Technical Papers

Presented At
The 20th Annual NAB
Engineering Conference

March 28-30, 1966
Chicago, Ill.

ENGINEERING DEPARTMENT
NATIONAL ASSOCIATION OF BROADCASTERS

1771 N STREET, N.W. WASHINGTON, D. C. 20036

PROCEEDINGS OF THE 20TH ANNUAL NAB ENGINEERING CONFERENCE

Table of Contents

---

*Film, based on enclosed booklets
**Paper not furnished by speaker

FCC TECHNICAL PANEL

Moderator: Leslie S. Learned, Director of Engineering, Mutual Broadcasting System

FCC Panelists:

Hart S. Cowperthwait, Chief, Rules & Standards Division

Otis T. Hanson, Chief, Existing Aural Facilities Branch

Wallace E. Johnson, Assistant Chief, Broadcast Bureau

Harold L. Kassens, Assistant Chief, Broadcast Facilities Division

Harold G. Kelley, Supervisory Engineer, TV Applications Branch

Curtis B. Plummer, Chief, Field Engineering Bureau

(Taken from the official transcript)
20th NAB BROADCAST ENGINEERING CONFERENCE
Chicago, Illinois
March 28-30, 1966

FCC TECHNICAL PANEL

NAB Broadcast Engineering Conference
Chicago, Illinois
Wednesday, March 30, 1966

MR. LEARNED: Good morning, ladies and gentlemen, and a happy welcome to you as I start as moderator of this star-studded list of panelists.

The panel has proved to be very successful in the past, and there is no reason for me to believe that it will not continue to be so in the future. As a matter of fact, we are about to embark upon a rather unusual experience, a kind of man bites dog operation. Where else will you have the opportunity in open meeting to directly put your questions to the FCC? I am told that they sometimes ask you very direct questions, and I believe they come in numerous forms and some of them even on different colored paper. So now is your opportunity to at least meet some of these people face to face, and it is my sincere hope that in so doing, you will come to the general conclusion that these people are not quite the ogres that you have often thought them to be.

As a matter of fact, I hope that they, too, will come to the similar conclusion that you people, perhaps, are not always juvenile delinquents.

Inasmuch as this is a very large hall, we have four microphones on the floor for your questions from the floor. Now if it makes you feel any better, I might say that it is not absolutely necessary that you identify yourself.

As you know, I am Les Learned of Mutual and our distinguished panelists are as follows:

Hart S. Cowperthwait, chief, Rules & Standards Division;
Otis T. Hanson, chief, Existing Aural Facilities Branch;
Wallace E. Johnson, assistant chief, Broadcast Bureau;
Harold L. Kassens, assistant chief, Broadcast Facilities Division;
Harold G. Kelley, supervisory engineer, TV Applications Branch; and
Curtis B. Plummer, chief, Field Engineering Bureau.

Due to illness, Ralph Garrett, chief, New and Changed Facilities Branch, is unable to be with us.

Our first question deals with the go-no-go rules. What are they and how are they working?

MR. JOHNSON: I'm sure you are all acquainted with the go-no-go rules. It is a new method we have devised for processing new stations or major changes in existing stations. It went into effect in August of 1964. You remember under the previous allocation rules, for AM, we went through a procedure whereby we first determined whether a new application would cause interference to an existing station and if it did cause interference to an existing station, how much interference it would cause. We went through a calculation whereby we determined the extent of the interference as far as miles are involved. Finally, we determined how much interference was caused to existing operations, how much service was lost, and we weighed the gain in service against the loss in service to the existing stations and finally came to the conclusion that in AM, the service had pretty well matured. We had over 4,000 stations and they wanted to come up with some device whereby it would be simpler to process these applications and come to a final conclusion. So the go-no-go rules were devised.

This is a system where we take the pertinent contours, that is the protecting contours of an existing service, then determine where the interference and the interference contour would fall, and if there is an overlap of those contours, we say "no-go".

As one broadcaster downstairs said to me yesterday, griping, "Go-no-go, I sure found out what that means. I wanted to go and all you kept telling me was 'no-go'."

Then we added another thing for nighttime where you have to serve a 25% wide area. As far as actual operation is concerned, we don't think it has really saved us much time in processing the application. The engineers processing the application, since it is a very specific determination they make, you are either in or you are out, it is probably a little more difficult to come to a conclusion and it takes a little more time to come to that specific conclusion on these real close ones. So it is probably taking a little longer to process the applications initially. But we are saving a lot of time, especially in the hearing areas. We don't go through hearings any longer on the new applications, coming up with involved studies and testimony on services in the area that are lost and services that are gained.

So, on an over-all basis, we think it has saved us time, but it has increased the processing time somewhat in the initial processing.

MR. LEARNED: Thank you.

This question, I believe, is a kind of double-pronged one and perhaps Mr. Kelley might be the logical one to answer it.

QUESTION: When we were required to reduce our aural power recently, we were able to bypass the aural amplifier and feed the antenna system directly from our aural driver stage in order to attain 20% aural power. Would it be possible to obtain authority to use the surplus aural amplifier as either an auxiliary or alternate final amplifier for the visual transmitter?

MR. KELLEY: Yes, assuming that the surplus aural final amplifier can be adapted to the visual side, it could be used as either an auxiliary or alternate transmitter. This would require an application on Form 301 for CP to make the change. As a matter of fact, a number of stations have already done this.

MR. LEARNED: The second part of that question is, "What is the difference between alternate and auxiliary transmitting equipment insofar as their use is concerned?"

MR. KELLEY: By alternate we mean just that, that you may use the alternate equipment without any specific purpose. In other words, you may use the alternate one day and your regular equipment the other day without any purpose at all.

On the auxiliary equipment, we usually limit that to use during an emergency, for maintenance, and for test purposes. And the requirements are slightly different on the two in that an application for a license for the alternate equipment requires the full proof just the same as if it were the main, and it must be type-accepted equipment. And on the auxiliary, we don't stick to the requirement that it must be type accepted, nor do we normally require complete proof of performance on the auxiliary equipment.

MR. LEARNED: What should an FM or TV engineer do to his modulation monitor to keep from being cited for over-modulation?

MR. KASSENS: Wally says, "Get out of the business." Well, I don't think it is quite as complicated as we have tried to make it. I mean, the industry as a whole. The simple answer is to read the instruction book.

Now, we are all engineers, we know how this thing works. The first thing you do when you get a piece of equipment is unpack it. The last thing you ever do is read the book. If there are any equipment manufacturers here who are thinking in terms of next year's show, I have a suggestion: if you can somehow figure out how to get the pages of the instruction book into the latest Playboy Magazine, you might get somebody to read it, especially if you put it in the center fold.

We have found, in cooperation with the NAB Engineering Advisory Committee, that the modulation monitors work acceptably if you calibrate them properly. Now a little over a year ago, we went down to Raleigh, North Carolina, representatives of the Advisory Committee, representatives from the Commission, and we brought our truck along to see how bad this thing really was. Virgil Duncan had set the thing up for us.

Now we recognized the fact that we were using specific types of programing. He had taped various programs. We recognized that you can get different answers with different types of programs. But we tried several different kinds of modulation monitors and we compared the readings we got from the modulation monitor with what we got in our truck and we found we could get agreement if we didn't try to set the flasher at 100% and if we didn't try to set the meter at 100%.

This is why I make the statement about the instruction book. If you look in most instruction books, it tells you not to try to run the meter over 50, 60 or even 70 percent. If you do that, I don't think you are going to have any problem with us.

The fellows we run into are the fellows who are modulating as much as 100% on the meter which means that quite often we are getting readings of 200% modulation.

Now the statement has been made that you are required to use the modulation monitor of the type we approve, which implies that it is approved for this use. But we approve it with the statement in the instruction book and I suggest you would find it very helpful to go back and calibrate this thing and I think your readings and ours will be much closer together.

MR. PLUMMER: I have one comment. Ever since we started issuing citations in my department, I have disliked the word "citation". A citation to me is something good.

The policy at the moment is that we are not closely adhering to something over 100%. I am not going to give you any magic figure, but we have to use some discretion, so unless you are pretty bad, we are not going to hand out the citations.

QUESTION: Having been cited for undermodulating an FM station, the question comes up, when an inspector is on the premises and stands around and watches the station monitor for a while and says, "O.K., when are you going to hit 95%?" Now I know, on voice particularly, if we are more than about 40%, we are really 100%. Does he know?

MR. PLUMMER: As I understand it, the instructions to the inspector are to watch this for a long period of time. He is not going to walk in and say it is 40% and here is the citation. He is going to watch it for a long time. Sure, if you are playing symphonic music you are going to have low passages which is all right for a period of time, but he can judge that. If the announcer comes in with a spot, the normal practice is to run it up as high as you can and he will be watching for that too.

MR. LEARNED: The next question I have here is, "Has the draft and the Viet Nam conflict caused a shortage of operators in the broadcast field?"

MR. PLUMMER: I would say over-all, no, but there are some spot situations here and there that pop up where people have difficulty getting operators. Now to be very frank with you, I want to tell you about one of our indicators of the situation.

We give out short-time waivers to allow you to find operators. And the request for waivers has actually been going down. I will give you a few figures here. Take the second quarter of the year which has just finished. In 1964, we handed out 46 waivers and in 1965, 28 and in 1966, 31. Now it has come down considerably from the first year.

The first quarter figures are 62 in 1964; 50 in 1965 and 34 in 1966. And we consider that that situation is fairly significant. If I may be a little bit catty, I also think economics comes into this.

MR. LEARNED: In the new UHF television table of assignments, the FCC stated that the individual channels were picked by a computer. Question: Our city has not been assigned a station - do we need to buy a computer to find one or will the FCC accept our petition for a channel that we know will work here?

MR. COWPERTHWAIT: No, as unreasonable as we appear to be at times, it won't be necessary for you to buy a computer or even rent one. Any computations that are done with computers can also be done manually. It just takes a little longer. So, therefore, I would suggest that in conducting your search for a channel that you do it by manual method, using the priorities that we set forth in our Fourth Report.

After you have found the channel, you can petition us. Upon receipt of the petition, we will interrogate the computer to see if that is the most efficient channel. If it turns out it is not, we will substitute the channel that the computer selected, but we will still put out your petition for rule-making, other matters being satisfactory.

Now the question may come up, why go to all this trouble when the Commission is going to select the channel anyway? Well, the answer is, you don't have to, if you trust us. You can merely submit your petition, giving the reasons why you think a channel should be assigned to your particular city and we will go ahead and find the best channel for you and issue the rule-making.

MR. LEARNED: If the operator cannot see the transmitter, can extension meters be installed?

MR. HANSON: Unfortunately, the rules do not provide for extension meters. They provide for either remote control or direct control by the operator of the transmitter. We have the rule, if you want to call it that, if you can see the meters on the transmitter, not necessarily read them, but can see the indications, to know the meter is reading within the ball park, shall we say, by means of a mirror up on the wall or through a window, this is fine. But you still have to go and read the meters every half hour as you are required. We do not, at present, permit extension meters as such.

MR. LEARNED: I am a daytime only operator. During the Northeastern power failure, the local Civil Defense Director called and requested that we operate beyond our assigned time. Just what are our responsibilities in this type of situation?

MR. JOHNSON: That is a good one. We get a lot of questions raised by operators; we get long-distance telephone calls from operators during emergencies and sometimes the Civil Defense Director is standing next to him and sometimes he takes the phone. And every time they call, we are sure that the operator has a lot of hesitancy about complying with the request of the Civil Defense Director or some other authority in the area. Sometimes, some of the other authorities in the area, of course, are pretty eager. They want one particular station to operate for some reason even though some others are providing the service.

