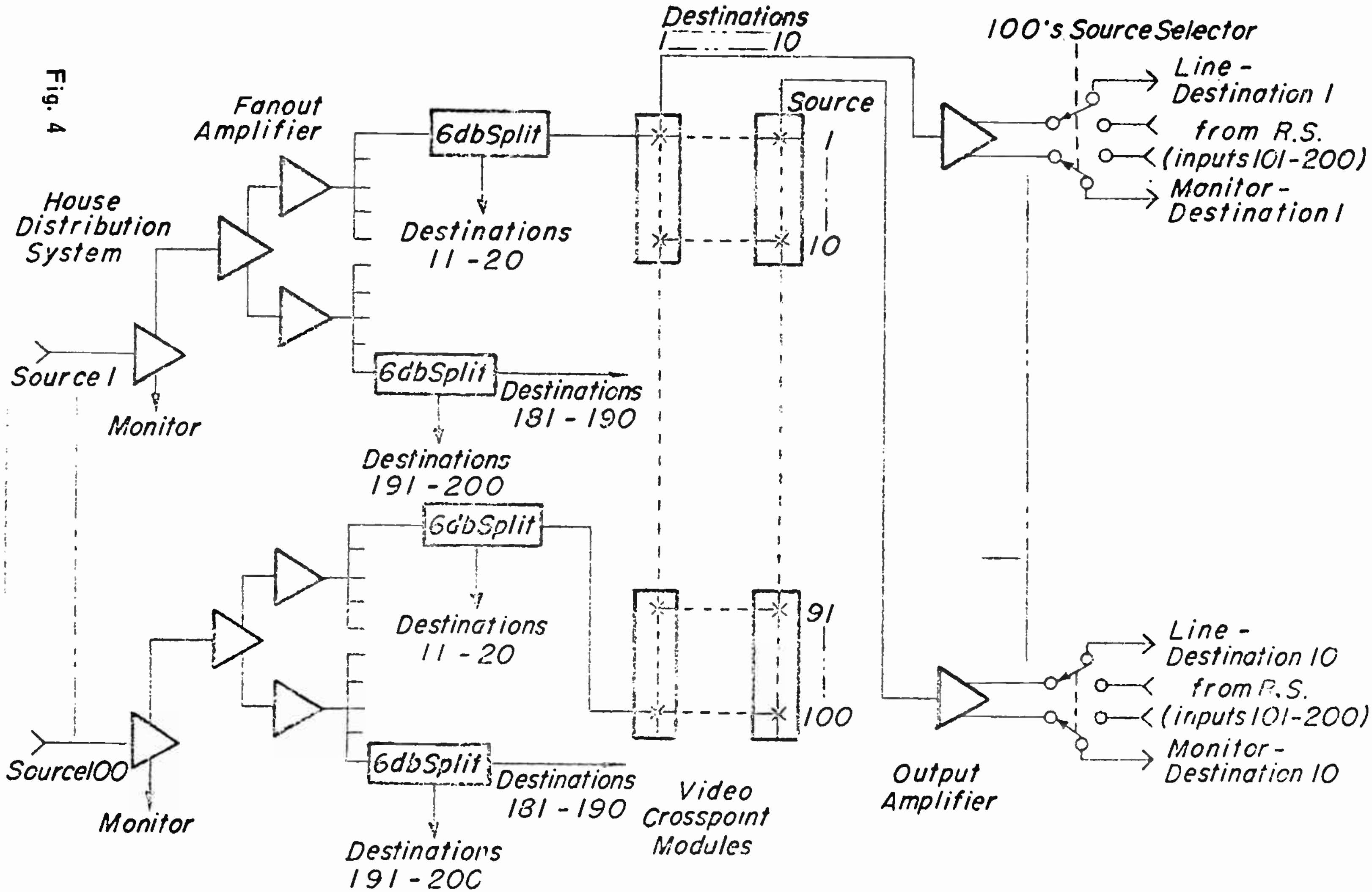

Destinations
1 ... 10
100's Source Selector
Line -
Destination 1
from R.S.
(inputs 101-200)
Monitor -
Destination 1
Fanout
Amplifier
6dbSplit
Source
1
House
Distribution
System
Destinations
11 - 20
10
Source 1
6dbSplit
Destinations
181 - 190
Monitor
Destinations
191 - 200
6dbSplit
91
Destinations
11 - 20
Line -
Destination 10
from R.S.
(inputs 101-200)
100
Monitor -
Destination 10
Source100
6dbSplit
Destinations
181 - 190
Video
Crosspoint
Modules
Output
Amplifier
Monitor
Destinations
191 - 200

Fig. 4

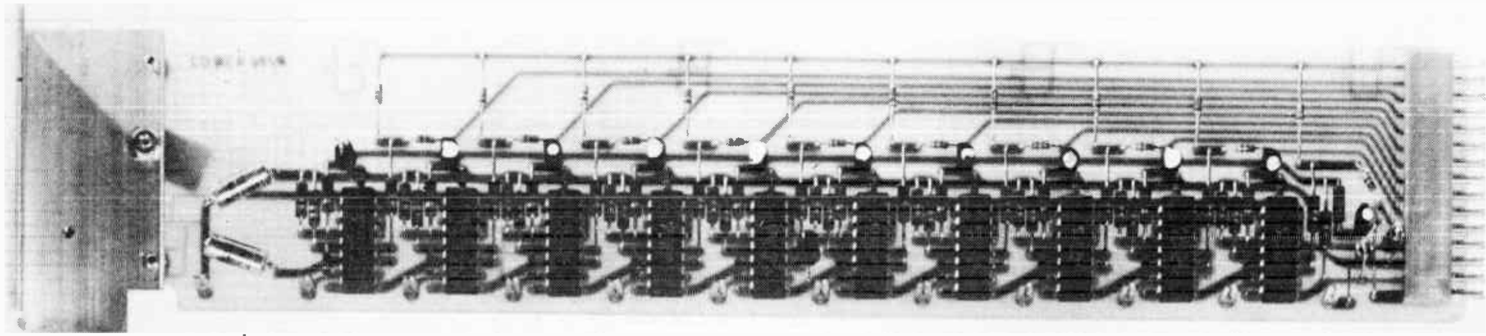


Fig. 5

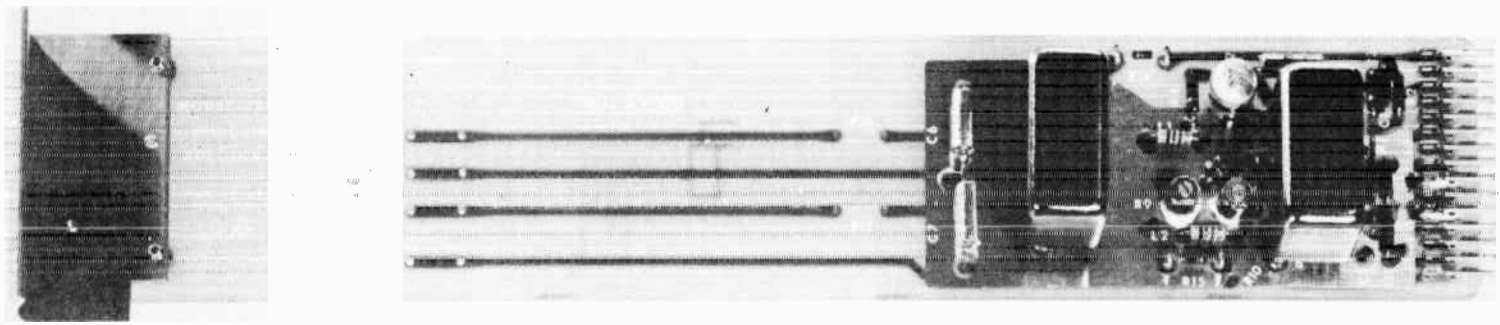


Fig. 6

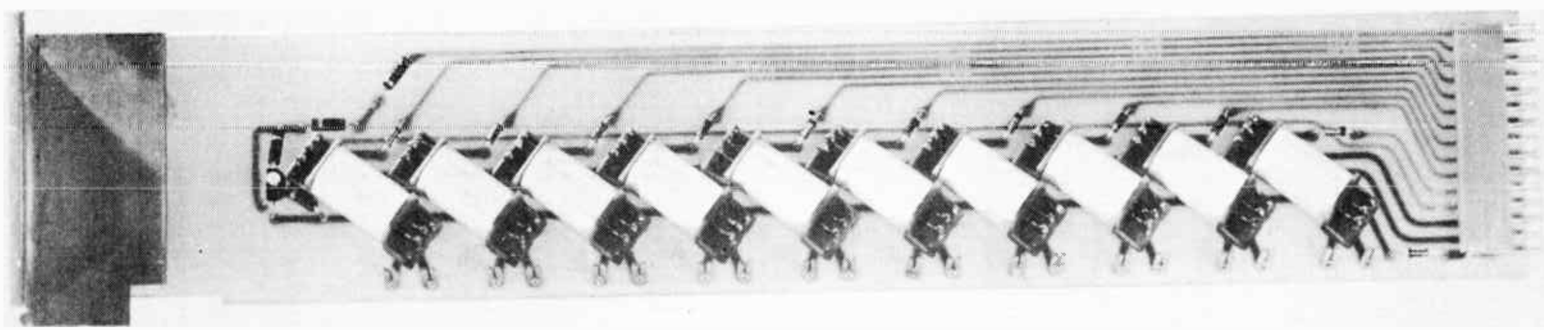


Fig. 7

point selection signal stored in the destination 12 control module to the readout on the maintenance control panel. If the source "in use" display reads 71, it shows that the control panel at destination 12 and the destination 12 control module are normal.

4. The last step tests the output amplifier. He dials source 000, a test signal, into the operational source preset control. The readout appears in the preset window. If it is correct, the dual Enable and Initiate Buttons are depressed. The source seen by destination 12 changes and the in-use display does likewise. The dual entry precaution is taken because an inadvertent entry into an "on-air" destination could be very bad. If the signal is satisfactory as viewed by proper selection of destination 12 on the output monitor panel, the output amplifier is normal.

The maintenance engineer has eliminated the input source, fanout amplifier, output amplifier, control module, and control panel as trouble areas. The only failure can now be in the single 10 X 1 crosspoint module associated with source 71, destination 12, or connecting cables. He has done all this without moving from the control panel.

All of the above mentioned monitoring was accomplished via relay switching and no amplification. Just as we have isolated the switcher into 200 destination compartments, we have isolated the program lines and their controls from the monitor signals and controls. We have provided a simplified thumb-wheel switch and relay monitor selection system that leaves no doubt that the signal selected and observed is the correct and accurate representation of the line signal. A similar system has been provided for audio.