And I think it is Commissioner Lee who keeps saying the best experts we have in broadcasting in the field are the operators of stations. They should be in a position of determining when an emergency justifies their operating beyond their normal hours of operation. They are the ones who are going to be responsible if any questions are raised. And in our emergency rules, we have made the determination; the determination that is put on the operator; the operator determines whether the emergency justifies his extended hours.

So we considered the request of the other officials, Civil Defense and others, as some need in the community for additional operation, which the operator should respond to. This is one bit of information he uses to help him determine whether the emergency justifies his continuing operations. We want the operator to make the determination.

MR. PLUMMER: Do we second-guess whether it is a good determination in the end?

MR. JOHNSON: Very seldom do we ever have kick-backs, if you want to use that word, on an operation of a station past its normal hours. Most of the stations are really good about it. They will operate in areas where there is no other station. They will have a real emergency situation which justifies their continued operation and offhand I can't think of anyone whom we have gone back to and really tried to question him about his judgement in the particular situation.

QUESTION: As state chairman of SIAC, I would like to clarify a point here. Is it not true that under EBS that a daytime only station can only operate in its licensed hours in the daytime only but that the emergencies you are referring to are where there are tornadoes and things of that sort?

MR. JOHNSON: Yes, I think we should straighten that out. A lot of questions were raised during the Northeast power failure, what happened to EBS?

SAME QUESTIONER: EBS can only operate daytime?

MR. JOHNSON: In some of the state plans, daytimers are included. However, you say "daytime"...it depends on the state plan you have. The problem that we have is differentiating between EBS which is a national emergency evoked by the President and the localized emergency. One of the things that is being worked on is trying to fragment the emergency operation to fit the local operation and I think there is a subcommittee of NIAC who is working on that where we will take the facilities that are provided and set up in EBS and fragment them and make them available for local operations.

QUESTION: I think the point that needs qualifying here, you are going to get a lot of requests. This is under the EBS plan only, on the stateside. We have been discouraging the specified hours for daytime only stations from applying for hours beyond that. We have been discouraging their area Civil Defense Commander asking for their operation beyond that. Now this is under the EBS plan only, not under any other type of emergency. They were limited. The theory being for maximum service by other stations, if the daytime only stations operate they are cutting down the service area perhaps of other stations.

MR. LEARNED: As far as I know, and I think you can probably back me up on this, Wally, there is no current plan afoot to permit daytimers to operate beyond their operational areas.

MR. JOHNSON: I know in some of these state plans, some of the daytimers have submitted their request.

MR. LEARNED: None have been granted?

MR. JOHNSON: No.

QUESTION: I would like to refer back to a previous question regarding remote control. Some manufacturers can supply you with meter reading to add to your transmitter, to remotely meter and control it for distances, we will say, of 50 to 100 feet where it is not practical to knock out walls and use mirrors and so forth.

My question is: What about "Fail-Safe?" Can we get by without absolute "Fail-Safe", because I don't know the exact definition as to your rules, as to what "Fail-Safe" constitutes.

MR. HANSON: The transmitter then is on the same premises where it is being controlled, on the same floor or maybe the floor above.

I think that we have, well I can't say, it has not actually come up before, but I think we would probably look askance at it. I hate to be arbitrary on it, but I think the rules are, it is remote control or not remote control, so if you have remote control, you have to comply with the rules.

I will go back and say that if somebody doesn't particularly like the remote control rules, they are perfectly welcome to come up and convince us that they should be changed, I am sure Mr. Cowperthwait would be willing to do it. Maybe this is something that was not contemplated when the Commission adopted the remote control rules. It was actually thinking about the transmitter being at a distance somewhere and not in the same building. It is something that could be very well taken care of.

QUESTION: From a technical standpoint, almost all of the aspects of "Fail-Safe" would be caused by it. That is, we would comply in almost every respect but in order to be specific you would have to define what constitutes "Fail-Safe" that is whether the grounding of the circuit or opening of the circuit or closing of the circuit would constitute "Fail-Safe," and there are no definitions I can find in the rules regarding it.

MR. HANSON: The main thing in remote control is being able to do at the remote point what can be done at the control point itself. And if it is only a short distance away, you can get to the transmitter and you know it is happening and you can do something about it.

MR. KASSENS: Let me go just a little bit further. If you are talking "Fail-Safe" and you have a provision for shutting off a transmitter from the control board, this would be acceptable. We have to be sticky on this point. The rule says it is either remote control or it is not remote control. Unfortunately, you have to draw a line somewhere. We can look at these on a case-by-case basis, but it gets a little bit difficult if the transmitter is in the next room and you say, "Let's be reasonable and you walk around the corner." And the next guy comes in and says, "Well, the transmitter is only one floor below." It gets confusing to us to try to distinguish one from the other. So we either say you are in or you are out.

It may sound unreasonable, but we do try to look at these things on a case-by-case basis.

MR. LEARNED: Because of the program schedule problems, we sometimes find it necessary to video tape certain color programs directly off the network for broadcast at a later time. However, our particular video tape machine is not designed for color playback. Consequently, the chrominous information is transmitted, but the 3.5 Mc/s reference burst is wiped out. Is there any FCC rule governing this or what is the policy of transmitting color programs in monochrome in such cases?

MR. KELLEY: Well, being facetious, I would suggest you get a tape recorder that transmits color. But other than that, there is no requirement that a station transmit programs in color received from a network or any other source. So the transmission of color is purely voluntary by the station.

In this particular case, I can foresee there might be some problem - some of the chrominous information may get through and trigger the color killer on the receiver. It might give flashes of color on the receiver. That, perhaps, might be undesirable. But so far, we have had no complaints on this particular point.

MR. LEARNED: The Commission's Rules were recently revised to make each licensee using a single antenna structure requiring obstruction lighting, responsible for checking the condition of the tower lighting and entering the information in the station's log (now the operating log, per Docket #16005). In the case where a single licensee uses the main station antenna tower as supporting structure for his own associated auxiliary station, such as remote pickup base station, or STL station, does this tower lighting information also have to appear on the log for the auxiliary station?

MR. KASSENS: No, it does not, not in the same fashion that you indicate on the log. You can cross-reference it, for instance, just to put a note in the log saying, "see main log," and this will be acceptable.

The same question comes up where you have multiple licensees where one man, by contract, assumes the responsibility for checking the lights and the other licensee has referenced his log to the licensee with whom they had the contract.

MR. LEARNED: The next question I have here is directed to Mr. Plummer.

"I am the owner of an AM broadcasting station and my modulation or frequency monitor has become defective. A period of 30 or more days may pass before I can have the meter repaired. What procedure do I follow?"

MR. PLUMMER: This is one that is always coming up and there is always a misunderstanding. We get telegrams in Washington requesting permission to operate without monitors. All I can say is, save yourself the price of two telegrams and just notify our inspector in charge that you are operating without a monitor and put in an oscilloscope to check it during that time.

MR. KASSENS: I think the rules are rather specific on this point. It is permissive and you may operate without the monitors as long as you notify us and do certain things.

MR. KELLEY: In TV, I think, this is missed completely by a lot of people.

In view of the change in our rules about a year ago, on the frequency measuring and checks for television, a frequency monitor per se is no longer required for television.

MR. LEARNED: Next question, "I plan to change my studio location. This will change my remote control point. Can I just report this change when I report the studio change?"

MR. HANSON: Unfortunately, no. I get frantic telephone calls and telegrams saying, "I am going to move my studio out of my remote control. Must I file an application if I notify you?"

Under existing rules, every time you move or change your remote control point, you have to file 301-A. We act fairly fast on them. But you have to file it. We are working now on some simplifications of that rule and I hope we can get agreement on it and put it up for rule-making very shortly. I hope that it will let you move the remote control point when you move your studio. If you have authorization to move your studio from X Street to Y Street, since you already have it, you would just pick up the pieces of gear and move them. We think maybe we may go along with it.

MR. LEARNED: What is the status of the U.S.-Mexican AM Treaty?

MR. JOHNSON: That is something that has been asked me many times at the convention here, of course, and I guess my answer should be "gracias."

There is quite a history. I don't know how far you want to go into this thing, but we have been so deeply involved in this for some time. But basically, we have two basic AM agreements. One, the North American Regional Broadcasting Agreement which has not expired, has an automatic extension clause and continues on that basis until the parties decide they need another agreement. But the Mexican Agreement does not have automatic extension clauses and it expires by its terms in June of this year. We have had some difficulty making contact, of course, with the Mexicans on what happens at the end of this present agreement. We have had contact with them within the last two months. We have discussed the problem with them and there is a desire on both sides to negotiate various points of the agreement. But there is also a desire on both sides to continue the present agreement in force until a new one can be renegotiated.

On March 15, we had an industry-government meeting where representatives of their State Department and ours and interested parties in our industry who were concerned, came to Washington, and we told them what the situation was at that time. We told them we were working with the Mexican Government trying to come up with an extension. And as it now stands, the extension that has been worked on is to continue the present agreement through December of 1967, during which time we will go through a renegotiation period.

MR. LEARNED: The second part of that question is, "I am a daytime only operator, on a Mexican clear channel. What are the possibilities that the new agreement will permit me to operate additional hours?"

MR. JOHNSON: That is the question I am getting at. There are only approximately 270 daytimers on the Mexican clears, but I think they are the more vocal of the other groups at the present time as far as the Agreement is concerned. There are presently six Mexican clear channels that we permit daytime operation by the Agreement with no nighttime operation. Mexico, in turn, cannot operate on our 25 1-A channels nighttime.

The main problem that developed during the last negotiation which ended up covering some seven-year period, was operation on clear channels. The Mexicans just don't want any other operations on their channels at night. We are not sure at this particular point whether they have relented any. If there is any way that we can try to get extended hours for our daytime - we are assuring everyone who has a daytime license that we are going to try our best to get some extended hours for daytimers, not only on the Mexican clears but on some of our other clears, either unlimited time or some additional time in the morning or possibly some additional time in the evening.

So, I think, both the State Department and the Commission are committed to try to get an Agreement which will permit extended hours in some form.

MR. LEARNED: Do the Commission's rules require that the aural-to-visual power ratio for auxiliary transmitters be changed to comply with the 10-20% standard or may the auxiliary transmitter continue to be operated at higher ratios provided the authorized power of the main transmitter is not exceeded?

MR. KELLEY: Well, the latter part of that statement is generally true. In other words, if you have an auxiliary facility and during an emergency when your main aural transmitter is out, you may go up to the main authorized aural power but not exceed that authorized for the main.

As for the first part of the question - generally speaking, the auxiliary transmitter licenses are of two different types. There is one type where we do not specify the operating parameters or the ERP on the authorization, and the other type we do. The thing that determines whether we do specify these operating parameters is dependent on two things. One is when it is possible to obtain an aural or visual ERP equal to or greater than that authorized for the main. And the other is where the auxiliary facility is located at some remote location from the main facility. In those cases, where the operating parameters have been specified on the authorization for a license, it would be proper to file application to reduce the aural power for the auxiliary transmitting equipment.

MR. LEARNED: Thank you. Does that generate any further questions?

MR. JOHNSON: Most of the questions that have been raised in the Mexican agreements have been from the daytimers. But there are several other points I want to touch on before we leave this and give you the wrong impression. We also have several other problems we have been attempting to negotiate with Mexico. One of them is the problem we have with the local stations on the Border. There is a strip along the Border, 62 miles from it, each side, where we cannot permit local stations to increase power of kilowatts. In that particular case, there are approximately 20 stations on each side of the Border, so we feel somewhat optimistic on that score; at least we can trade same numbers of stations on each side.

For someone more optimistic, we may be able to get some more power for the stations in that particular zone.

And then another problem is the clear channels. We don't know whether the Mexicans have relented on their previous position of just trying to protect our clear channels on their contour protection of 50%, but that is something we will find out very soon in the negotiations. So it is not just the daytime station problems you have, but several other problems.

MR. LEARNED: When an FM station is in stereo, how does the engineer do his annual proof of performance?

MR. KASSENS: Well, at the present time, he has no choice but to run two monoproofs, one through the left channel and one through the right channel.

We have had this proceeding going on now for several years on stereo monitors and it should be finalized quite soon. We tried to make it for this convention, but didn't quite do it. It will be out in a matter of weeks.

At the time when we have type-approved stereo monitors, we will be able to require a complete stereo proof which will include the separation measurement. But there is no way now to measure and be sure you get the correct separation, at least an official value of separation. But when we have the stereo monitor rules adopted, then they can run it with the stereo monitor.

MR. LEARNED: Is it necessary that the tower be climbed in order to make the required inspection?

MR. PLUMMER: The answer is no. It all depends on where you put your apparatus for switching.

This gives me a good chance to get in a commercial. Two or three people have asked me if we were going to have little handouts like we did last year as to what we inspect at stations. We have these little packets here and we will hand them down at the end of the meeting. We have a list here of what we inspect in television stations also.

MR. LEARNED: I believe Mr. Hanson might be interested in this next question - "Have there been any requests for substitutes of some other material than copper for use in the ground system of broadcast stations?"

MR. HANSON: I have had only one request. This was because they couldn't get copper. They wanted to know if they could use aluminum. So temporarily they are operating with an aluminum ground system. We have not licensed and probably will not license this station until the ground system is replaced by copper.

Copper is scarce, apparently. Whether it is because it is actually scarce or moneywise, I don't know, but we know it is. They are not selling it for ground systems, or transmission lines. But temporarily we have authorized the aluminum ground system but not for too long.

MR. PLUMMER: Could I add a little something here? On the priorities we have made some effort to see if we could find some source of, we will say, scrap copper. Some of you may remember during the Korean situation, Western Union had available hard drawn No. 10 they had taken down from open wire lines. There were thousands and thousands of miles of it available. We checked with Western Union and they said they were still taking lines down, but in very small quantities and, therefore, they couldn't come up with any organized national basis to make this scrap copper available.

I am not sure whether any of you involved in this problem could do anything on a local basis or not. Western Union did say they are still taking down open line wiring in certain parts of the country, so this is a hint for a local contact who might be able to do something.

By the way, scrap copper, you perhaps noticed, is bringing something like 70¢ a pound against a fixed price of 36¢ a pound for new copper. There lies part of our trouble. The World Market is also up around 75¢ a pound.

MR. LEARNED: What is the engineering situation at the Commission? Are you actively recruiting engineers in competition with industry and what success are you having?

MR. JOHNSON: Well, Mr. Plummer will probably want to get into this. He was executive director of the program instituted in the Commission to really do some active recruiting. We engineers are facing a crisis where the number of engineers has been decreasing steadily in the Commission. For instance, I see there are undoubtedly lawyers in here, so this is not for their ears, but one of the things that has concerned us, to give you an illustration of the problem we have in the broadcast area, we have been fairly stable as to total number. But, within about the last 14 years, the percentage of engineers out of the total has completely reversed. For instance, we have 35 engineers out of approximately 250 total people in the Bureau right now, which represents about 14% of the total, whereas we have about 28% lawyers. Fourteen years ago, that was just reversed. We had 28% engineers and 14% lawyers.

There is another problem that we are facing also, because you notice year by year we are all getting older and within about five years a good percentage of our present engineers will be eligible for retirement. So we think a good number of our engineers will be gone within the next five years. And, actually, after this program today, we may have some forced retirements. Some of us may be retiring earlier. But anyway, we have had a very active recruiting program.

We have visited universities during the last year. We have actually tried desparately to get new students interested in working for the Commission. One of the things we are pointing out to them, of course, is that the jobs at the top will be vacant within the near future so that their prospects of advancing in the Commission are very good. And in our active recruiting program where we have discussed promise vs. performance, we can just about promise an engineer better advancement at the Commission right now over a five- or ten-year period than any members of the industry we have run into. So we will actually, in the broadcast area, have five engineers come to work for us when they graduate in June. That is the first time for many years we have actually had graduate engineers we have successfuly recruited. And some of you who appear dissatisfied with your work - we will be glad to talk to you later about it, also.

MR. PLUMMER: I would like to add a little bit there. We are also starting a program of recruiting technicians in the Commission, and even that has its difficulties. One of the basic problems we are running into is we are no longer, in the scheme of things, a very glamorous agency. The average fellow coming out of college can generally get a little bit more per year by going to industry, in terms of dollars. A great many fellows want to work in research laboratories. As a matter of fact, we have certain industry people come to us and say, "What do you pay a starting engineer?"

We tell them, and they say, "Fine, we will pay them $1000 a year more." That is tough competition.

Well then, within the government, we have lost our glamor as compared with NASA, the space effort, the Department of Defense. So what we have to do is get some fellows with a little twist who like to come to work for the FCC for some personal reason. So, as Wally said, we must make a lot of calls to get a few persons.

MR. LEARNED: Gentlemen, our time has run out. I wish to thank you very much, on behalf of the audience, the NAB, and the Engineering Conference Committee, for your kind efforts and a most enlightening presentation.

XXX

Luncheon Addresses
at the
20th Annual Broadcast Engineering Conference

Chicago, Illinois March 28-30, 1966

GEORGES HANSEN, *Director of the Technical Center,*
European Broadcasting Union

JOHN CHANCELLOR, *Director,* Voice of America

JOSEPH V. CHARYK, *President,* Communications Satellite
Corporation

and

PRESENTATION OF THE NAB
ENGINEERING ACHIEVEMENT AWARD

to

CARL J. MEYERS

Senior Vice President and Director of Engineering

WGN Continental Broadcasting Company

National Association of Broadcasters
1771 N Street, NW
Washington, D. C. 20036

GEORGES HANSEN
Director of the Technical Center
European Broadcasting Union
Monday, March 28, 1966

It is a great pleasure for me to take part in an N.A.B. Broadcast Engineering Conference, to meet so many fellow Broadcasters including quite a few old friends . . . friends who, according to the definition, know you well and like you just the same.

I have been invited to talk to you of the European Broadcasting Union (E.B.U. for short) and of its work in the engineering field. The E.B.U. is a non-governmental international association of organisations which exploit broadcasting services, in fact, just as you have in NAB. The term "broadcasting services" is here quite general; it includes sound-broadcasting services and television services. The E.B.U. has twenty-eight full Members in twenty-five countries of the European Broadcasting Area (which, by the way, includes the countries in Africa bordering the Mediterranean Sea). It has forty Associate Members in other parts of the world: Africa, Asia, Australia, North and South America. Eight of them are in the U.S.A.: A.B.C., Broadcasting Foundation of America, C.B.S., N.A.E.B., N.B.C., N.E.T., Time-Life Broadcast, U.S. Information Agency. They are surely also members of the NAB and are therefore a link between NAB and EBU.

You may be surprised at first by the rather small number of full Members, but all of them provide *national* services, that is to say their programmes cover the whole of the national territory, which implies that they are normally rather large-scale organisations having main production centres in the national capital with subsidiary studios in other important towns, feeding a more or less large number of broadcasting stations. The local station comprising a studio and a transmitter is quite rare in Europe.

In the countries of the European Broadcasting Area, excluding the countries the other side of the "iron curtain" where the E.B.U. has no Member, there were in November, 1965 just a thousand AM transmitters broadcasting, with a few exceptions, the programmes of E.B.U. Members. Their total power was nearly 25,000 kilowatts. In the same area, on 1st January, 1966, there were over 2600 FM transmitters with a total ERP of just on 30,000 kilowatts. It might be of interest to you that 65 of these transmitters already broadcast regular stereophonic programmes.

On 1st January, 1966, there were more than 2400 VHF television transmitters with a total ERP of 22,000 kilowatts and more than 400 UHF television transmitters with a total ERP of 65,000 kilowatts.

In the same area, again, on 1st January, 1966 the number of sound broadcasting licenses was about 91 millions, the number of receivers being appreciably greater, as in most countries only one license is required for each household, irrespective of the number of receivers used in it.

The number of stereophonic receivers was about 900,000, 90% of them in Western Germany. There were 50 million television licenses and about the same number of sets, as there are not yet in Europe many homes with more than one television set.

These figures might give you a better idea of the means at the disposal of the twenty-eight E.B.U. full Members, and of their potential audience. But enough of statistics—which are, as some of you may have heard, like a bikini: what they reveal is important, but what they hide is vital. So let us turn to the story behind the figures.

The E.B.U. is governed by a General Assembly composed of representatives of all its Members, and by an Administrative Council which consists of eleven "administrative" seats to which full Members are elected. To handle its tasks and to coordinate the work it carries out with the participation of its Members, the E.B.U. has a permanent staff of over a hundred persons including engineers, jurists and administration staff, of various nationalities, who are usually recruited from the Members of the E.B.U. The non-engineering activities, that is, the administrative, legal and programme work, are handled at the Administrative Office at Geneva, Switzerland; the engineering activities at the Technical Centre in Brussels, Belgium. Four specialized committees play a consultative part, but a very important one, within the Union; they are the Sound Broadcasting Programme Committee, the Television Programme Committee, the Legal Committee and last, but not least, the Technical Committee. Let me hasten to say that none of them and especially not the Technical Committee are of the type of committee defined as a group of people who individually can do nothing and who collectively decide that nothing can be done. Our Technical Committee meets once a year in the Spring, but its meetings are nothing like this Broadcast Engineering Conference. There may be about sixty participants, mostly Technical Directors, that is to say, Vice-

Presidents in charge of Engineering, and Chief Engineers. The purpose of our meeting is different from yours, but I must admit frankly that there are many things which I should like to copy from you. Our Technical Committee's main task is to review the work undertaken by its Sub-committees, which are called Working Parties, and by the Technical Centre and to give them guidance for future work. I believe that I can say that the really constructive work of the EBU is done by the Working Parties. Here are a few examples:

Working Party B deals with ionospheric propagation. Since 1951, it has organized, with the aid of twenty-three receiving stations in fifteen European countries, systematic measuring campaigns during which 45,000 hours of field-strength recordings were made in the long and medium wavebands. The results (which were also submitted to the C.C.I.R.) have been condensed into a series of formulae and curves which make it possible to predict the value of the field-strength under the most diverse conditions. We are going on now with measurements, with longer distances of 2,000 to 3,000 miles. We are doing so with the help of our friends from Canada. Working Party B has also undertaken in recent years—and it is going on now—a measuring campaign to study the ionospheric propagation (through sporadic-E notably) of television signals in the low VHF band.

Working Party K deals with television and FM sound broadcasting. It has developed frequency-planning methods based on rather sophisticated mathematics and requiring the use of an electronic computer. These methods were utilized at the European VHF/UHF Broadcasting Conference held in Stockholm in 1961 as well as at the African VHF/UHF Broadcasting Conference at Geneva in 1963. One of the problems with which Working Party K is now confronted is how to plan the introduction of color television in the VHF band in Europe, where the channels adopted in the various countries have different bandwidths, and overlap. This is just one of the problems which we, unfortunately, have in Europe, due to lack of standardization.

Happily our Working Party S, dealing with stereophonic broadcasting, was more successful. It managed to reduce to one the number of systems in competition and we could here doubly rejoice, as the system selected was the one used in the United States: the pilot-tone system.