DESIGN

Final design of the switcher has produced a blend of tried-and-tested concepts and components and the very latest integrated circuits and novel mechanical devices. ABC has had extremely successful experience with reed relay video crosspoints in a number of production switchers. It was certainly a strong temptation to follow up with the same type in a switcher of 40,000 crosspoints. However, newly available IC packages provided us with the opportunity to go with a much smaller solid-state switch. Extensive testing of an RCA dual in-line IC over wide temperature extremes proved the component to be of the highest reliability. After ascertaining the fact that the type CA-3046 is being produced in large quantities for a variety of users, it was decided to use it on the 10 X 1 crosspoint module shown in Fig. 5.

The video input and output amplifiers, on the other hand, use discrete components in the main. However, this is not obvious from the photograph in Fig. 6. The majority of the components are mounted in a tight configuration inside the metallic cans and are encapsulated in a rubbery material. This packaging distributes heat well and provides an approach to integrated circuit performance with discrete components.

The audio crosspoints are a throwback to our past experience. As you can see from Fig. 7, we have used sealed dual reed relays to handle audio switching. Machine controls and return tallies are switched via 4-pole reed relays mounted on similar modules. This is possible in our system because all controls and tally returns are multiplexed on a pair of wires in each direction.

Although the electrical design was no small task, the mechanical design appeared to present even greater challenges.

MECHANICAL DESIGN

The destination orientation of the switcher made some very critical demands on the mechanical configuration of the circuit modules. The most suitable rack layout was one in which all the modules associated with one destination are aligned in a vertical row. Fig. 8A shows the video section, Fig. 8B, the audio section.

There are 1000 crosspoints, 10 output amps and 10 control modules in 35 inches of rack space. It does not take long to realize that it is not possible to mount all the required BNC connectors to handle the video, let alone the standard connectors to handle the fifteen control and power connections to each 10 X 1 crosspoint module. The solution is shown in Fig. 9. Ten video inputs are connected to the right side of each deck, and each is connected by a printed circuit across the deck to ten equally spaced bifurcated Elco pins. The video connections to these pins are made along the length of the module. The control power and video output connections are made to fifteen pin connectors, ten in all, at the rear of each deck. Thus each board has 25 connections in 2.8" vertical height. The module is withdrawn by the grasping of the handle with four fingers, release of the latch with the thumb, rotation of the wrist and pulling.

The entire deck is secured in the rack. A mechanism is, therefore, required to disengage the crosspoint module from the video connections on the deck before it can be separated from the connector at the rear. This is accomplished by rotating the module and the 15-pin control connector approximately 15° clockwise and then pulling the module from the rear mounted connector directly out of the rack. The module rides in a channel guide of extruded aluminum to which the rear mounted connector is attached. The guide is held by a spring in the clockwise position when the module has been removed and is ready for reinsertion of a module. The module can only be inserted into the guide, in this position, because of the presence of a block on the deck. This block will allow rotation of the module only when the module is firmly seated in the connector. It also serves two other functions. It prevents withdrawal of the module when the guide is in the vertical position by engaging a cutout in the module. When the guide is rotated counterclockwise and the module is properly seated, it is locked into position by the latch shown in Fig. 10, which slides into a slot in the block mentioned above for its third function.

CONTROL

The control system is designed to allow for operation of the crosspoints either from:

Individual destination control panels (IDCP)
Studio control panels (SCP)
Maintenance control panel
or computer

in any combination. There must be an order of priority in the selection process because the computer (which is not being used in this phase of the switcher) and the Maintenance Control Panel operate through a common interface into the Destination Control Modules (DECM) associated with each control panel. In Fig. 11 we see that the IDCP and SCP drive their control modules directly. They have overriding priority at all times except for the case of the studio switcher input that has an "on-air" tally activated.

The IDCP is shown in Fig. 11 and appears simply as a keyboard and readout. These are located at tape machines and monitoring locations to route the input to a single

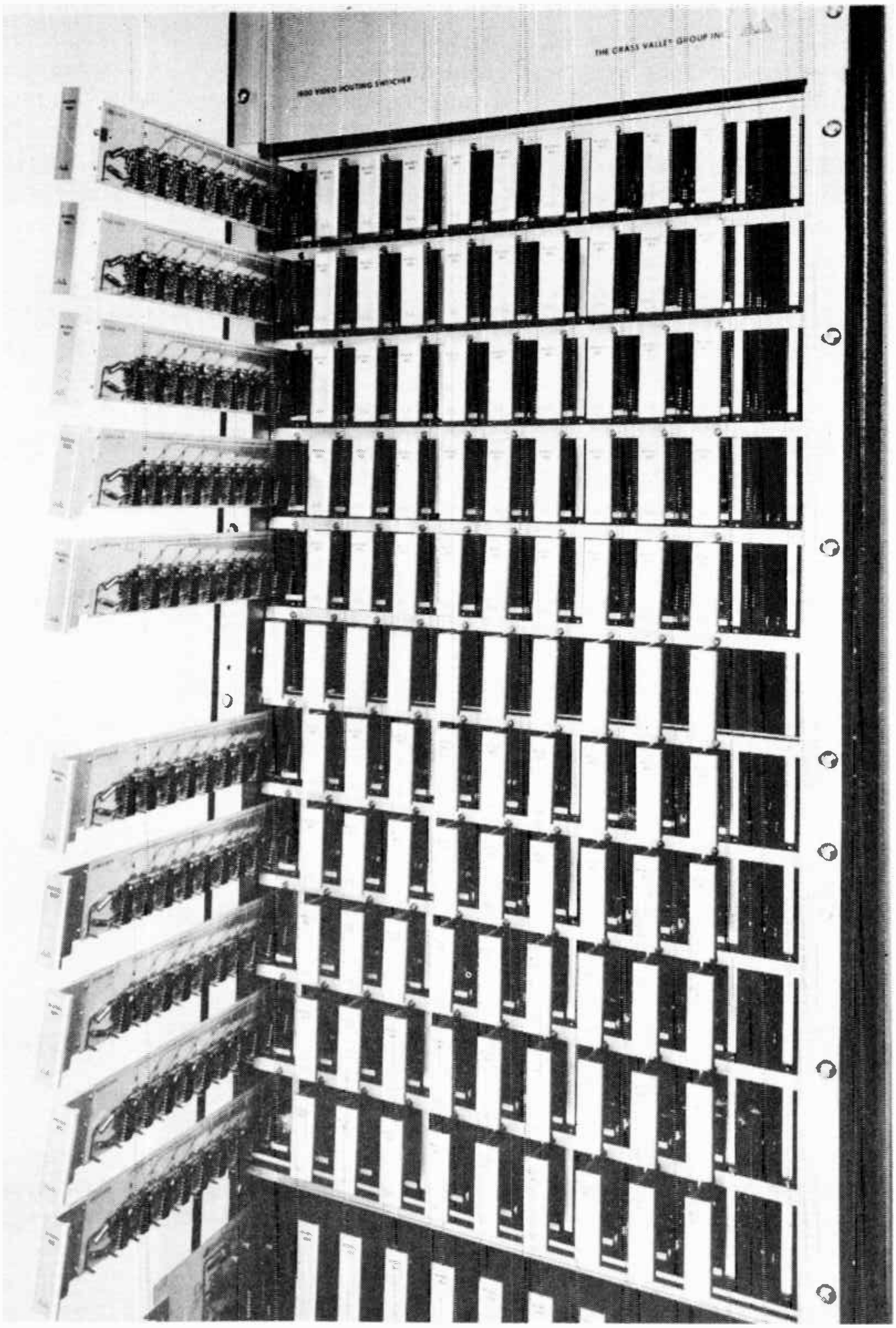


Fig. 8 A

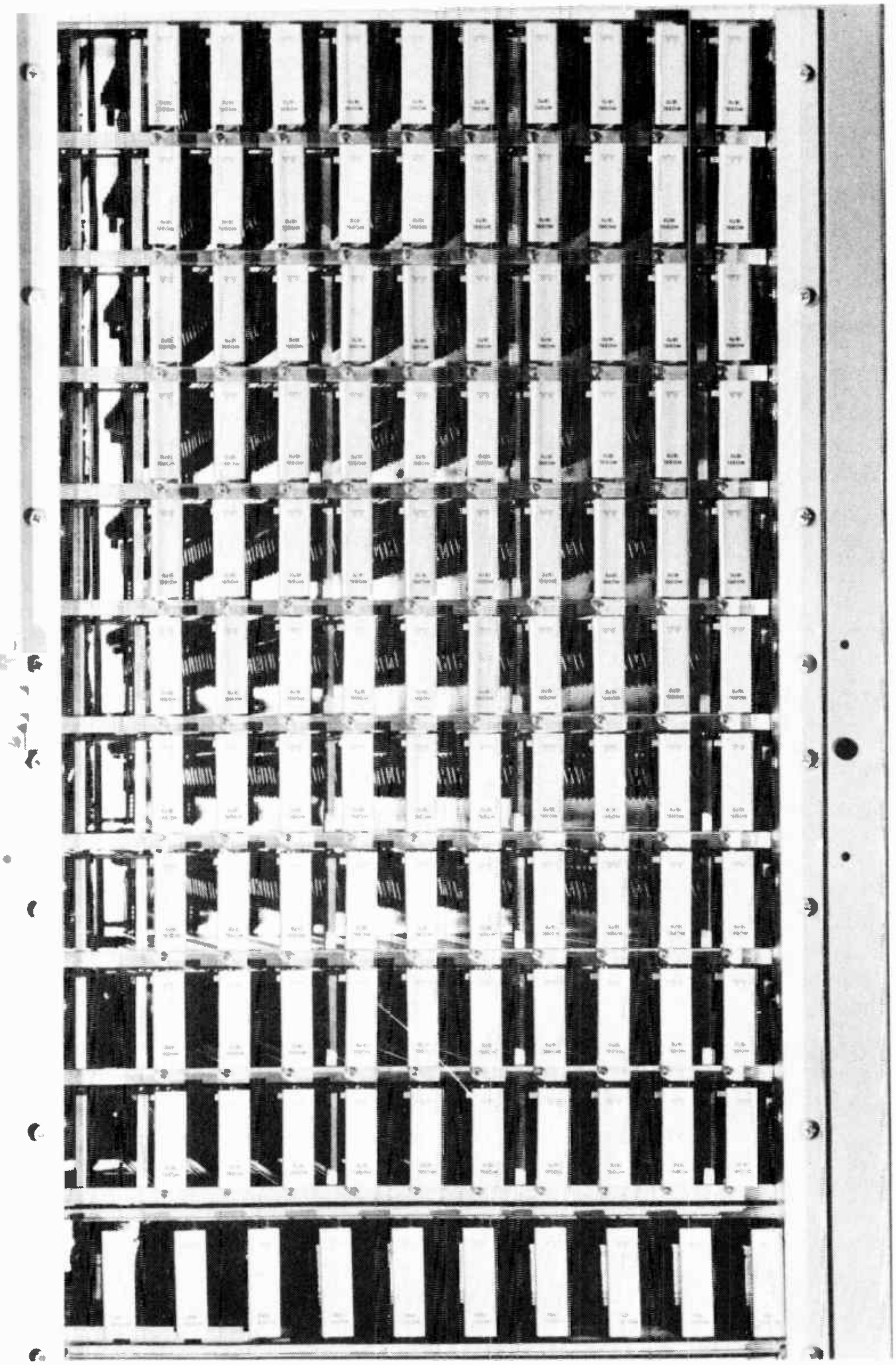


Fig. 8 B

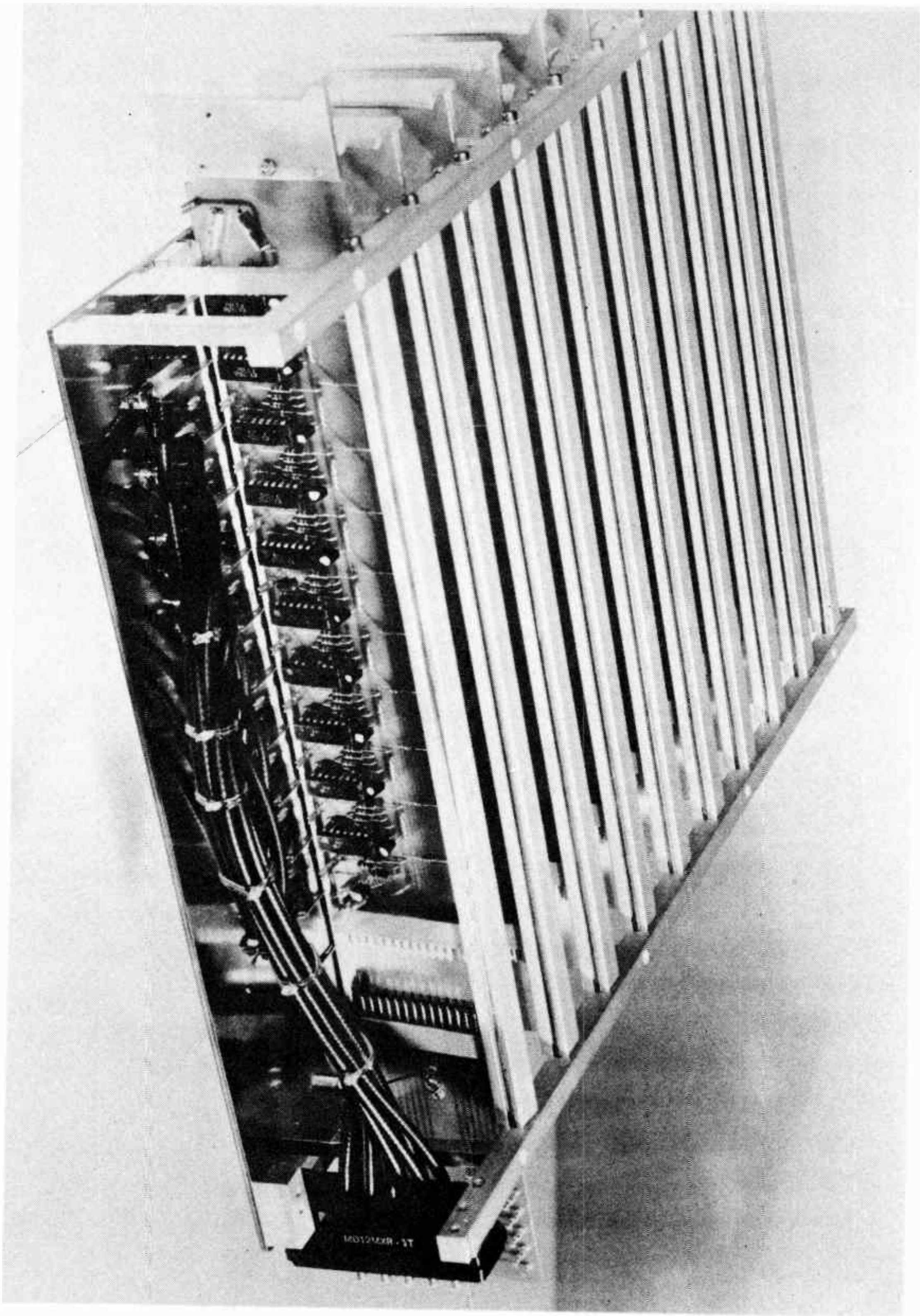


Fig. 9

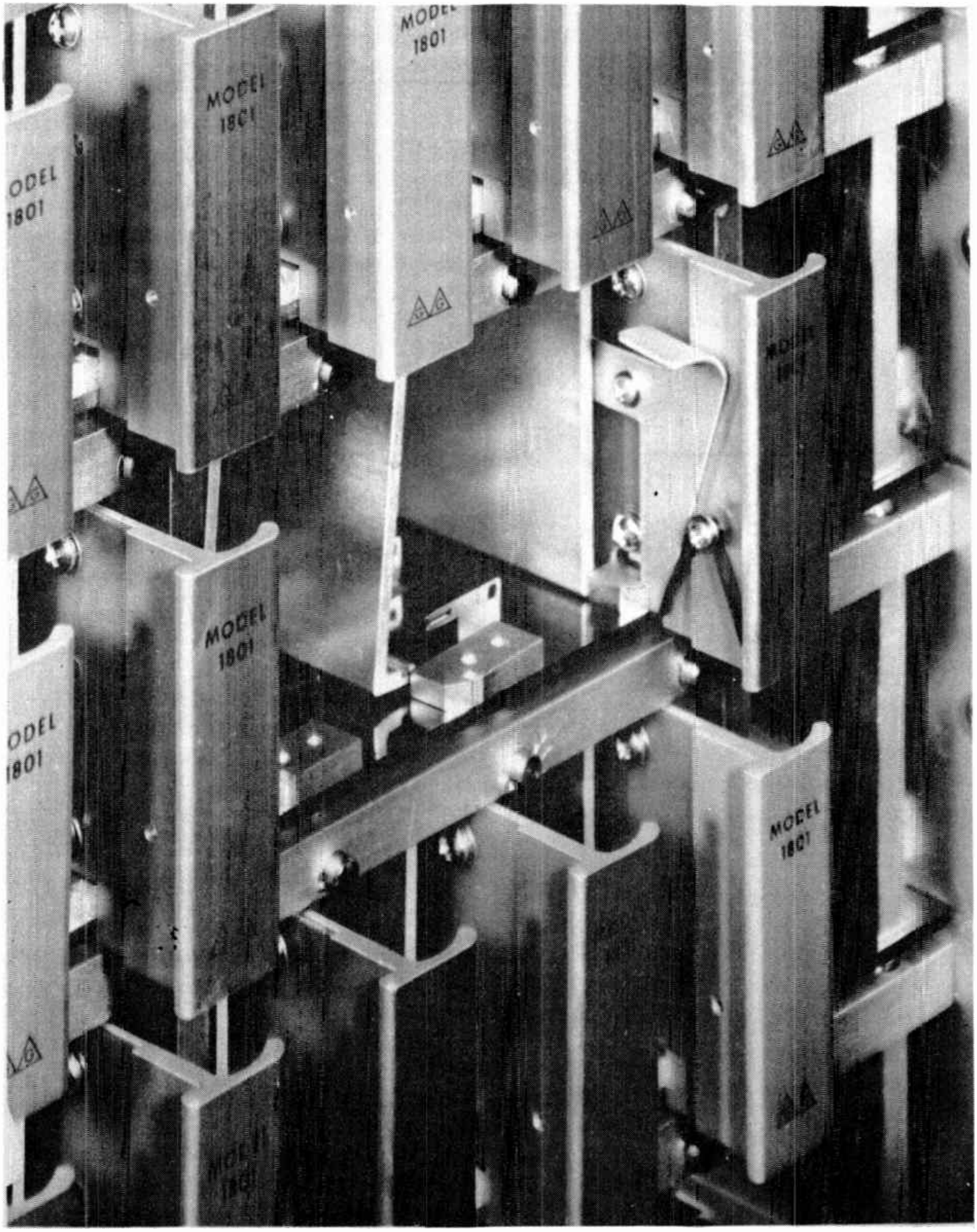
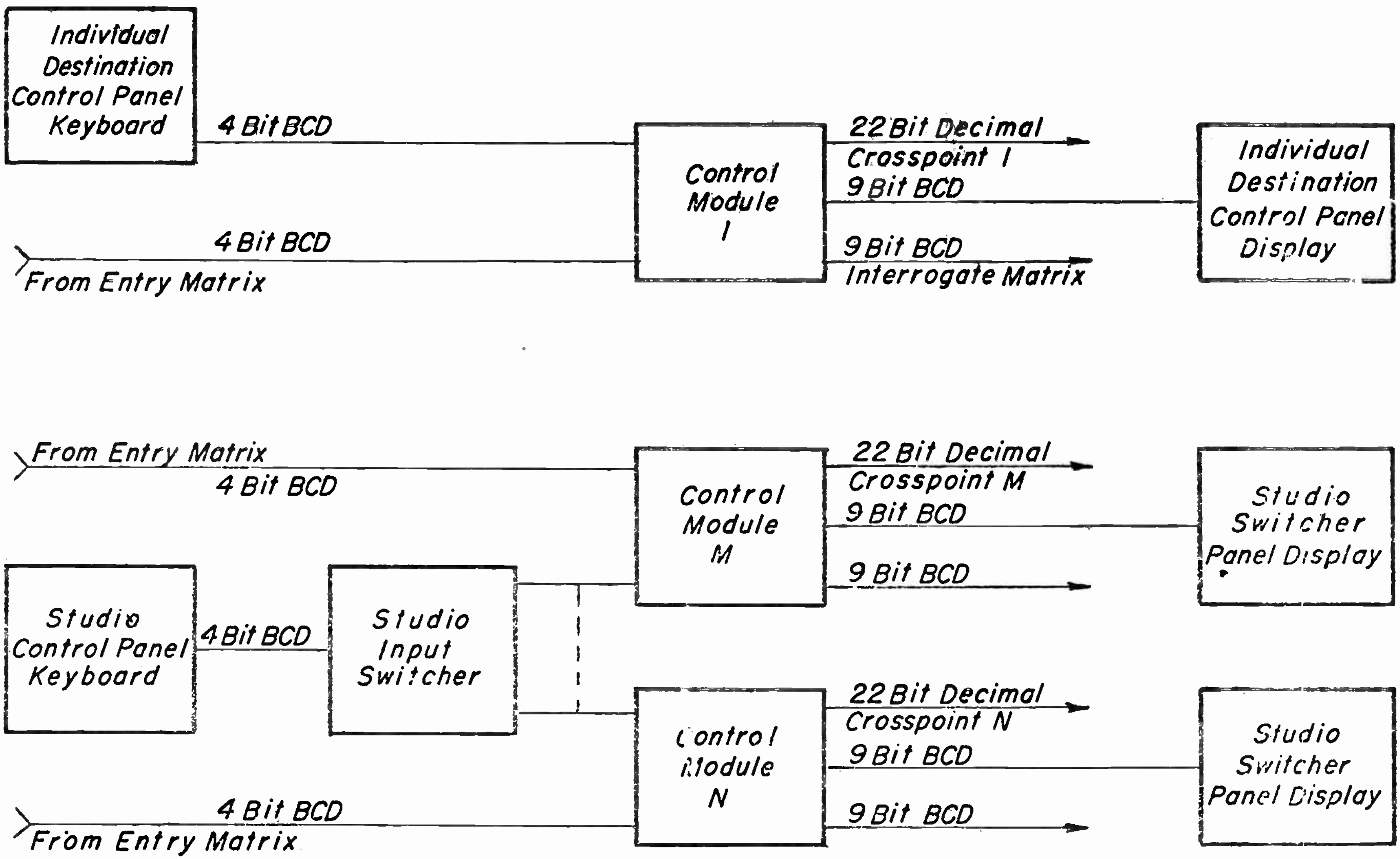