In the field of color-television, an Ad-hoc Group was set up by the E.B.U. in November, 1962, a kind of I.T.S.C., comprising experts not only from the broadcasting organizations, but also from the Administrations and from the radio manufacturers. It worked extremely hard, but was unable to reach an agreement on a unique color-television system to be proposed for adoption in Europe. Nevertheless, it did a great deal of useful work in producing a report, which evaluates and compares the NTSC, SECAM and PAL system in a most comprehensive, objective and fair way. The last edition of this report has just been submitted to the C.C.I.R. (the International Radio Consultative Committee) in view of its next Plenary Assembly in Oslo from 22nd June to 22nd July, this year.

It is not possible here to describe—even to summarize—the work of all our Working Parties; nine in all are functioning at present. Let me just mention that Working Party A deals with AM sound broadcasting and is at present preparing for the next LF/MF frequency assignment Broadcasting Conference, just as Working Party K did for the VHF/UHF Broadcasting Conferences. It deals with questions such as the technical quality of service of indirect-wave reception (in the secondary area), protection-ratios and compatible single-sideband broadcasting. Working Party G deals with the tape and film recording of sound and pictures in which field international standardization is of capital importance for the broadcasting organizations. Working Parties L and M deal with different aspects of international television transmission over radio relays. One matter studied by Working Party M is that of standards conversion for television. Great progress has been made in this field by the introduction of all-electronic converters, that is, converters which obviate the intermediate optical stage. Work is going on on such converters for conversion from American to European standards and vice versa when not only the number of lines, but also the number of fields differ. And conversion of color pictures comes next. We hope that we will have converters ready for that before 1968. Working Party P deals with counter-measures against radio interference caused by industrial equipment, domestic appliances, fluorescent tubes and the like. That is all for our Working Parties. If I have taken some time dealing with them, it is not only to boast about our achievements, but also because I believe that there is room for collaboration or at least mutual information between the NAB and the E.B.U. in this field.

With the same idea of cooperation in mind, I would like to speak now of our publications. There again we do not work exactly on the same lines. So far as I know, you have nothing corresponding to our E.B.U. Review.

On the other hand, you were able to produce in 1960 the N.A.B. Engineering Handbook, which is quite a remarkable achievement for which I should like to use this opportunity to congratulate Mr. Prose Walker (I know he is somewhere here) and Mr. Bartlett. The E.B.U. Review consists of two Parts published alternately each month: Part A—Technical published by the E.B.U. Technical Centre in Brussels and Part B—General and Legal published by the E.B.U. Administrative Office at Geneva. Our aim, in the technical Part, is to keep the Members of the E.B.U. and the other readers informed of all significant developments and problems concerning sound and television broadcasting engineering, not only in Europe but throughout the world. We are thinking of the poor harassed chief engineer our friend, our brother who simply hasn't the time to read a tenth of the technical periodicals that arrive on his desk and we try to give him, in a condensed and more or less predigested form, what he needs—and nothing more—by means of short articles, news-items and abstracts of the more important articles published elsewhere. We try to cover operational matters not dealt with, usually, by other technical or scientific publications. We all know that the professional life of a successful engineer consists successively of fifteen years of engineering, fifteen years of administration and fifteen years of diplomacy. Our job, as we see it, is to provide up-to-date technical information for engineers already engaged in their fifteen years of administration, if not in their fifteen years of diplomacy. The French moralist Montaigne had a quite pessimistic view about such enterprises. He said, "Ignorance, which was inherent in us from the beginning, has only been confirmed by our continuous studies." But chief engineers and vice-presidents of engineering need not despair; another thinker said: "What counts is what remains when one has forgotten everything"—and surely, what remains is probably really "experience", when the things which one learnt have passed from the conscious into the subconscious.

Other Technical Centre publications are the Monographs prepared with the cooperation of experts from various countries. The following Monographs have been published recently, or will be published shortly:—

—Lighting for Television—using the image-orthicon tube in the studio

—Receiving and Measuring Stations for broadcasting purposes

—Towers and masts for VHF and UHF transmitting antennas

—Site selection for VHF and UHF transmitting stations

—Safety regulations for broadcasting organizations

Specimen copies of E.B.U. Technical Monographs can be supplied to interested N.A.B. Members on request. A descriptive brochure entitled "This is the E.B.U." is also available. I should not omit to mention our periodical reports describing the situation, channel by channel, in the wavebands utilized for broadcasting in Europe. Some of those publications are based on observations and measurements made by our Receiving and Measuring Station at Jurbise, in the south of Belgium.

I have not spoken up to now of one of the E.B.U.'s most important activities, certainly the one that has made the greatest direct impact on the public—namely "Eurovision". I should like to tell you the story of Eurovision from its modest start in 1954 to its present state of development when on an average four multilateral exchanges of television programmes take place every day between countries of Europe, when every afternoon there is a news exchange over the Eurovision radio-relay network which enables the Members to pool their visual coverage of the day's news, for utilization in their evening news bulletins. I should like also to recall how, since July, 1962, satellites have made possible the exchange of live television programmes and news across the Atlantic.

I should like to explain to you the work of the "back-room boys" in our so-called CICT, that is to say, our International Master-Control Centre in Brussels, working in conjunction with Sub-Centres in Copenhagen (Denmark) and Zurich (Switzerland), and also in direct contact with National Centres in all the countries concerned. But not today. There is no time. Maybe another year. There is only one thing which needs to be explained now. You may wonder why I make such a fuss about the organization of programme exchanges over a radio-relay network. Is it so difficult? The answer is: Yes, it is difficult in Europe because of the lack of standardization. Differences of status, scale of operations and financial resources of the various organizations concerned, differences in the television standards which make conversion necessary, differences in the equipment and possibly the methods of measurement and, last but by far not least, the differences in language which make it necessary to distribute sometimes as many as fifteen or twenty sound components in different languages with a single vision component. Those are the inherent difficulties of Europe. But precisely the struggle to overcome those difficulties, to effect standardization and attain uniformity in the various technical fields and to continue to shape Eurovision as a veritable European Television Community, is what makes our job a wonderful, a fascinating one.

I must apologize for having spoken at length of the E.B.U. and not enough of yourselves and the N.A.B. You may judge me severely for that, as it is well-known that a talkative man is a man who talks about others and a bore is a man who talks about himself. The man who talks about you is, of course, a brillant conversationalist!

And so let me end by assuring you that this my first visit to an N.A.B. Broadcast Engineering Conference is both a pleasure and an inspiration. Thank you for asking me to come.

JOHN CHANCELLOR
Director, Voice of America
Tuesday, March 29, 1966

It is more than a pleasure, it is an honor to be speaking to you here today. I am honored because you have chosen as your speaker someone who grew up on the news and program side of broadcasting, not the engineering side.

And I am well aware of the distinction between these two necessary sides. Program people sometimes grudgingly admit that the terribly important things they say have to get to the audience, which brings in the engineers; and the engineers grudgingly admit that as long as they've got such a good signal, maybe somebody ought to say something on it.

(Remember the old story of the two clergymen of different faiths who had concluded a joint community project? One turned to the other and said,—"Reverend, it's been a pleasure. We were both working in the way of the Lord: you in your way, and I in His.")

But I think I have perhaps more than the average broadcaster's experience with engineers, since I have spent much of my career in the field. I think back to the early days of Wide Wide World, when, on a Sunday afternoon, fifty or sixty live cameras at remote locations would be fired up for a two hour technical performance. I always seemed to have been at the remotest remote location, and familiarity with engineers on those occasions bred in me a great respect for the craft.

There is, moreover, an inter-relation between the processes of broadcast engineering and the liveliness of the programs. I was once asked by NBC to stand by at my post in Moscow to participate in a closed-circuit show for some affiliates gathered in New York. On a remarkably good circuit I was told by my colleagues in New York that Chet Huntley would give me a clear introduction, and would I please stand by. Yes, I would. Later, I heard Huntley, quite clearly, saying something on these lines: "And finally, gentlemen, let me say that some day soon, we will have color television on the moon, on the planets, in outer space as easily as I say, now, 'come in, John Chancellor in Moscow . . . come in, John Chancellor in Moscow . . . come IN John Chancellor in Moscow.' " Well, Moscow never came in. I have since learned to say, in Russian, "It's all right leaving here, Chet."

Well, these were humble beginnings, indeed, but I don't know how someone like me could have been at all prepared for a job in the management of a planetary broadcasting network, which I think, is a workable description of the Voice of America. We are in the business of broadcasting to this planet: and looking at only some of the new technical facilities which the VOA has recently constructed is a mind-stretching exercise.

We have a new VOA plant at Greenville, North Carolina, which I recently visited: it consists of 18 high-power short wave transmitters ranging in power between 50 and 500 kilowatts. The plant transmits a total of 260 hours a day to Western Europe, areas of Africa, and the entire Western Hemisphere from the Texas border to Cape Horn, off the southern coast of Chile. At times, programs in as many as six different languages are transmitted simultaneously from Greenville. The gross cost of operating this plant amounts to approximately $3,000,000 a year. This includes all operating costs, salaries, overhead and depreciation and amortization of equipment.

Focusing on just the Western Hemisphere, transmissions start at 6 AM and end at midnight, local time. At times, just to Latin America, four different languages are broadcast simultaneously to this area. About 70 of the total of 260 hours transmitted daily from Greenville are beamed to the Western Hemisphere. This means the pro-rated cost to USIA for reaching the entire Western Hemisphere south of the USA amounts to less than $1,000,000 a year.

As another example, in Africa the VOA has a new short wave plant near Monrovia, Liberia, where eight high-power short-wave transmitters, ranging in power between 50 to 250 kilowatts, reach at least 90 percent of the African continent. This costs USIA approximately $2,000,000 a year.

That is only part of what we do, and that will conclude the technical recitation at this luncheon; but it strikes me as big-time broadcasting. Nevertheless, given the signals we get and the areas we reach with all of our transmissions from new and old plants, the unit cost is still relatively inexpensive.

And short-wave as I can report to you remains the basic tool of the international broadcaster. The number of short-wave sets, thanks to the transistor, is rising steadily and remarkably. In some parts of the world these foreign-made sets are used almost as currency. They are becoming part of the daily life of the poorer people in the underdeveloped areas of the world. (A few weeks ago, I was in south east Asia, on an inspection trip. Way out in the country in central Thailand there were peasants preparing the rice paddies for the rainy season which is just about to begin. One of them had a long stick which he kept stuck in the ground near him as he tilled his field.

When he would move, he would move the stick. Tied to its top was a transistor radio.) and when you find it that far from civilization, you begin to realize its importance to us as broadcasters and its importance to us as Americans. If the world audience is large now, soon it will be huge. Some day it will be total.

As the audience grows, so does our ability to reach it. What the future will bring in international broadcasting, what wonders are in store for us, you gentlemen know better than I. What I have is the faith of a technical innocent: I believe there will be major changes, because of the accelleration of science in our time, and because the latter half of this century has shown us the positive results of intensified international communication. There is now ample evidence and that communication has changed, and will further change, our relationships with one another as inhabitants of this planet.

Communication—and very particularly communication through international broadcasting—is not just a pleasant, informative and entertaining accessory to modern life. International broadcasting is a weapon of profound importance in a world of swirling ideological conflicts, surging populations, and a dangerous abyss between the rich nations and the poor nations. The winds of change blow steadily, and there is constant danger that they will drown out the voices of civility and reason in the world. The pressures will grow as the decades of this century pass by, and no country which plays a major role in this intensifying drama can afford to be silent, or speak less clearly.

Seven months ago when I came to the Voice of America I was astounded at its gigantic size. One hundred fifty-two million dollars worth of equipment pouring out strong signals to much of the world and more being built to transmit 800-odd hours a week of programs in 38 languages. It is an immense undertaking.