MODEL
1801
MODEL
1801
ODEL
1801
MODEL
1801
ODEL
1801
MODEL
1801

Fig. 10



Individual Destination Control Panel Keyboard
4 Bit BCD
Control Module I
22 Bit Decimal Crosspoint I
9 Bit BCD
Individual Destination Control Panel Display
4 Bit BCD
From Entry Matrix
9 Bit BCD
Interrogate Matrix
From Entry Matrix
4 Bit BCD
Control Module M
22 Bit Decimal Crosspoint M
9 Bit BCD
Studio Switcher Panel Display
9 Bit BCD
Studio Control Panel Keyboard
4 Bit BCD
Studio Input Switcher
Control Module N
22 Bit Decimal Crosspoint N
9 Bit BCD
Studio Switcher Panel Display
4 Bit BCD
From Entry Matrix
9 Bit BCD

Fig. 11

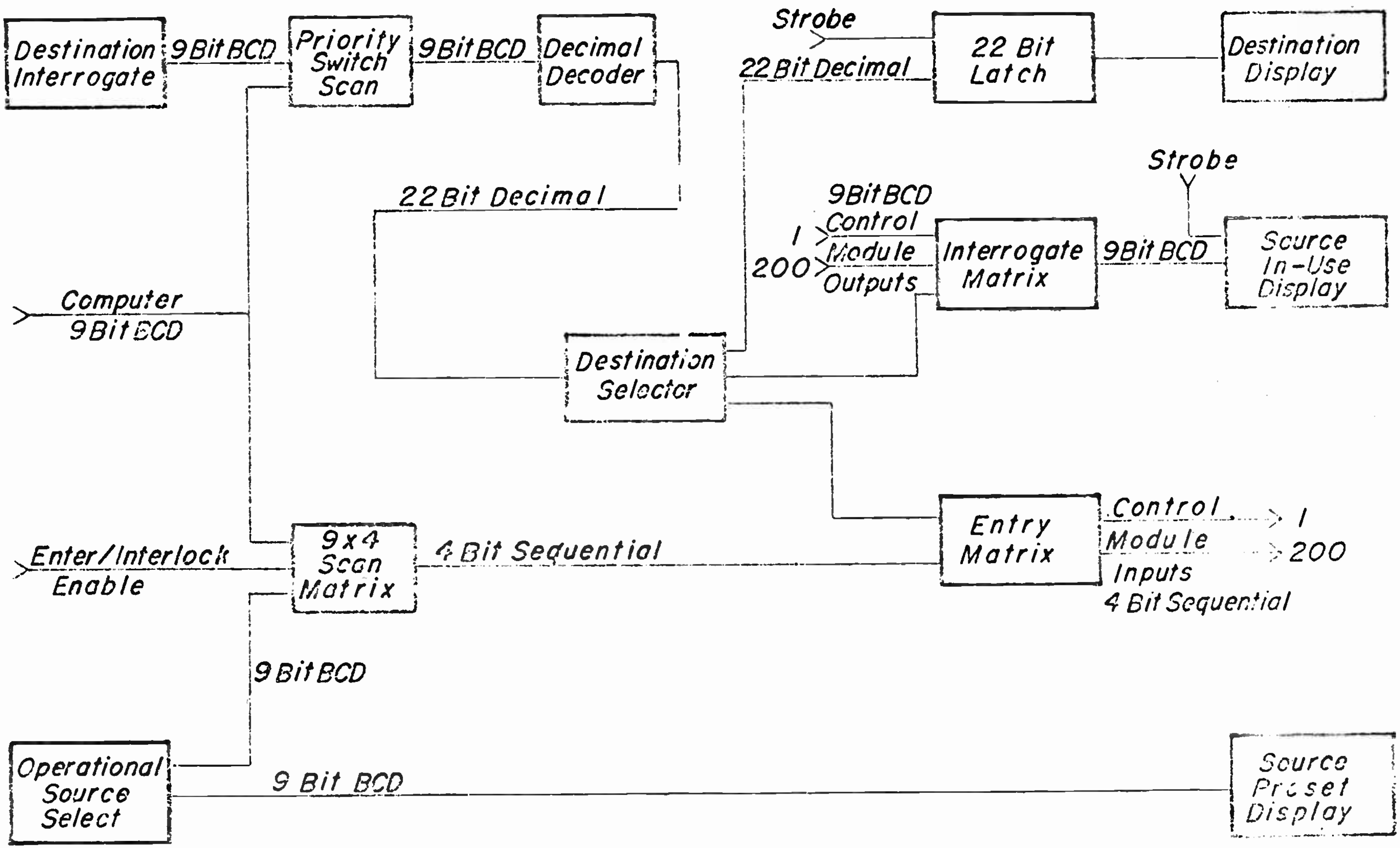

Destination Interrogate
9 Bit BCD
Priority Switch Scan
9 Bit BCD
Decimal Decoder
Strobe
22 Bit Decimal
22 Bit Latch
Destination Display
22 Bit Decimal
Strobe
9 Bit BCD
Control
Module
Outputs
1
200
Interrogate Matrix
9 Bit BCD
Source In-Use Display
Computer
9 Bit BCD
Destination Selector
Entry Matrix
Control
Module
Inputs
4 Bit Sequential
1
200
Enter/Interlock
Enable
9x4 Scan Matrix
4 Bit Sequential
9 Bit BCD
Operational Source Select
9 Bit BCD
Source Preset Display

Fig. 12

device. The SCP also shown in Fig. 8 enables a directors to feed up to twenty inputs of a program switcher from a single keyboard. The readouts for each program switcher input are located on the program switcher panel below the row of video selection buttons.

All transfer of information between control panels and control modules is handled via binary-coded decimal signals. Four bits of binary information are required to handle the decimal numeral, 0-9 in each decimal place, units and tens, hence binary-coded decimal or BCD. These are transmitted sequentially, one decimal digit at a time, as the keys are depressed on the keyboard panel, over the four lines between the panel and the control module. The control module stores the four bits of units information and the four bits of tens information. It is necessary to store only one bit to cover the hundreds position because it need only be a zero or one. Thus one output of the control module is a nine bit-signal representing the selected source that feeds the readout on the control panel. Another output of the DCM is the decimal equivalent of the source selected and is routed to all crosspoint modules. It appears on twenty-two lines, ten for each of the units and tens and two for the 0 or 1 in the hundreds position. The third output is a parallel of the BCD readout which goes to the Maintenance Control Panel interface for Destination Interrogation.

The Maintenance Control Panel shown in Fig. 12 in functional form is designed to give a technician the ability to control the entire routing switcher from a single location for purposes of fault location. He can verify the source selected at any destination and he can place any source into any destination from the same panel. The panel is operated in two phases: Destination Interrogate and Source Selection. Introduction of a destination into the destination selector will immediately bring up two readouts: the destination just selected and the source in use. A second selector provides means of entry for a source preset which appears in a third readout on the panel. After studying the preset source and destination readouts and assuring himself that these are indeed the numbers he desires, the technician depresses the Enter and Interlock Buttons to affect the transfer of the new source to the destination selected. The source preset readout then transfers to the In-Use readout.

The computer interface will take BCD data inputs, routed through a control entry matrix to a selected DCM, to assign any source to any destination. The 9 X 4 scan matrix is time-shared between the computer and the maintenance control panel. The interrogate matrix can provide a continuous status output of all destinations; useful as a computer input, display on a monitor with character generator, or printer.

PERFORMANCE

The exact audio and video performance characteristics are available in the appendix. Overall, the signal characteristics are similar to those one might expect from two distribution amplifiers in tandem with the exception of crosstalk, a major item in a complex device such as this switcher. We have one hundred different inputs in the same rack. Careful design permitted us to record better than 60 db of isolation between any one output and all the other inputs and outputs where all the others had the same signal connected thereto. This compares to 90 db of isolation of the integrated circuit crosspoint itself or about 70 db for a 10 X 1 module with coherent excitation of the off crosspoints. The active circuit crosspoint provides better than 60 db isolation from output to input, permitting any number of outputs to select the same input without noticeable effect on transmission. Special precautions taken in the shielding of the printed-circuit deck of each crossbar, shielding of the output bus of each destination, power supply isolation, and provision of a regulator for each destination kept the reduction in isolation to a maximum of 10 db but in many instances in the order of 5 db.

Routing Switcher Performance

Video

Relative chroma level	0 plus or minus 0.1 db
Relative chroma time	0 plus or minus 10 ns
Differential gain	less than 1.0%
Differential phase	less than 0.5 degrees
Differential delay	plus or minus 1 degree of 3.58 MHz
Waveform response	less than 0.5%
Signal-to-noise ratio	greater than 75 db
Signal-to-crosstalk ratio	greater than 60 db
Type of switch	approximately 1 us lap
DC output	0 plus or minus 5 mv

Audio

Frequency response	plus or minus 0.5 db, 50 Hz to 15 kHz
Signal-to-noise ratio	greater than 75 db
Signal-to-crosstalk ratio	greater than 65 db
Harmonic distortion	less than 0.5%

We trust that this presentation has shown some of the highlights of this new switcher and invite any questions you may have concerning the system.

Microwave Economics

Albin R. Hillstrom
Director of Engineering
KOOL AM-FM-TV
Phoenix, Ariz.

As the title of this paper implies, it looks at the economics of a station-owned and operated intercity microwave system. It is our purpose to:

1. Describe an operating, station-owned intercity microwave system, serving KOLD-TV in Tucson from KOOL-TV in Phoenix.

2. Consider the installation and operating costs.

3. Compare these costs with AT&Ts old and new rates for the same service.

4. Try to answer any questions you may have.

On October 2, 1969 the new AT&T rates for television service went into effect, subject to the outcome of a hearing as to whether they are just and reasonable. In 1964 we decided that the AT&T rates were too high already and that we could install and operate an intercity microwave system more economically ourselves with top quality video and audio. There are many stations using their own microwave systems. Some have been operating them for quite some time and some have elaborate multi-hop systems. Before the KOOL-TV to KOLD-TV intercity was built, KOLD-TV received their CBS-TV net via leased facilities from AT&T and regional programming from an "off the air" facility from KOOL-TV. The off-the-air type of service, which is the most economical, just isn't good broadcast quality.

SYSTEM DESCRIPTION

Technically our system is straight forward in design, taking advantage of Arizona's mountainous terrain. We use Lenkurt 76TV equipment throughout, which is all solid-state except for the klystrons. The system is a four-hop 156-mile path, with hops of 8, 72, 58, and 18 miles as shown in Fig. 1. The first hop of eight miles is from the KOOL-TV studios in downtown Phoenix to Mount Suappoa (South Mountain) KOOL-TV's transmitter site. This is the only unit operating in the 13-GHz band; all others are 7 GHz. It uses 6-foot dishes for both transmit and receive. The second hop of 72 miles is from South Mountain (elevation 2600 feet) to Pinal Peak (elevation 7800 feet) using 10-foot dishes. The third hop of 58 miles is from Pinal Peak to Mount

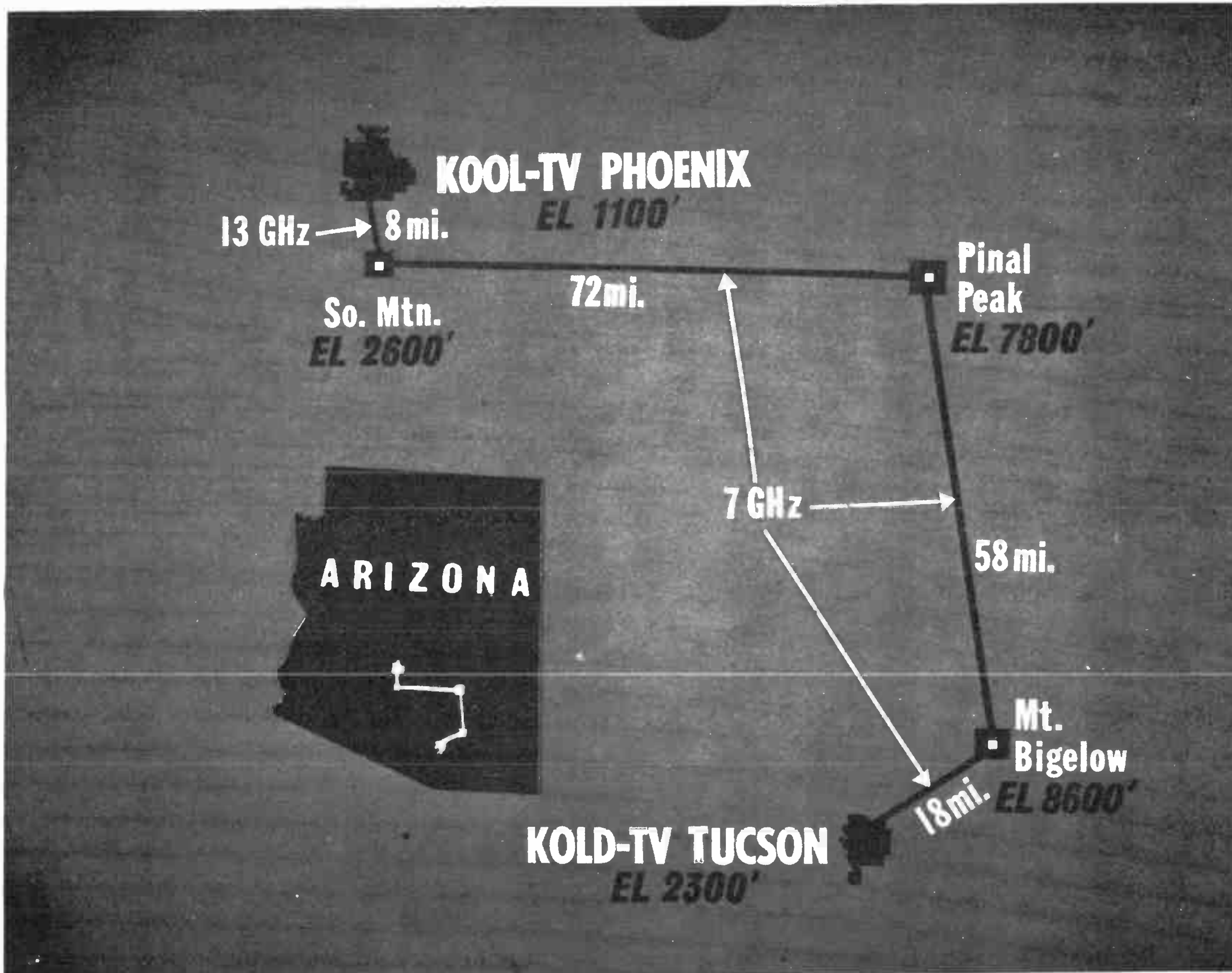

KOOL-TV PHOENIX
EL 1100'
13 GHz
8 mi.
So. Mtn.
EL 2600'
72mi.
Pinal
Peak
EL 7800'
7 GHz
58 mi.
ARIZONA
Mt.
Bigelow
EL 8600'
18mi.
KOLD-TV TUCSON
EL 2300'

Fig. 1

Bigelow (elevation 8600 feet) which is KOLD-TV's transmitter site. It also uses 10-foot dishes. The fourth and final hop of 18 miles is from Mount Bigelow to KOLD-TV studios in Tucson using 6-foot dishes.

It is a simple system; that is, there isn't any frequency diversity, space diversity, elaborate alarms or back-up equipment, except for power. (The old "off-the-air" route is used for a back-up system, which has an "off-the-air" pickup point 23 miles north of Tucson and is microwaved from there to KOLD-TV studios.)

The power supplies at both TV transmitter sites are operated from 30 minute batteries, a float battery charger, and a DC-to-DC converter. Both TV transmitter sites have auxiliary deisel generator power plants. By using batteries, a float charger, and a DC-to-DC converter instead of AC power supplies for the microwave equipment, the system will be stable even if commercial power is lost or unstable, which is often the case on Mount Bigelow, KOLD-TV's transmitter site, during the winter snow and ice storms and summer thunderstorms.

The unmanned repeater site on Pinal Peak has a triple power source, commercial power, 7.5-KW propane generator and 10-hour batteries. Simple alarms were added to tell us at the transmitter sites what power source (commercial, generator, or battery) the repeater is operating on. If the alarm indicates that we have lost commercial power and the generator, then we have 10 hours to get to the mountain top and repair the problems. (From Phoenix it normally takes three hours; however, during a winter storm in December 1967, it took 28 hours to get to the Pinal Peak repeater and 20 hours to get down. Ice completely had covered our building, causing the propane engine to be choked off due to a lack of air.) The studio terminals do not have battery or auxiliary power.

The Lenkurt 76TV equipment is base-band equipment; that is each receive terminal demodulates to base-band (video) and each transmitter remodulates. There are two (2) 15-kHz program channels on the system which are not demodulated on the Pinal Peak or Mount Bigelow sites. The system performance specifications are excellent with negligible degradation of the video and audio signals. (Predicted propagation reliability is 99.97%; so far it has exceeded that.)

The entire installation was done by the stations' engineering staffs. The personnel responsible for the microwave maintenance attended a one-week training school at the San Carlos, Calif., Lenkurt plant.

INSTALLATION COSTS

The installation cost includes the following:

1. Electronic equipment
   6 microwave transmit units
   6 microwave receive units
   Parabolic antennas (four 10-foot, four 6-foot), waveguide, batteries, battery float chargers, and radomes.

2. Fuel tanks, towers, (one 20-foot, one 60-foot and one 15-foot), building (10 x 10-foot concrete block), generator, installation, outside labor.

3. Engineering costs (all the engineering design was done by the staff.)

Total investment of 1, 2, and 3 — $100,000

(The back up system original cost was $18,000. However, it was fully depreciated when the all microwave system went into operation.)

MAINTENANCE

The system has been operating for 57 months as of today (April 8). The maintenance for a 4 year period of January 1, 1966 to December 31, 1969 breaks down as follows, giving us a good idea of the average yearly cost:

Twenty trips total to the unmanned Pinal Peak site at $100 per trip	$ 2,000
Six klystron tubes replaced, $253 each	1,518
Miscellaneous parts and building repairs	800
Site accessibility costs $300 per year	1,200
Power and fuel	2,000
	$ 7,518

or approximately $2,000 per yr. Maintenance costs on the back up system is approximately (most of this goes for the site rental) $1,000 per yr. NOTE: The figures used are not to the penny, but as noted as rounded off, which serves our intentions. Also, the maintenance cost figures do not include any manpower except for the Pinal Peak site; on the other sites routine maintenance is done by the transmitter and studio personnel.

Actually our experience has been that the equipment needs very little maintenance except for periodically checking the power supply voltages and replacing the transmit klystron tubes every two years or so. Most of the maintenance on the unmanned site is an annual spring clean up and repainting of the building which does get pretty beat up by the winter ice storms. As noted, we average five (5) trips per year to the remote repeater.

Summarizing the costs of installing and operating this system:

On a total investment cost of:	$100,000
On a 5-year depreciation schedule amounts to	20,000/yr
Maintenance cost per year on the main all-microwave system	$ 2,000
Maintenance cost per year on the back up system	1,000
TOTAL annual operating cost	$ 23,000

(If the back up system was depreciated, it would add about $4000 per year to operating cost.)

COMPARISONS

The rates for CBS-TV Network service only for KOLD-TV in 1965 was $4000 per month or $48,000 a year. We immediately saved $25,000 per year with our own microwave. Under the new tariff, AT&T rates for network service alone are about $7,000 per month or $84,000 per year. Compare that with our system cost and we save $61,000 per year.