But it nevertheless consists, I would submit for your consideration, at its core, of one American talking to one person in a foreign country. It is an instrument not so much of giant size, but rather of extraordinary intimacy. The words we speak into our microphones in Washington travel thousands of miles, and are listened to in the quiet of living rooms, bedrooms and dormitories of the world.

In the city of Timbuktu, recently, an officer of the USIA spoke with a group of Taureg tribesmen, nomads who roam the wastes of the central Sahara. "What are you?", they asked him. And he replied, "An American." "Ah," they said, "Voice of America—7:30 p.m."—for that is the hour each night that these families tether their camels, gather in their black tents, and turn to the transistor radio. They listen. Students in schools where pupils are taught to hate America listen, at night in their bunks with earphones. Prime Ministers listen. Plain people listen. And all of them are part of a simple human relationship involving one American in a Washington studio talking calmly, sanely, reasonably, to one other human being somewhere else.

The magic of all this is enhanced when we realize that in part of the world where the influence of the United States is limited or denied, our radio signals can still overcome restrictions and barriers. And we have recent evidence of our effectiveness in one of most important target areas: the Soviet Union.

Three years ago this June, the Soviet authorities closed down their jamming transmitters and opened the country to free international broadcasting. In the months that followed, Soviet citizens were free to turn to their short-wave radios—of which there are many in a country the size of the Soviet Union—to learn about the outside world. It is not easy for the VOA to run a rating service in Russia, but we began to perceive an audience there of great size, open to honest information from the West. For decades, the authorities in the Soviet Union had maintained an informational monopoly: they controlled the news which went to the people. That monopoly still exists in books and publications and films, but it has been broken in radio broadcasting, and in a very short time has produced a change in the attitude of the Soviet government toward its own people.

I once lived in Moscow, reporting on Soviet affairs for the National Broadcasting Company. There were then about 214 million people in the Soviet Union, but on some days, many days, nothing ever happened. There were ten daily papers in Moscow, but often no news in them. No planes crashed, no buildings burned, nobody beat up his wife. To an American accustomed to the free and aggressive coverage of news, this was rather remarkable and was occasionally suffocating.

But, in June of 1963, the Russians, for a complex series of reasons, stopped jamming, and the people began listening. And, the authorities began listening, to our broadcasts and the broadcasts of the BBC.

And only a year or so later evidence began to accumulate that the authorities felt the pressure to change the old closed-mouth attitude toward news. An article printed in *Kommunist,* the chief ideological journal of the Soviet Party, argued that Communist newspapers should be brighter, more responsive to news in their own communities. Moscow radio, at least in its external broadcasts, became a bit more flexible, reasonable.

This evidence of a new attitude continued to mount last year. Only last week, a Moscow dispatch in the New York Times, dated March 24, read in part:

"Communist party leaders across the Soviet Union are expressing concern about the impact of Western short-wave broadcasts among ordinary Soviet citizens.

"Young people and minority nationalities in particular have been singled out as susceptible to 'hostile notions' spread by foreign radio stations.

"A series of reports delivered at regional party congresses this month suggests that ideological indoctrination inside this country is being undermined by this exposure to non-Communist ideas and news.

The Times then listed a number of examples including young kids walking around listening to our jazz programs on transistor radios on short-wave. The evidence now is overwhelming from various parts of the Soviet Union that we are having, and BBC is having, a definite liberalizing effect on young people of the Soviet Union.

If you want to go back to that 152 million dollars worth of equipment we have mounted and the more equipment that we are building now, it seems to me to be cheap at twice the price if we could in this most extraordinarily important country in the world, induce the waves of liberalism within that society through our broadcasts. We are extraordinarily proud of this. I will skip to only other quote we had which we gathered ourselves from the deliberations of the Kazakstan Communist Party within the Soviet Union and it read this way: "We, Communists, should not forget that in our country Communism is being built in conditions of a sharp struggle between two ideologies on the international scene, and that it is practically impossible to close the channels through which bourgeois ideology penetrates into our socialist society."

And I stand before you today, ladies and gentlemen, as someone who sends a great deal of bourgeois ideology every day. I underline that sentence, "it is practically impossible to close the channel."

And he's right. It *is* practically impossible to close the channels of international communication if they are being operated with vigor and skill. It is my belief that attitudes are being changed in many parts of the Soviet Union because of these outside broadcasts: relationships between students and teachers; between editors and readers; between the people and government officialdom. This is not to say that the Soviet Union is necessarily becoming any less troublesome, any less dangerous. It is to say that radio—the only new factor in this informational equation—has begun to influence an audience in a country of extreme importance to us.

The point which should concern us here is, it seems to me, that effective broadcasting can change, has changed, attitudes even in a society as rigidly directed as the Soviet Union.

What kind of an effect might it have were we able to beam a significantly stronger signal to the USSR? It is my belief that, one day, we'll be able to do that, and do it in many parts of the world. I am not sure I will be around when you engineers think up how to do it. I may be in the old VOA directors' home, rocking on the porch. But the fact is that I have a simple belief that the signals we now are able to get to target audiences, we will be able to increase significantly over the coming years.

And it is also vital that we keep in mind that other technologically developed societies may be able to do it, too.

And what is likely to happen then? Here in Chicago this morning, thousands of motorists driving to work listened to WMAQ, or WBBM, coming in loud and clear on their car radios. What if they had the option now—today—to turn the dial to the external service of Moscow Radio. Suppose they heard soothing music, no commercial interruptions, perhaps some weather information, or a bit of news. And the voice of a Russian announcer describing in plain English the current Soviet line on disarmament, or Viet-Nam, or the U.N.? (The Russians are spending millions doing that right now, in their short-wave North American service, but very, very few Americans listen at all in short wave.) Would the Russians get an audience on then standard broadcast bands here in the United States, here in Chicago during the rush hour?

What if the Cubans, or the Chinese were also available on the car radio? Would people listen?

I think it is possible to say that some people might tune in, out of curiosity, boredom, or a desire to get away commercials. I doubt, in the long run, whether these broadcasters would gather a large audience: there is after all, a fundamental difference between the regimes I have mentioned and the American government. We are a free society, and we do learn through our own open channels what's going on elsewhere.

Nevertheless, it's interesting to speculate on our reaction to an audible invasion of our broadcast band. We have never jammed a foreign signal. The United States has never created a government-operated radio facility for broadcasting to Americans. I concur in that wise decision. But would there then be pressure to counter these foreign broadcasters?

What I have been trying to do in this recitation is to make you think for a moment what it might be like to be a target audience for a skilled and persuasive foreign broadcaster. The American people have been on the sending side of this business for 24 years, through the Voice of America, but we never have listened enough in short wave to be on the receiving end.

My point is that 20th century technology may one day make *us* a target audience, and it is not too early to begin thinking about it.

There is every reason to believe that American audiences would be bored by foreign propaganda: particularly given the clumsy state of the art as practiced in most communist countries today. There is also the fact that Americans today have a rich fare of entertainment and information—and that local radio and television stations will be able to meet I hope, more fully the specific needs of local audiences as the years pass.

And even more fundamentally, free societies have very low potential as targets for propaganda. The informational richness of an open society produces in its citizens very little need to turn to foreign sources. The people of the United States, of Great Britain, of Scandanavia, to name only a few audiences, don't need Radio Moscow to tell them what Soviet policies mean: these audiences learn that, honestly, from their own news media.

On the other side, too many commissars make for inefficient propaganda. The rigidity of control of a closed society almost always means dull programs, and it probably always will.

But having said that, we must equally acknowledge the great sums spent by Communist societies on propaganda. There is, in every Communist country, a very high priority given to propaganda (the Soviet Union now leads the world in hours of international short-wave broadcasting), so there is no basis for complacency. If these countries can improve their international signals with satellites, some of them will undoubtedly do so. We can at Voice of America and we are.

So it is surely not too early for sensible men in this country to begin serious consideration of what our attitudes should be toward what in my view is the inevitability of more international broadcasting to mass audiences around the world.

If we allow our thinking to lag behind our technology, then it will some day be a mighty crowded and confused broadcast band.

If we handle ourselves properly, such broadcasting could be the overture to what we all want: a world at peace, a prosperous, educated world, given a sense of purpose and communality through international broadcasting.

As I say, it's something to think about.

DR. JOSEPH V. CHARYK
President
Communications Satellite Corporation
Wednesday, March 30, 1966

Distinguished Guests, Ladies and Gentlemen:

I guess that your program committee decided that after several days of serious down-to-earth business and after several nights of being regularly uplifted from the daily routine, that on this last day you might as well be taken completely out of this world into space.

In any event, it seems to be a rather popular place these days with all kinds of new unidentified objects hovering about. Some people, as you know, consider this whole space business to be a tremendous boondoggle. Many find difficulty in separating fact and fiction. And there are even some who believe that flaunting the sacredness of the heavens this way has religious overtones.

Well, despite all this, our corporation has been established as the first to seek to explore the commercial potentials of space for communication purposes. In this endeavor, we have sought and achieved the participation of telecommunications entities from 47 other countries in the goal of establishing a world-wide communication network by satellite.

1962 was the year in which the dramatic potential of communications satellites was first brought home to millions of people on this side of the Atlantic and in western Europe when, through the medium of Telstar, the first demonstration of live intercontinental television took place. It was also in that year that after much debate the Congress enacted the Communications Satellite Act. Early the following year the Corporation authorized by that legislation began to take form. And about one year ago, the Early Bird satellite, in a stationary orbit over the Atlantic, heralded the commercial advent of a new communications era.

Perhaps the most colorful description of this event came from Frank Stanton, who said: "The mountains have been leveled and the oceans dried up by an 85-pound piece of scientific jewelry transmitting a six-watt signal."

This year regular commercial service by satellite will be expanded in the Atlantic area and initiated for the first time in the Pacific area through satellites having about double the power of Early Bird. Beyond that we see a rapidly growing potential for satellite service on a global basis to handle all types of traffic internationally and domestically.

Although in this first year of limited commercial operations the focus has been on telephone traffic as the regular user of satellite services, the impact of satellites on the broadcasting business is an area of great promise and interest. It is, therefore, a particular pleasure for me to be with you here today and to tell you something of our plans and programs and what the future may hold in store in this exciting and glamorous new field.

As we stand on the threshold of the global application of satellites for communication purposes, it is difficult to foresee the full impact that this new capability may produce. One hears from time to time that satellites afford simply another supplementary or complementary means of communication. In my opinion, this is akin to describing the advent of airplanes as affording simply another supplementary or complementary means of transportation and completely missing the vast civil and military implications attendant thereto.

I believe that an instantaneous communications capability for oral, visual and electronic messages on a global scale will, in due course, have a profound influence on the political, economic and social relationships between the countries of the world.

And as we move into the new age, we will have need to cast aside historical and artificial concepts and organizational frameworks which are being made obsolete and impractical by the advances of technology. We must learn to adjust and adapt to exploit most effectively the fruits of these developments. The rate of progress in my opinion will not be governed by technical factors but by economic, social and political considerations and the inertia of classical concepts and organization will be great indeed. Historically, we can understand such things as the artificial separation between telegraph or teletype, voice, data or television transmissions. We can try to separate computer circuits and switching circuits and communication links. But in the last analysis we must realize that we are dealing only with bits of information and we are simply talking about information storage, retrieval, processing and transmission. We sometimes pretend that somehow voice and record communications are different and still organize that way, but the electronic signals that go back and forth from our satellites are unconcerned as to whether it is voice, teletype, facsimile, data or television. Actually, today's means for transmission of information by voice could be considered to be very inefficient. Normally, speech sound contains 32 phonemes. A normal speaker speaks approximately 10 phonemes per second. As a result, the rate of information transmission in speech is approximately 50 bits per second. The channel capacity in the information theory sense of a high fidelity voice channel with 5 kilocycles bandwidth and 30 decibels average signal to noise ratio is 50,000 bits per second. Therefore, one might say, normal speech transmission is 99.9% redundant, or a theoretical gain in channel requirements of up to a factor of 1,000 is possible. Basically, however, we must preserve fidelity and naturalness of sound and this means that the theoretical limit from information considerations alone will be substantially reduced, probably by a factor somewhere between 10 and 100 depending on the standards one may seek to achieve in preserving natural quality. Nevertheless, the gain of 10—100 is a most substantial one which in itself will have a significant effect on the efficiency and cost of voice transmissions. If we couple with this the attainment of security which can now relatively easily be achieved, the potential becomes even more intriguing.

Satellite technology, of course, is only a piece of this total picture but I think the advent of satellites will become a catalyst to this information revolution that will recast the nature of the world in which we live. And I believe that we must seek to understand and appreciate the direction and the impact of the developing technology and to seek in an equally dynamic fashion to plan, organize and manage the application of this technology to best serve the needs of individuals and of business in the new world of tomorrow.

It seems inevitable, for example, that we will continue to move towards the effective establishment in metropolitan centers of what will amount in fact to a communications utility. This would be a system which would link homes, business offices and stores in a community through wide-band high capacity transmission facilities to central switching and computing centers to provide a wide variety of services. These would include color television and stereophonic FM radio, aural and visual telephone service, high speed facsimile data and newspapers, library reference, theatre and transportation booking services, access to computer facilities, shopping and banking services of all types, centralized charging and billing. Communications destined beyond this metropolitan area would be directed to a processing and transmission center which, in turn, would be linked through a suitable terminal station in that community to a worldwide satellite system. I believe that this is a far more likely course of development than the one of a direct link between the satellite and the home. It is a more natural and logical development more economical and more compatible with the efficient utilization of the frequency spectrum.

In the interim, I expect we will see satellites being put to use to provide better and more flexible communications services of the conventional type—telephone, teletype, telex, facsimile, etc., and to provide a means for doing new and different jobs. We are now proposing, for instance, a satellite over the Atlantic to be deployed next year for the purpose of providing high quality voice communications between commercial aircraft flying the heavy North Atlantic routes and appropriate control centers on both sides of the ocean. Some of the leading international airlines agree that satellites appear to offer the best prospects for solving their communication problems. Pan-Amierican, for example, has installed test equipment on some of its regular jet aircraft and has participated in successful satellite communication tests. The Federal Aviation Agency is evaulating this proposal to utilize aeronautical communication by satellite rather than consider an intermediate phase that would involve the use of single side band radio. We estimate that, even initially, service could be provided at a cost of about $150. per flight. About a child's economy fare. This would provide two channels of communication which is deemed adequate to supply the present needs of all the international airlines on that route.

Another potential application of satellite technology of obvious direct interest to you is that of using a synchronous satellite over the equator and at a longitude bisecting the continental United States, to provide the basis for a television network distribution system. Programs beamed from transmitters on either coast, and from a limited number of points in the interior, could be received by network affiliated stations across the country through relatively inexpensive receiving stations. Probably of the order of $100,000 or $150,000. The three major networks report that they spend on the order of $50 million per year for microwave and cable facilities and it is contended in some quarters that an even substantially larger number of stations could be tied together by such a satellite system at a great reduction in cost.

Here the problem, at least in the near term, is much more complicated than the aeronautical service. Rather difficult interference problems need to be resolved, costs associated with ground communications between the pickup point and the transmitter need to be adequately assessed. To keep the cost of receiving stations to a minimum, maximum power in the satellite is desired but there are limitations established by international agreement on the energy flux density that can be produced by a satellite. The frequencies available for use by satellites are limited and they are shared by other services. I am afraid that in this application many of the exotic pronouncements have been on the glib side. But the practical potential is there and the Corporation is engaged in detailed studies on these matters and has been in active discussion with the various television entities as to their needs and requirements.

On another front, communication satellites appear to have an attractive early application to meteorological purposes. In the not too distant future it is easy to contemplate centralized computing facilities receiving through the satellite system appropriate meterological satellites—digesting and processing such data and providing high quality weather forecasting services on a global basis.

In the educational field the influence of communications satellites can indeed be profound. They hold the promise of meeting some of the most sophisticated educational demands as well as some of the most fundamental and basic ones. Studies are underway aimed at evaluating their use for medical application as well as education; for tieing universities together for special courses and programs. On the other extreme, the task of offering rudimentary educational help to millions of underprivileged people over vast continents appears capable of solution by satellite at a relatively modest cost. And we recently completed a study of an educational system for the Continent of India using satellite receiving stations and rebroadcasting facilities. It turns out this is by far the most economical route for the solution of that problem.

These then are but a few of the new and novel possibilities that lie in the near future. Let me revert now, however, to the basic application—that of providing high quality communication links for telephone, record and television traffic on a global basis.

When the Corporation came into being nearly three years ago, we were faced with the question of what type of satellite system would best serve the initial global needs. The total experience at that time rested on the results of the experimental satellites, Telstar and Relay, which were both of the medium altitude variety with no provision for orbit adjustment. On the horizon was the program for the initial orbital tests of satellites of the synchronous variety. Satellites positioned so that their speed is synchronized with the revolution of the earth. Original analyses indicated that although it was likely that on economic grounds the synchronous approach would be most attractive in the first phase, serious questions remained. In the first place, it appeared that such satellites were likely to be more complicated and, hence, probably less reliable than satellites of the medium altitude variety. The problem of launching and successfully emplacing such satellites was obviously a much more complicated one. Most importantly, serious questions existed as to the suitability of a satellite of this type to meet high quality commercial telephone needs. Sufficient data were simply not available to determine whether the combination of time delay and echo suppressor behavior would produce telephone circuits of acceptable commercial quality. With a satellite at a synchronous altitude it takes about half a second for a message to go from one party to the other and for the reply to come back. Accordingly, it was decided in order to get answers to these cirtical questions and to take the first step to gain operational experience at the earliest practicable date, that a program should be launched to place an experimental/operational synchronous communications satellite in orbit as soon as possible. This, then, was the genesis of Early Bird.

Early Bird, as I stated earlier, was launched on April 6 of last year. Extensive tests of telephone, television and data services were conducted. The success of this experience led to the initiation of regular commercial service in late June. Since that time, the satellite has been in regular service for telephone purposes. Some 75 circuits are being used daily between United States, Canada and Europe. In addition to these telephone and data circuits, which have been provided on a regular basis, special service has been provided to meet special needs such as to fulfill emergency requirements caused by cable failure. Only last Friday, a failure in one of the trans-Atlantic telephone cables resulted in the temporary loss of over 150 badly needed circuits to Europe. During the Christmas holiday period, some 3,320 circuit hours of additional telephone service were provided between North America and Europe to meet the holiday peak telephone load.

With respect to international television, more than 40 hours of television service have been provided via the Early Bird satellite and associated ground stations, both here and in Europe, since June 28, 1965. The programs involved embraced many subjects, including Pope Paul's visit to the United States, a track meet from Kiev, Russia, the Gemini 6 and 7 splashdowns, the first international version of "Meet the Press" which featured the Secretary of State, with interviewers in England, France, Germany and Italy, and a special "Town Meeting of the World" program last month. And this week the British election results are scheduled to come to this country via satellite. With the Early Bird satellite, television and telephone and data service cannot be provided simultaneously. This limitation, however, will not apply to successor satellites. And this has led to some of the difficulties we have experienced; namely, if a television program is to be put on, all other traffic must be eliminated from the system. Now this is a severe limitation but it will not apply to the successor satellites, including those that will be launched this fall.

Now I think it would be worthwhile to discuss something about the reliability of this system.

The reliability of the communications satellite system has been exceptionally good. With the system consisting of the four alternating European ground stations and the one at Andover, Maine, plus, of course, the Early Bird satellite, and the interconnecting lines on the ground, the reliability of commercial service since June 28 has been 99.4%. This reliability figure compares most favorably as a matter of fact it exceeds any other means of international communications service.

The experience with Early Bird has been a material factor in the determination of the characteristics of the satellites which will be used in the developing global commercial communications satellite system over the next few years. Out of the Early Bird technology has evolved a successor satellite, with approximately twice the power of Early Bird and with improved communications characteristics, which will be launched this year. One is to be deployed over the Atlantic Ocean, the other over the Pacific. This early activation of an expended communications satellite coverage is directly related to the interest of NASA in commercial communications satellite capacity to meet its communications requirements in connection with the Apollo program—needs which can only be met reliably by communication satellites. With the NASA requirements being fully accommodated, substantial additional commercial capability will be available in the Atlantic area and, for the first time, in the Pacific area. This means that it will, as of this fall, be possible to simultaneously handle in both oceans both television and other forms of traffic.

The combining of these government needs with other commercial service will benefit economically all users of the communications satellite system.

With the successful deployment of the two new satellites this fall, potential satellite coverage will include all areas of the world except for a narrow band which extends from approximately West Pakistan to Malaysia. The coverage could of course, be made global by the deployment of a third satellite over the Indian Ocean. However, the limitation now becomes a suitable deployment of earth stations on a global basis. Planning is active in many areas of the world but the implementation schedule for such stations is the determining factor for global communications satellite service.

Since its formation, the Corporation has continuously investigated in detail the available technical choices for a satellite system. We have concluded that the initial deployment of the so-called global satellite system in 1968 should be synchronous, and the Interim Communications Satellite Committee, representing the international consortium, has unanimously endorsed this view.

I have indicated that the satellites that will be launched this fall will have twice the power of Early Bird. Actually, we also expect they will have twice the lifetime, which means they will have four times the number of circuit years which is an important term for us because circuit years really means revenue potential. But hard on the heels of the satellites which will be launched this fall, are satellites which are in development which will be launched in 1968, which will have substantially greater capacity, actually capacity for something on the order of 1400 telephone circuits, or a combination of television channels and telephone circuits adding up to that number. Beyond that, we are looking at a high capacity multipurpose satellite which again will increase the number of circuit years by a substantial amount.

Now this later satellite we are envisioning would be built on a modular basis and each module—and there may be 10 to 12 modules in the satellite—but each module will be capable of handling 600 to 700 telephone circuits, one color television channel or one circuit from an aircraft to the ground. And if we look at the circuit years over this generation of satellites we find in the relatively short time span of 4 to 5 years an increase of about 100. And since this means revenue potential this is a very substantial change in the economics of satellites in an extremely short period of time.

Now if one compares the cost of providing satellite services (even in this early time frame) with cables, one finds that the tremendous improvement in the number of circuit years the satellite system possesses, its flexibility to provide a wide variety of services, provides a substantial advantage even over the most modern cables.

As a matter of fact, something of the order of a factor of three to one over the most modern transistorized cables which have actually not yet been laid. Of course, a cable connects only the two points on the end of the cable. A satellite once it is deployed can be used by any country which is visible to the satellite. And in the case of the satellite deployed at synchronous altitudes, this means approximately one-third of the earth's surface can be seeing one satellite. The problem, as I said earlier, now becomes one of deployment of earth stations around the globe in order to utilize the satellite potential which will be there.

We have also sought to stimulate interest in the use of satellites to meet all kinds of domestic communication needs.

The growing needs for wide-band facilities for data, record and television transmissions suggest a high promise for the utlization of satellite capabilities. It is highly gratifying to have the formal expressions last week from the American Telephone and Telegraph Company and from the Western Union Telegraph Company that they are anxious to explore and make arrangements for the early use of satellite circuits to meet their growing domestic needs. We feel this represents a most important milestone in the story of communications satellite development.