In addition, our microwave system includes more than just network service. Since KOLD-TV is part of the Arizona Broadcasting Network, they receive many hours of regional programming from KOOL-TV in Phoenix. Also, the fact that Arizona is in the Mountain Standard Time zone and does not change to Daylight Saving Time in the summer really complicates life. To simplify it, we video tape delay a large portion of the network schedule at KOOL-TV in Phoenix and play it back one or two hours later on the air. Therefore, the service we require is from the KOOL-TV studios to the KOLD-TV studios for a minimum of eighteen (18) hours a day continuous service. AT&T would gladly supply this service, but look at the costs:

Under the old tariffs it would be $7,400 per month but under the new October 2, 1969 tariffs it breaks down as follows:

$ 9,298.30	Interchange channel per month (107 miles)
3,079.00	Station connections per month
725.00	Local channels per month
$13,102.30	Total per month ($500 extra for first month)

That is:

$157,227.60	Per year
23,000.00	Our cost per year
$134,227.60	We save per year

Now I'm sure that there are many points that could be used to show that our private microwave system doesn't offer the same service as the leased service from AT&T; however, the quality and reliability are excellent.

You hear non-engineers very often use the expression "But I'm not an engineer" whenever they are expounding their engineering knowledge. I'm quite certain that an economist could nit pick many points that I have left off in considering the economics of private microwave, but $134,000 per year leaves a lot of nit picking room and besides "I'm not an economist."

A System for Low-Cost Front Screen Background Projection

James W. Hulfish, Jr.
Spindler & Sauppe, Inc.
Glendale, California

The greatly increased level of studio lighting required when television stations convert from black-and-white to color telecasting enormously complicates the job of getting big projected pictures behind news and sports commentators. Conventional rear projection systems, which were adequate for studios, washout completely under the intense ambient light level required in the colorcasting studio.

Most television directors have been unwilling to abandon the widely accepted format of the "live" newscaster positioned before a large projection screen which carries related visual material. But, until recently, there were only three alternate ways to retain this capability in the color studio: electronically mixing color-masked images from two or more televised sources; televising projected images directly on the projection axis through a beam-splitter; or switching to a larger format of transparency for use with a rear projection system. Each of these alternatives introduces new problems, and all share one common drawback; they are far more costly than anything previously required for B&W television.

Typical of the medium size metropolitan stations facing this dilemma, WSAU-Television, Wasau, Wis., began a search about a year ago for some fourth alternative which might avoid the high cost and technical difficulties of electronic mixers and projection beam-splitters, and which might retain the use of economical, quickly processed 35mm slides for news photos.

This investigation led directly to the development of a straight-forward, relatively inexpensive system for front-projecting large screen images behind news and sportscasters, using 35mm slides. This system has subsequently been packaged and is now available in several screen sizes as the "Ultralight TV Background Projection System" from Spindler & Sauppe, Inc., Glendale, Calif.

As is the case with existing beam-splitter systems, the Ultralight System takes advantage of the extremely high gain of a very directional screen material. While the optimum viewing angle is limited, it is possible to televise a satisfactory picture from a point near the projection axis, but not necessarily on it. This is accomplished by using maximum light output slide projectors which flood the screen with so much light that the color camera can tolerate a certain amount of light fall-off occurring off the projection axis. In this way, the need for a beam-splitter has been eliminated.

Basic components of the package are (1) the Dynamic Dissolve Slide Projection System, and (2) the Ultralight Screen. The two projectors in the dissolve system are "Ultrabright" Selectroslide units which are capable, according to A.S.A. measurements, of putting 3,000 lumens onto a screen. By contrast, Kodak Carousel projectors, generally used in beam-splitter systems, are capable of putting about 600 lumens on a screen in conventional projection systems, but half of this light is lost in beam-splitter systems at the beam-splitter itself, which reflects only 50% of the light and "passes" the other half. Therefore, the Ultralight System functions with about ten times as much light reaching the screen as is the case in similar beam-splitter systems.

One advantage of this additional light on the screen is that with the Ultralight System the projected picture is visible from anywhere in the studio, though its legibility is poor when viewed from points well off the projection axis. In beam-splitter systems, however, the projected image is visible only on monitors, and is otherwise completely invisible to those in the studio.

The Dynamic Dissolve System offers television directors three distinctly different speeds of dissolve, one of which is infinitely variable. Slides may be changed instantly using a "cut" or high-speed dissolve. There is a 2-1/2-second "medium dissolve." And there is a variable "lap dissolve" which may be set for anything from a 3-second to 60-minute dissolve duration. In every case, the black screen which normally occurs between slides, has been completely eliminated. All of these dissolve speeds and related visual effects operate entirely independent of the TV camera system, and require no mixing of video images.

The most unique characteristic of the Ultralight Screen is its ability to return virtually 100% of light directly back to its original source, regardless of the angle at which the light originally strikes its surface. This is significant to the Ultralight Projection System in two ways:

With conventional audio-visual screens, the projected image loses brilliance as it is stretched more and more thinly over larger and larger screen sizes. Because it returns all of the original light back to its source, however, the Ultralight Screen theoretically retains its maximum brightness regardless of projected image size. Therefore, very large background pictures are fully as practical as small ones, without requiring an increase in projector light source or an increase in materials format size.

Equally significant, studio lighting is reflected from the screen back toward the studio lights, rather than bouncing toward the television camera. Consequently, as long as studio lighting strikes the screen at better than a 45-degree angle off the projected axis, it does not affect the projected image as it would with a conventional screen. Studio lighting, which would totally washout a projected image from a regular audio-visual screen, has little or no effect at all on the Ultralight Screen's images.

Recent tests reveal the startling reflective characteristics of the Ultralight screen. Using a magnesium carbonate control surface, a reading of 4.2 foot lamberts was obtained. A pearl screen gave a reading of 7.14 foot lamberts and a typical glass beaded screen gave a 10.5 foot lambert reading. In this same test setup, with the Ultralight screen a reading taken 6 degrees off the projection axis (two feet above the projector at a 20-foot throw distance), resulted in 20 foot lamberts; at 3 degrees (one foot from the projector), 54 foot lamberts; and at about zero degrees (3 inches from the projector), 450 foot lamberts!

Translating these findings into terms of screen gain, the control surface having a gain of one, the pearl screen showed a gain of 1.8, the beaded screen showed a gain of 2.65, and the Ultralight screen showed a gain of 107.14.

The test results clearly demonstrate the extraordinary advantage of the Ultralight screen over conventional audio-visual screens from an optimum viewing point. However, they also demonstrate that this advantage is quickly dissipated as the viewer (or camera) departs from the projection axis. The final step, then, in the development of the Ultralight Projection System was to design the facilities setup to take optimum advantage of the system's characteristics.

WSAU-Television accomplished this by suspending the projectors in a cabinet from the studio ceiling at a height just exceeding that of a television camera. During telecasts, the TV Camera is moved into position immediately beneath this cabinet and the projectors of the dissolve system. The camera, therefore, is off the projection axis at a downward angle.

The projected image actually falls onto the commentator, seated about six feet in front of the screen. But because he does not reflect the light as does the Ultralight screen, the image projected onto him is not visible on the monitor. The resulting shadow cast by the commentator onto the screen falls directly behind and (due to the downward angle between the projector and camera axes) below him so that he blocks this from view on the camera.

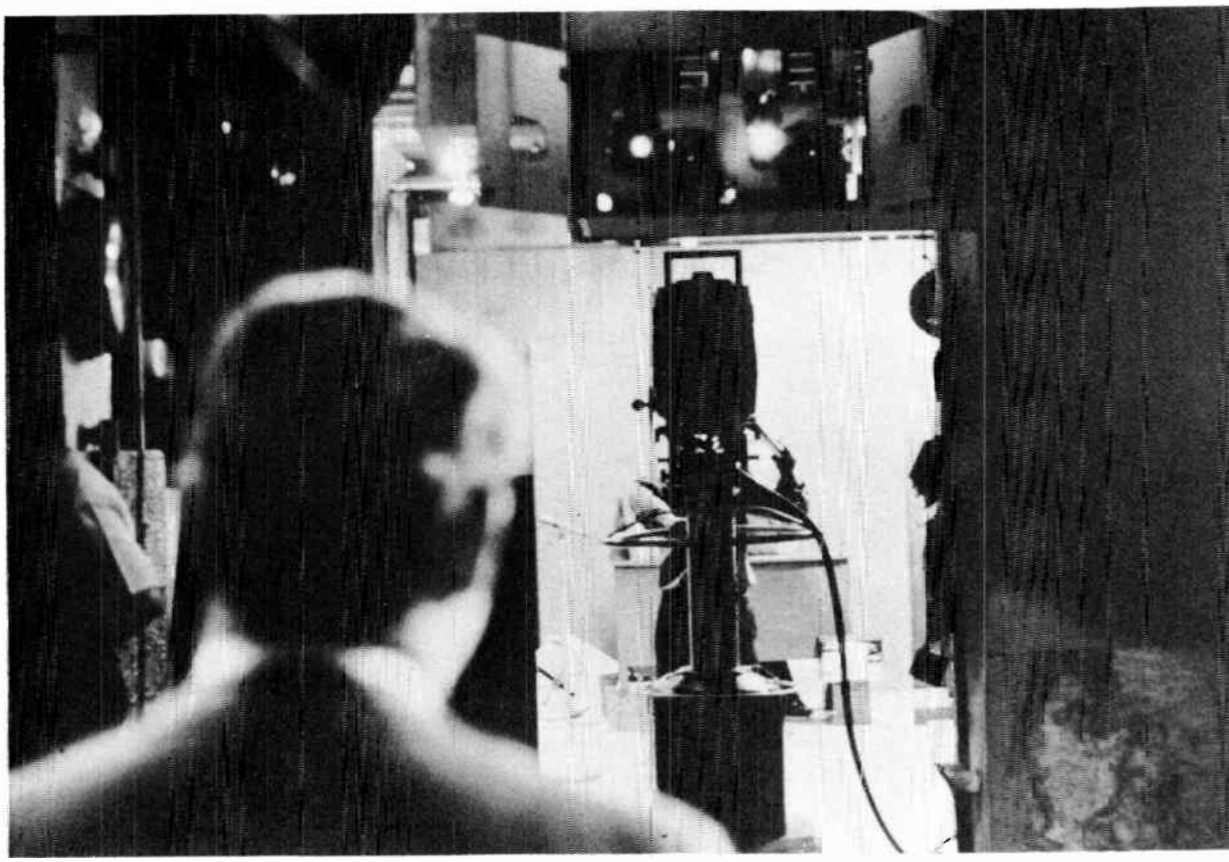
Because all cables (both power and remote control) are carried across the ceiling area, the area immediately below the projectors is completely free. There is nothing to inhibit the free movement of cameras either when the system is in use or when it is not. The television camera itself remains completely unencumbered by bulky external accessories and attachments, and it is not subject to severe limitations in movement as is the case in beam-splitter systems.

The Dynamic Dissolve Master Control is housed in the cabinet with the projectors, and the standard Remote Controller is affixed to the console in the Control Room. Remoted functions include three speeds of dissolve, "standby," reverse, and focus. But more than anything else, the Ultralight Background Projection System is not as much a breakthrough in TV production capabilities as it is a breakthrough in costs. While the dissolve system makes possible certain production techniques previously not available to TV directors, the real significance of the package is the dramatic reduction in the price of big-screen background projection.

The complete Ultralight Projection Package, including a remote-controlled Ultrabright Dynamic Dissolve System, plus a 6 x 8' Ultralight, aluminum framed, snap-on flexible screen, is priced at $3,200. The package with an 8 x 10' screen is $3,600.00; with a 9 x 12' screen, $3,950.00; and with a 10 x 12' screen, $4,075.00. Efforts to further sophisticate the package have suggested one possible modification to the system as presently used by WSAU-Television and others.

Spindler & Sauppe has developed special "periscope-type" projection lenses which include a built-in mirror. These experimental lenses are physically long in length, but function as fairly wide angle 3-inch focal length lenses. These right-angle lenses make it possible to align the two projection axes of the dissolve projectors to within inches of each other, virtually eliminating a slight side-to-side keystone effect which normally occurs with the two-projector system. This also corrects a minor side-to-side light fall-off as slides are alternately screened from the projectors. The substitution of these "periscope lenses" would add nearly $600 to the price of the projection package. Further information about the Ultralight TV Background Projection System is available from Spindler & Sauppe, Inc., 1329 Grand Central Avenue, Glendale, Calif. 91201.

During WSAU telecasts pictures projected onto the screen also fall on the news commentator but are not visible to viewers. The camera is aligned so that the commentator's shadow falls on the screen directly behind him and is not visible on monitors.



Photographed from directly in front of the Ultralight Screen, the commentator's view of the background projection package shows the twin Ultrabright Selectroslide Projectors housed immediately above the television camera. The hinged, ported projection cabinet doors are normally closed for soundproofing.

Preparing to go on the air, the WSAU-TV newscast camera backs into position immediately beneath the Ultralight Projection System. Slide trays for the 96-slide system are loaded between programs from the back of the projection cabinet.

At WSAU-Television the pair of Ultrabright Selectroslide Projectors and Dynamic Dissolve Master Controls were housed in a ceiling-suspended cabinet to allow the TV camera to move freely in beneath the projection axis. Ported doors enclose the projectors to reduce noise level.

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U. S. Communications Corporation
Philadelphia, Pennsylvania

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Federal Communications Commission
Washington, D. C.

MODERATOR WOLFE: Our panelists are:

Lloyd Smith, who is Supervisory Engineer of the TV Applications Branch of the FCC.

Robert E. Leach, Director of Engineering, U. S. Communications Corp., Philadelphia.

Harold L. Kassens, Chief of Rules and Standards for the FCC.

Wallace E. Johnson, Assistant Chief, Broadcast Bureau, FCC.

Robert W. Flanders, Director of Engineering of Station WFBM, Indianapolis.

Albert H. Chismark, Director of Engineering, Meredith Broadcasting Co.

This panel is being presented to help you answer some of your problems. However, before you speak, I would appreciate it if you would identify yourselves.

We all have a lot of problems. For example, some of them deal with power compatibility, the land mobile, the sharing of channels, the Commission's recent report requiring new TV contours, high fidelity, de-icing, and the recent petition by the NAB for relaxation of the first-class operator rules as well as the seriousness of citizen band interference to TV.

Being the moderator, I will take the privilege of asking the first question. What will the FCC actually require in the way of TV proof-of-performance measurements?

MR. KASSENS: Of course, there are a lot of difficulties involved in exactly what we will require. We have all lived with AM for a good many years and it is obvious what has been accomplished there. However, with TV it becomes a little more difficult. For example, if you are going to measure the performance, how much can you rely on the TV demodulator.

MR. SMITH: I would like to make a comment regarding TV proof of performances. This question came up last year at the NAB and so I did a little research on the question.

We require both AM and FM to make an annual proof of performance. The reason lies, in part, in the fact that the AM method of allocation is on an ad hoc basis, and there are interference considerations that we have to keep in mind.

The proof of performance for AM stations includes antenna resistance and pattern measurements. If the pattern of a particular station gets out-of-adjustment, then this means that there is the possibility of interference to some other station.

To cause interference to another station, involves 316 problems—that is, Section 316 of the Communications Act—and would constitute modification of a station's license. This is one reason why we have AM stations conduct proofs on an annual basis.

However, this is not true in TV because of the method of allocation. We have a table of assignments and have maximum permissible antenna height and power requirements.

MODERATOR WOLFE: In the matter of TV and STL microwave frequency tolerance, many of the newer systems incorporate AFC loops, with an accuracy of .005 percent.

It seems to me, referring back to what is required in this connection, we have the question as to what is tolerance and is the AFC loop of the crystal-controlled AFC system adequate to guarantee the proper frequency?

MR. SMITH: Insofar as the frequency measurement is concerned, I cannot go into detail about broadcast auxiliaries. However, I will give you a number that you can call at the FCC in Washington to get specific details. We have one man that takes care of all broadcast auxiliary services.

Insofar as the measurement of frequency is concerned in TV, I get a lot of questions regarding whether the use of a type-approved frequency monitor is required.

There is no requirement to have a type-approved frequency monitor in a TV station or, in fact, you don't have to have a frequency monitor in a TV station. We simply say that you must keep your frequency within the prescribed tolerance, and you can do this by having your own equipment or from an outside source.

Now, I would assume that the same type of situation exists with the broadcast auxiliary services. Does this answer your question?

REPRESENTATIVE: Then, actually, when they make reference to a .005 frequency tolerance in the Rules, they really don't apply to an STL? They make reference to the STL and also the translator relay, intercity relay?

MR. SMITH: We do have a prescribed frequency tolerance and you are required to maintain your frequency within the prescribed tolerance. As to how you insure that your equipment is operating within these tolerances, that we leave up to you.

REPRESENTATIVE: What is being done to clarify the FM stereo standard regarding signal-to-noise ratio?

MR. KASSENS: First of all, we do not have a requirement for stereo proof of performance as yet, but I would anticipate that within a few months we will. The signal specifications are in the Rules insofar as how you should operate, but there is no requirement that you run an annual proof for stereo.

REPRESENTATIVE: Since the present feeling is that AM and FM is one service of equal magnitude, when are the Rules with respect to SCA going to be taken off FM since the addition of SCA on any FM affects the main channel signal?

MR. KASSENS: Well, if you will go back to 1954 when the Commission first said that simplexing in the FM band had to stop and the simplex operator said that multiplexing was impossible, the Commission justified its multiplex decision on the basis that FM stations needed the added revenue. I am sure that it was true in those days. However, I don't know that the Commission is now at a stage where it would be willing to come out and say that FM stations are making so much money that they really don't need the added income. However, I note that, in discussing the problem with background music operators, the SCA business is starting to trickle off; in fact it is more than a trickle in some locations, because of the competition built up by other systems.

I think it is conceivable that within the next few years we will see a considerable number of FM stations giving up their subcarrier. For example, I have heard in the past year of some FM stations with good dynamic range who have decided they don't want to bother with SCA anymore.

REPRESENTATIVE: I wonder if someone would care to comment on the receiver problem that seems to have arisen—where there is wide dynamic range used by some stereo stations and in connection with which there have been some complaints or comments that SCA does seem to be generating some low residual signals and the factor of FM receivers seems to have come into discussion.

MR. KASSENS: Very interesting! We have known for a long time that stereo and SCA create a mutual problem. The problem, of course, is the 9-kHz whistle. This, however, is down to as low a level as it can be. It is not too objectionable unless the station still likes to get a good dynamic range. But, surprisingly, many receiver manufacturers do not understand what the SCAs are and what the problem is. It would seem that a manufacturer would put the proper SCA trap into the receiver.

There are some who have omitted the trap and, consequently, this caused some problems. I think that you will find cases where the 9-kHz whistle shows up. The problem, most of the time, is the fact that the receiver manufacturer is trying to save a few dollars by leaving the SCA trap out.

QUESTION: When will the Commission authorize VHF-TV remote control?

MR. KASSENS: Well, if you would like to spend a few hours and listen to all of my problems I will be glad to devote the time to tell you about them. We operate under a budget and with postage stamps going up to ten cents I don't think it is going to help me very much. However, we do have some urgent priorities, one of which is the land mobile problem. This has first priority. Hopefully, we will get back to remote control of VHF and get it out within a few months. The exact date I would say depends on the answer to the land mobile problem.

As to how this is going to be done, I think that you have had a sufficient amount of experience in AM-FM to know where we went wrong and what we have to do to improve the situation for VHF.

REPRESENTATIVE: We have heard several comments regarding AM positive modulation and, of course, there are transmitters available now which will modulate up to 150%. Is the Commission looking into this situation and what would be the final positive modulation limit that the Commission would set?

MR. KASSENS: This is a serious problem and I would not want to cast any reflection upon any manufacturer, but I think that every AM engineer in this room should stop and give some serious thought to this question. A good many years ago, on petition, the Commission deleted the requirement that positive peaks be limited to a hundred percent and the answer was obvious. We all know what went on in AM stations. The fact that positive peaks went up to 120% on occasion did not really disturb anyone.

We have two requirements, of course, that concern this modulation problem. One is carrier shift and the other is distortion. Now, if you can show me how you can modulate a transmitter up to 170% and meet these limits, I would like to see it. We were concerned with this when this animal raised its ugly head, and we were scared of what was going on. We had one manufacturer come in; we talked the situation over and we asked for measurements.

Now, think about it for a moment; how do you make measurements to prove distortion under operating conditions? Well, we have asked for the measurements, and I understand from talking to a manufacturer this morning that they were sent to the Commission about two weeks ago. I have not seen them. If the measurements show that distortion and carrier shift are within limits, then I think that we are going to have to consider other factors.

Of course, if everyone is modulating at 100% and one guy goes up to 170%, then he is going to cause a lot of interference to the station sitting next door to him unless that second guy turns around and does the same thing. If you want a limit on positive peaks, we can put it in but then it will bring us back to where we were twenty years ago, and you will have to cut down the modulation. I don't know the answer, but I think it is a serious problem.