This, then, is a brief report on what we are, where we have been and where our plans for tomorrow are directed.

For broadcasters, a new and decisively important communications medium is at hand. It will profoundly influence international television and radio communication. As the means expand so will the possibilities for international television coverage and interchange. It may also influence the means of distribution to local stations throughout this country. It may establish new arrangements and new patterns that will have a profound effect on the national television and radio picture. No one can paint the picture in detail but I believe that the pace and the impact will be faster and more significant than most of us can visualize. On the total picture of satellite communications, I am confident that what we might see today is likely to be too modest and too conservative. A good start has been made but the task is still in its infancy. In any event, I am sure that the new communications age which has now dawned with the advent of satellites will impact directly on the way of life of peoples throughout the world. It has, through its means for bringing people together aurally and visually, a tremendous potential to contribute to world peace and understanding. Let us hope it will be so used.

PRESENTATION OF THE NAB ENGINEERING ACHIEVEMENT AWARD
to
CARL J. MEYERS

by
GEORGE W. BARTLETT
Vice President for Engineering
National Association of Broadcasters

Ladies and Gentlemen, Honored Guests and Friends:

It is indeed a genuine pleasure for me to be standing before you today to honor a man who is so well-known, respected and admired by our industry. A man who has dedicated over 50 years of his life to the betterment of broadcasting, and has contributed so heavily to the electronic storehouse of knowledge in our common field of endeavor.

Engineering has been the cornerstone of Carl J. Meyers' life whose interest in radio began in 1913; who obtained his first commercial license in 1919 and spent four years operating land and ship stations; later to be followed by a laboratory assignment where he worked on the development of precision test equipment.

From 1923 to 1925, he was chief engineer of Station WTAS, Elgin, Ill., at the time one of the most powerful stations in the country.

In 1925, he joined the Chicago Tribune's radio station WGN and has been continually associated with them since that time. Carl interrupted his association with that station in 1942 to serve with the United States Navy as a commander in the Bureau of Aeronautics where he played an important role in the development and use of television by the armed forces.

Upon his return from military service in 1945, Carl was named director of engineering of WGN, Inc., with the responsibility of the design and installation of their ever-expanding studio and mobile facilities.

On May 16, 1961, he was elected vice president and director of WGN to replace the late Chesser M. Campbell, publisher of the Tribune. He was later elected a director of KDAL, their sister station in Duluth, Minn.

On June 26, 1961, when WGN dedicated its new Mid-America Broadcast Center, he was rightfully acclaimed the "father" of the new facility ragarded by the industry as one of the finest broadcasting structures in the United States.

On May 21, 1964, Carl was elected senior vice president and director of engineering, a post which he rightfully enjoys today.

He is the author of numerous engineering articles and a world-wide authority on color television. He is a member of countless technical societies and above all, undisputed champion of our free system of broadcasting.

In recognition of his distinguished professional career; for his outstanding leadership and untiring efforts to the lasting benefit of the industry; for his many contributions to our nation's knowledge in the fields of radio and television; and for his pioneering spirit which has so richly enhanced the forward progress of broadcast engineering:

It is my great pleasure on behalf of the National Association of Broadcasters, its membership and staff, to bestow upon Carl J. Meyers, senior vice president and director of engineering, WGN Continental Broadcasting Company, the 1966 NAB Engineering Achievement Award.

ACCEPTANCE

by
CARL J. MEYERS
Senior Vice President and Director of Engineering
WGN Continental Broadcasting Company

Thank you, George. It is an extreme honor and privilege for me to accept the National Association of Broadcasters' Engineering Achievement Award for 1966. I want to thank the NAB and in particular, two good friends of mine for many years, George Bartlett, vice president for engineering committee ,along with all other members of this great NAB Engineering Committee.

In accepting this coveted award, I do so only if I can express publicly my gratitude to my management and engineering colleagues at WGN Continental Broadcasting Co., for their assistance and encouragement over the years in the experimentation, for the advancement of color television. To these fine folks and the NAB I extend my hearty thanks for this day which I shall always remember and cherish the rest of my life.

And further, my dear friends, I trust and hope that the recipient of next year's engineering award has solved the great problem that confronts us, namely, loud commercials.

5M-5/66

RESEARCHES IN LOUDNESS MEASUREMENT *

Benjamin B. Bauer and Emil L. Torick

CBS Laboratories, Stamford, Conn.

Abstract

CBS Laboratories has performed a fundamental study of loudness from which several results already have emerged. A new set of equal-loudness contours has been obtained using octave bands of "pink" noise in a simulated living room environment. The CBS Laboratories contours differ radically from the Fletcher-Munson contours. Forward vs. backward inhibition tests were performed, from which a new summation function was deduced. A new duration vs. loudness level function was obtained for octave bands ranging in frequency from 125 Hz to 8KHz. This data is being incorporated in an instrument for measuring sensory loudness level.

1. Introduction

This paper is a progress report of a study on the measurement and control of loudness level conducted at CBS Laboratories under joint sponsorship with CBS Radio and Television Broadcasting Divisions. The project was started approximately a year ago and is still unfinished. Nonetheless, we believe that sufficient new and significant information has been found to deserve presentation at this time. If you ask us whether we are prepared to offer a meter for the measurement and control of loudness level, at present we must answer in the negative. However, we are prepared to advance a

*Presented at the Annual Convention of the National Association of Broadcasters, in Chicago, March 28, 1966.

cautious claim of being able to measure the level of sensory loudness of sounds with randomly distributed frequencies. To extend the scope of this claim to the ultimate objective of our research will require considerable additional effort, but the goal seems to be within reach.

"What is so difficult about measuring loudness?" you ask. "Can't a VU meter be used?"or,"how about using a sound level meter?". Unfortunately, the solution is not that simple. For a given VU meter reading, tones of different frequency may differ in loudness level by as much as 20 to 30 dB; and the VU meter by itself does not respond properly to the sensory loudness of combination tones. A sound level meter has a microphone, an amplifier, three frequency-shaping networks, and a two-speed indicating instrument. Whereas the networks are related to the characteristics of the ear, it is not always clear as to which one should be used, and again, combination tones are not properly measured. Also, the speed of the meter is not related to the dynamics of the ear. Thus, the sound level meter is useful as a yardstick for engineering specifications, and when used with care it will measure quantities which can be related to loudness of steady-state sounds. By itself, however, it is not to be relied upon for measurement of loudness level of complex sounds.

To find a way to measure and control sensory loudness first we must ascertain how people react to sounds of different character. This is not a simple matter because no two people will agree in all cases on which of two sounds is the loudest. To obtain information about sensory loudness a group of listeners must be used to obtain average consensus. Therefore, valid loudness investigations are long, tedious, and expensive. Work on this subject has been going on for many years, and we will review some of the earlier studies to give you a good feel of the subject.

2. Sensory vs. Perceptual Loudness

What do we mean by "sensory loudness" and how is it different from other aspects of loudness? We clarify this question with a few examples. You are playing your HiFi set for company. Being considerate of neighbors, you adjust the volume to a reasonable and proper value -- say the minimum needed to reproduce the full dynamic range of the record. The wife says, "Turn down the loud sound -- I can't hear the girls talk." So you see, a sound may be considered soft or loud depending on our interest in it.

Another example: Some years ago we were engaged in developing an instrument for the automatic control of level in broadcasting -- the CBS Laboratories AUDIMAX of today. We observed that a person shouting seemed to sound louder than the same person speaking normally, even if the measured levels in both cases were equal. Perhaps the difference in perceived loudness was due to a change of frequency spectrum in the two modes, but we don't think so. It appeared to us that the shouting voice seemed the louder because of the feeling of urgency which it communicated.

And lastly -- Who has not been awakened in the middle of the night by the sound of a whimpering child, which in the daytime might have gone unnoticed? Why was this sound at night so compelling? We don't know, but evidently psychological conditioning plays an important role in our assessment of "loudness" of certain sounds.

Despite these psychological factors, there is an important body of scientists who believe that loudness sensation can be related directly to the neural activity of the inner ear, which, of course, is a physiological or sensory phenomenon. One might think, therefore, that if we could produce sounds free of semantic content, and measure the sensation of loudness they cause in typical observers, we should be in a position to construct a device to measure loudness. Therefore, as a first step in an investigation of sensory loudness, we must find means to produce sounds -- especially speech sounds -- which are as much as possible, devoid of semantic content.

There are several ways of approaching this problem: 1) The use of thermal noise, which is devoid of meaning; 2) Scrambling speech by electrical or mechanical means, such as by cutting the tape and resplicing at random; 3) Using foreign languages; 4) Using synthetic English -- made-up words which have the syllabic content of English but otherwise have no significance -- e.g. double talk; 5) Recording ordinary English and playing the tape backwards so that the energy content remains unaltered. By the way, we experimentally determined that methods 4) and 5) produce quite equal loudness sensation, and since then we have frequently used backward running tapes in the study of loudness of words and phrases.

In summary, we believe that loudness has two aspects: 1) Sensory or physiological aspect which can be ascribed to the activity of the peripheral organ of hearing -- the inner ear, and 2) Perceptual or psychological aspect which involves the central function -- psychological conditioning, memory, emotional factors, etc. We refer to these two aspects of loudness as "sensory loudness" and "perceptual loudness", respectively. The phase of work in which we are currently engaged is limited to the study of the means of measuring and controlling the level of "sensory loudness", and when we make reference to the term "loudness" in this paper, we mean sensory loudness.

3. Loudness and Loudness Level

Until now we have not distinguished clearly between the terms, "Loudness" and "Loudness Level", but at this point it becomes important to do so.

Forty years ago when Fletcher and Munson began a scientific study of loudness, it became apparent that it was difficult to assign numbers to the sensation of loudness of various sounds without comparing them audibly against a standard sound. In acoustical engineering the pressure level of sound, in dB, is referred to 0.0002 dynes per sq. cm.; this corresponding approximately to the lowest audible sound at 1000 Hz* for normal human hearing. Fletcher and Munson chose to measure the audible level of any sound by comparing it against a 1000 Hz tone. The loudness of the comparison tone is adjusted until, on the average, it is judged to be as loud as the sound being measured. Then the level of the 1000 Hz tone in dB is called the "loudness level" of the sound being measured, in "phons".

This procedure works well in practice, and is used to this day. Furthermore, we have demonstrated that sounds having the same loudness levels sound equally loud when compared with each other.

Thus, although loudness level determination involves human judgment, it is a definite measurable quantity. However, from the point of view of a Psychologist, loudness level is not a measure of loudness. For example, it does not tell us "how many times louder" is an 80 phon sound than a 60 phon sound. How then can an absolute scale of loudness be established? Obviously, one has to ask people when a given sound is "twice as loud" as another sound. One way of doing this is to use a headset with independently accessible earphones, raising the signal level into a single earphone until it sounds as loud as when two weaker but equal signals are fed into both earphones.

---

*Hz, abbreviation for Hertz, has been adopted as name for cycles per second. KHz is 1000 cycles per second.

The theory behind this approach is to say that, when both ears are subjected to given equal sounds, twice as many nerve impulses are produced than when one ear is actuated by the given sound. The aforementioned procedure tells us how much it is necessary to increase loudness level to one ear to double the sensation of loudness.

Another method is based on the hypothesis that when the ear is subjected to two or more sounds of widely separated frequency, each of the sounds acts on a different patch of nerve endings in the inner ear and the impulses arising from these patches are independent. So that, for example, if a 500 Hz tone and a 2000 Hz tone are equally loud when sounded alone, they will produce twice the rate of nerve firings when applied together, therefore, doubling the sensation of loudness. Increasing the level of either of these equally loud sounds until it sounds as loud as both applied together will tell us how much must the level be increased to obtain twice the loudness.