MR. JOHNSON: Can we get some industry members on the panel to comment on that? We would like to get their views.

MR. CHISMARK: Doesn't this really point out one of the good reasons why we should be looking toward revision of rules for controlling some of the parameters; should we be thinking more along this line so that we can control them?

MR. KASSENS: I think that is a very good reason why you have the FCC. If everyone takes off on his own you have chaos. I think that the rule should be very seriously considered. I would not want to sit here today and say that I know the answer. I would hope the industry has the answer.

MODERATOR WOLFE: I don't think the industry has the answer, and I don't think they have done a lot of study on it either.

QUESTION: In reference to the petition for lessening of first-class operator requirements on directionals, what is your personal opinion on this in reference to the so-called eight-week wonders as we have heard of them?

MR. JOHNSON: I guess that every year we make a statement about operator problems and this past year we have had a study going on within the Commission with some help from the NAB in looking into the whole operator problem. We are trying to determine if there is some other way of handling the problem at the station which will insure that the use of operators in some way will assure that the station will operate in accordance with our technical standards. There are all sorts of ways of approaching the problem and, as you know, there are all sorts of problems with the present system.

The fact that we give a man a license doesn't assure anyone that he is going to be able to operate a particular station. All it does is to give us some assurance that he is somewhat familiar with the technical aspects of radio.

One of the things that we are looking at is the problem of logging; looking towards the possibility of recognizing an operator who will mainly log the parameters of the station as it operates and also recognizing in some way the technical operator. Of course, the word "technical" could take several different forms. We may come up with new classifications of operators and we may be adding questions to our operator exams which are related to the actual operation of the station.

One thing that concerns us is that we continually give citations because of bad technical operation of stations and I don't think this has been improving under our present system of licensed operators. Anything we do that changes the license requirements always seems to be considered a relaxation. When and if we develop new operator criteria the stations may in turn feel that we have relaxed the technical operating requirements.

You may see something coming from the Commission very shortly, probably in the form of a proposed rule-making or an inquiry proposing some possible solutions to the operator problem and requesting comments and suggestions of industry.

The other thing we are considering is the possibility of putting more of the burden and responsibility, as far as technical operation of the station is concerned, on the operator. It may be that we will actually place some of the primary responsibility for the technical operation on the operator. This is another matter that you should be watching for; and we will be undoubtedly asking for your help on that.

MR. CHISMARK: Do you think it would be advisable to go back to the essay type of questions rather than the multiple choice?

MR. JOHNSON: We have such a volume of examinations that are given that it becomes difficult to try to grade these exams, so we have to devise some scheme which has some possibility of getting answers in some reasonable period of time. If we go to the essay type of questions, it would be a very subjective thing and we could have different grading by different people who are grading the examination. Therefore, I think one of the things that would govern and control the essay type of question would be the volume of examinations given.

One part of the question had to do with operator schools. We are very much concerned with some of the schools and the graduates of some of the schools. We do not know exactly how to put a handle on this as yet, except through the examination route.

You have probably heard of some of the problems we are having with examinations. There is some cheating going on in examinations and one of the interesting developments was a set of pencils that came out where they had the answers actually written on the sides of the pencils. Someone apparently got hold of the answers in the examinations and then actually put them on the pencils. As a result, the individual using that pencil could come up with a pretty good grade.

MR. KASSENS: I would say that it would be pretty difficult to do that sort of thing on a pencil with an essay type of examination.

REPRESENTATIVE: I have a question on the profanity section of the regulations. Just exactly what is profanity? I am with an educational TV station and certainly any four-letter word that you can think of can be construed as profanity. Therefore, exactly what do we do?

I was particularly concerned about this some three weeks ago in connection with one of our educational programs, in which we were forewarned that there were going to be some bad words said and so I didn't know what to do about it. I still cannot get anyone in the Commission to make a flat statement on that.

Are all of these four-letter words (and I am sure you know what I am talking about) permitted to be on the air? What exactly is the status? What do you do under those circumstances?

MR. JOHNSON: I might say that Harold became Chief of Rules and Standards about a month ago and it did not mean an increase in pay. He was Assistant Chief of the

Broadcast Facilities Division and went over to Rules and Standards at the same pay. When we were coming to Chicago, I told him that he was really going to earn his pay by the removal of the word "Assistant" from his title. I think that thus far at this Convention he is earning it.

MR. KASSENS: Well, in connection with that question, I would assume that if you called the General Counsel of the Commission that you would receive an answer. I, at this stage of the game, would not want to give you an answer; but I can say that the Commission has been very much concerned about it; and I think that you will all have a chance to follow this one through.

In case you have not been reading the trade press recently, I might say that the Commission charged an educational station in Philadelphia with the use of some questionable language; and I would think that if this matter were to go to the courts, it would go all the way up to the Supreme Court; because I don't think that anyone else knows the answer.

You and I have reactions to this sort of thing going on; but the First Amendment to the Constitution, being what it is, raises a rather serious problem as to just how far you can go. If four-letter words are fine, then what is wrong with stag movies?

I don't know what the limit to this thing is but the Commission has decided to attack the problem because it recognizes that it is serious. Hopefully, within the next few years, we will be coming up with an answer.

REPRESENTATIVE: In light of the new rulemaking, do you want to give us a thumbnail description as to what you are going to expect of us in the way of TV measurements and contour calculations?

MR. SMITH: Effective today, and I see copies of the Report and Order here on the stage, we have made some slight changes in the method of predicting the Grade A and Grade B contours for TV stations. Until today, the antenna pattern reference was the horizontal plane and these contours were based on the height above the average terrain and effective radiation power in the horizontal plane. We have shifted that reference point to the effective radiated power directed towards the radio horizon.

In connection with the Report and Order, I am not sure as to the effective dates that are involved; but I think that from today each authorized TV station has approximately 90 days in which to either submit new exhibits regarding their coverage contours or a statement from a qualified person that there is no change in their coverage maps from what they already have on file.

REPRESENTATIVE: I note there is a formula in the Order. Does this necessarily follow the original figures or is this going to involve a change?

MR. SMITH: Some stations using beam tilt have contours showing on file based on maximum radiation lobe. If your maximum lobe would occur at the depression angle determined by this formula which we consider to be the radio horizon, there would be no need for a new filing. However, this doesn't necessarily have to be the case.

In order to get better close-in coverage in some cases there is quite a large depression angle. We also have provisions for the situation where if the radiation directed towards a radio horizon is within 90 percent of the maximum lobe value, then you can use the maximum lobe. Therefore, it depends on just what degree of beam tilt is involved.

MR. KASSENS: The date on that is July 9th and this applies to VHF stations as well as UHF. Every station will either have to come in with a statement or a new set of contours.

REPRESENTATIVE: What is the status of the FM modulation monitor problem? Has the Commission investigated any new monitors and what is the thinking on that?

MR. KASSENS: The modulation problem is linked into the RF amplifier problem. We have a rule-making proceeding on RF amplifiers. We are still looking for the answer. Nobody has come up yet with what appears to be the ultimate solution.

The nice answer is to have the monitor driven by an RF amplifier, but how will you make sure that this will guarantee that you still get correct answers? We have been searching for this one for a good long time but feel we still do not have the answer. The flashing light problem is connected with the RF amplifier problem and I wish that someone here could come up with the answer.

MODERATOR WOLFE: What is the Commission doing about the citizen band second or third harmonic interference problem as it effects TV Channels 2 and 5?

MR. JOHNSON: That is something that we were discussing last night. We are aware of the fact that this may be a problem. Some stations have told us about it, but I am not aware that we actually have any complaints coming to us. Maybe we could turn to some of the other fellows on the panel.

MR. CHISMARK: I was going to mention the educational FM interference to Channel 6. I think that is more important.

MR. KASSENS: You want an answer to it? Well, so do I. Of course, what we would like to do is to keep every adjacent-channel FM station at least seventy-five miles away from every Channel 6 TV station, but this is going to carve out some tremendous holes. Now that Congress has made money available for educational radio as well as TV, there is a tremendous upsurge. The problem, as any engineer knows, is the receiver, and as to how you get the receiver manufacturers to solve the problem I do not know. Unfortunately, our authority stops at the end of the transmitting antenna. I think that presently we are in a quandry on this one.

REPRESENTATIVE: I have a problem in connection with a station operating in a citizens band and this has to do with the insufficient allocation of funds for the inspectors to follow through on it. Is there any hope in the immediate future of eliminating some of this problem?

MR. JOHNSON: It is my understanding that some of the people who are trying to regulate the citizens band feel it is a nightmare. The field inspectors are trying their best. They usually investigate problems on the basis of complaints received. Our success in trying to increase the field force has not been good lately. We are not sure how many inspectors we need to get a handle on the citizens band, but the Commission has been urging local citizens band groups to assist on a self-regulatory basis.

I am not sure what we can do to increase our field force; but if you can think of something, we would sure appreciate it. Our funds are allocated on the basis of specific numbers of employees in each area, and we have not been very successful in increasing the number of employees in the field program.

MR. SMITH: I would like to say that we do get scattered complaints in our shop regarding these inherent sources, which we immediately refer to the field. The field bureau may have some ideas as to what the volume is. I don't, however, know off hand.

MR. FLANDERS: We normally direct phone calls to the local office which in our case is Chicago. It might be encouraging to know that the inspectors have been looking at the linear kilowatt and, as an added benefit, if they can do anything about it, they can clean up any four-letter words they find on TV programming.

REPRESENTATIVE: We have had several instances lately where local inspectors have indicated to us that the orange color on our towers has faded excessively. It seems that this is a judgment made at the discretion of the inspector. Is there any thought being given to setting up standards, giving us color chips or something so that we can tell in what range our towers are legally painted orange?

MR. KASSENS: We have been working with the EIA on a color reference signal and perhaps we need one in this area also. You are right; it is a question of judgment, and I would certainly hope that the field force is not overly anxious. Admittedly, the inspector coming by doesn't have to pay the painter's bill, but I would not want to let the towers get too bad. The condition of the paint on some of these towers is surprising, and I would certainly think that anyone would want to have his tower well painted for his own benefit in connection with rust if for no other reason.

REPRESENTATIVE: We have had trouble with the paint not holding up.

MR. KASSENS: Possibly there was something not entirely right with the pigment of that paint; there was some reason that it faded too quickly. Of course, we all have our problems and maybe the painter has also. Maybe he got a bad load of paint from somewhere, but then I thought that individuals like this were pretty well locked into the international orange. I am surprised to hear of your difficulty, and I have not heard of another case like it.

MODERATOR WOLFE: I think that our time is now up. Let me thank all of the panelists for a fine job.

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