A third method is more direct than the previous two: The subject is simply told to adjust the level of a sound until its loudness, in his judgment, doubles, trebles, etc. In this manner a "loudness" vs. "loudness level" scale is constructed.

It is a matter of interest and comfort, that the above methods as well as some others that had been devised, produce fairly consistent results (although the variations for any one subject, of course, are rather large). It is generally accepted today that the sensation of loudness doubles with approximately a 10 dB increase of loudness level. The unit of loudness, called a "sone", is defined as loudness corresponding to a 1000 Hz tone 40 dB above the listener's threshold. Since, for a typical observer, the threshold at 1000 Hz is at 0 dB, a sound having a loudness level of 40 dB, to a person with normal hearing, has approximately the loudness of 1 sone.

Fig. 1 shows the relationship between the loudness level of sound, in "phons" and the sensation of loudness in "sones" as recommended by I.S.O. (International Standards Organization).

It will be noted that in the region between 20 and 120 phons the relationship between phons and sones may be written:

$$S = 2^{(P-40)/10} \qquad (1)$$

or

$$P = 40 + 10\log_2 S \qquad (1a)$$

where S is the loudness in sones

P is the loudness level in phons.

The consequence of this relationship, proven in the Appendix, is that loudness (in sones) varies approximately as the 0.6 power of the ratios of pressures (in dynes per sq. cm) of the comparison tones; i.e. the relative loudness S_1 and S_2 of any two sounds, in terms of pressures of their respective comparison tones p_{c1} and p_{c2} is

$$S_1/S_2 = (p_{c1}/p_{c2})^{0.6} \qquad (2)$$

As in all psychological relationships, the expression in Eq. (2)

is subject to variations from observer to observer and from one type of sound to another. From the point of view of a psychologist, the sone is a preferable unit since it relates arithmetically to the sensation of loudness. For the engineer the loudness level in phons is more convenient, as it relates to the power level - a more familiar engineering quantity.

4. Equal Loudness Contours

Fundamental to the study of loudness is the measurement of levels of sounds of equal loudness as a function of frequency and intensity. The result of such measurements is portrayed as a set of "equal loudness contours". These contours are obtained, customarily, in 10-db steps to cover the desired range of sound pressure levels.

The classical equal loudness contours for pure tones presented by Fletcher and Munson[1] in 1933 are shown in Fig. 2. Despite the wide acceptance of these contours, especially in the U.S.A., there is divergence of opinion with regard to them. Thus, in 1937, Churcher and King[2] published another set of equal loudness contours, shown in Fig. 3, and a still further set was presented by Robinson and Dadson[3] in 1956, as shown in Fig. 4. Actually the contours of Robinson and Dadson are contained in the I.S.O. recommendation R 226. It should be noticed that from 60 dB up, the shapes of these contours is practically invariant. This is important in any projection for a loudness meter.

---

1. J. Acoust. Soc. Am. 5, 82 (1933).
2. J. Inst. Elec. Engrs. (London) 81, 57 (1937).
3. Brit. J. Appl. Phys. 7, 166-181 (1956).

All of the above measurements are predicated on the use of pure tones in free field, without reflections (as in an anechoic chamber), with the observer facing the source of sound. Under this circumstance the tests prove to be very laborious since but one observer can be tested at a time. In practice, therefore, earphones are used, usually after suitable calibration against the free field. Either of these tests are not representative of the typical conditions of listening. In the course of daily life the listener is immersed in a diffused sound field, and is subjected to rapidly changing sounds with continuously varying frequency content. Therefore the aforementioned equal-loudness contours may be suspected to be of limited utility.

The importance of ascertaining the equal loudness contours under conditions more nearly representative of everyday sounds has been apparent to several workers in the field. Thus, Stevens[4], of Harvard University, in describing his research on methods for calculating the loudness of a complex noise, obtained equal loudness contours for octave bands of white noise,[5] using calibrated earphones, as shown in Fig. 5. They are significantly different from pure-tones contours obtained by previous investigators. To overcome the shortcomings of earphone receivers, Stevens also ran equal-loudness contour curves for octave bands of noise with the listeners in a diffused sound field. His 73-phon contour, in comparison with the 75-phon contours of Fletcher-Munson and Churcher-King, and the 84-phon

---

4. S. S. Stevens, J. Acoust. Soc. Am. 28, 5, 807-832 (1956).
5. White noise is characterized by having equal energy per cycle. Thus, the 1-2 kc octave band has 1/2 the energy of the 2-4 kc octave band, etc.

contour of Robinson-Dadson, is shown in Fig. 6. It is seen that the free-field contour of Stevens (using octave bands of white noise) differs substantially from the other contours, mainly by exhibiting less rise at low frequency and an absence of high frequency rise. In subsequent paper in 1961[6], Stevens published a proposed set of equal Loudness Index contours which serve the role of Equal Loudness contours in his method of loudness calculation, to be described later, reproduced in our Fig. 7. These contours differ radically from those he published previously.

After reviewing the data of previous investigators we decided that, for the purpose of studying loudness in broadcasting, it was important for us to determine a set of equal loudness contours under conditions more applicable to everyday listening in the home. First , it seemed to us that the room in which the tests would be conducted should be representative of the type of room in which broadcasts are normally heard. Second, the subjects should be in a position to hear the sound arriving randomly from all directions, from a loudspeaker. Third , the quality of the sound system should be sufficiently high to ensure a uniform response throughout the frequency range of interest. Fourth , the sounds would be presented in bands corresponding to the bandwidth of the filter sections to be finally employed for loudness analysis. We arbitrarily decided, after the early work of Stevens, to use

---

[6] S. S. Stevens, Jour. Acous. Soc. Am. 33, 11, 1577 - 1585, 1961.

1-octave bands of noise, as wider bands did not appear to provide adequate discrimination between different sounds, and narrower bands would make any future "loudness level meter" prohibitively expensive. However, unlike Stevens and others, we decided to use "pink" and not "white" noise because of the favorable spectral distribution of the former*.

5. CBS Laboratories Equal Loudness Contours

CBS Laboratories measurements of equal-loudness contours were conducted in the summer and fall of 1965. A special measuring set, shown in Fig. 8, was constructed for these tests. The block circuit diagram is shown in Fig. 9. The input signal is divided into octave bands by means of 9 filters, covering a range of 32 hz to 16Khz. Two sets of output attenuators are provided, in correspondence with these filters, so that two different sets of response curves can be presented to the listener. Switching between the two sets, or between one set and an external source can be done by means of a motor-driven switch which actuates two vario-losser elements so as to avoid a click. This test set forms an extremely flexible device which permits a large number of different tests to be designed for loudness investigations and other psychoacoustic measurements.

The listening team used in our tests was usually composed of 10 women, although one set of contours was obtained with a group of 9 men. The median age of the groups was about 30 years. During the course of the investigation, 3 separate groups were used. With each new group the

---

*White" noise has equal average energy per cycle, whereas the average energy per cycle of "pink" noise is inversely proportional to frequency. Thus "pink" noise has equal energy distribution per octave band.

first session was a learning session. Tests were usually run in the CBS Laboratories small studio, 16' x 14' x 8', which has carpeting, drapes, and an acoustical-tile ceiling. Therefore, the reverberation time is short, being of the order of 1/3 second. Under these conditions equal-loudness contours were obtained at 50, 60, 70 and 80 phon levels.

Because of building noise in the small studio, the 50-phon contour was suspect. Therefore, a second series of tests was conducted in a more quiet environment of a suburban home. The room used, 25' x 24' x 7-1/2' high, had wood-panelled walls, vinyl-tile floor, and acoustic tile ceiling, and no carpet or drapes. This room was noticeably more live than the studio, exhibiting a reverberation time of the order of 3/4 second. Under these conditions, a set of equal loudness contours was obtained at 40, 50, 60, 70 and 80 phons. The two sets of contours were equal, within experimental error. The 70-dB contour was repeated each time a new team was used.

During the tests, a loudspeaker system with uniform frequency response and polar pattern was placed in the corner of the room, and the test team was seated on an arc so that each member was subjected to approximately equal sound energy. Octave bands of pink noise were used. The sound-pressure level of each octave band and the proximity of the chairs to the speaker were adjusted, using a calibrated sound level meter, so that the sound pressure at the listener location was uniform within approximately 1 dB. In order to avoid small errors stemming from the absorption by the clothing of the team, the sound pressure level was frequently remeasured with the team in place, by taking readings midway between the ears of the listeners. The comparison tone was a 1/3-octave band of pink noise centered at 1000 Hz, to avoid standing waves.

The octave bands were presented in 1 dB step adjustments, for 1 second periods, selected at random and alternating with the comparison tone. Each listener had a tally sheet on which the judgment of loudness of the octave band with respect to the comparison tone was entered as "L" or "S" (for Louder or Softer). No "equal" choice was provided. After the session, the entries were tabulated and scored. Average deviation from the mean judgment of equal loudness seldom exceeded 1 dB.

CBS Laboratories Equal Loudness Contours resulting from these tests are shown in Fig. 10 for women, and in Fig. 11 for men. It is interesting to note that the frequency of maximum sensitivity in women is 4500 Hz and in men, 3000 Hz. (Perhaps this is why women are more bothered by the Highs in HiFi!). A composite set of contours is shown in Fig. 12. It should be noted that the sound-pressure-level for octave bands at 1000 Hz is about 2-1/2 dB lower than the SPL of the 1/3-octave band of the same loudness. This is explained by the fact that the octave band acts on a wider patch of nerves in the inner ear than a 1/3-octave band and its effectiveness is greater.

6. Loudness Summation

One can provide a meter with a network which is the inverse of that of Fig. 12, and use it to measure the loudness level of steady-state octave bands of noise, but what if there are several bands of noise heard simultaneously?

When the workers in psychoacoustics attempted to predict the loudness of multi-component sounds from measured sound spectrum they employed the following line of reasoning:

1. Each component of the sound can be thought of as activating a given patch of nerve endings to "fire," producing a given sensation of loudness, S.
2. This loudness is calculable from the loudness level of the given component, (using Fig. 1).
3. If one were to determine the loudness S due to each component acting alone and all these loudnesses were to be combined by means of some arithmetical scheme, the combination would be related to the total neural activity and, thus, should yield the resultant total loudness.

Among the first to offer the above approach were Fletcher and Munson[1], however, their method is only applicable to pure tones. In 1951, Beranek, Marshall, Cudworth and Peterson[7] proposed a method for calculation of loudness of distributed-frequency noise following the same general idea. These authors divided the noise spectrum into bands approximately 1 octave wide (actually, 300 "mel" wide. Mel is a psychological unit of pitch). Following this, they determined the sound pressure level in decibels for each band. Next, using the relation between loudness level and loudness (similar to the one in our Fig. 1) they found the loudness in sones contributed by each band. And lastly, they added these individual values of loudness to obtain the total loudness, in sones.

---

[7] J.A.S.A. 23, 3, p 261 May 1951

Other investigators, however, questioned the validity of direct addition of partial loudnesses of the individual bands. For example, Stevens[4] asserted that under direct testing, the sum of the loudnesses in the separate bands of a broad spectrum could exceed the observed loudness of the total noise by a factor greater than 2. Stevens attributed this to "inhibition", that is, the interaction between bands, where a band of noise acting on a patch of nerves diminishes the ability of the adjacent patches to respond to a second band of noise as effectively as they would have if the first band were not present. Stevens offered the following refinement: Given N adjacent bands of equal loudness S, assume that the first one produces the full measure of loudness, i.e. S; but each added band contributes only a fraction F of S to the sum. Thus the total loudness S_t of the N equally loud bands, according to Stevens is,

$$S_t = S + F(N-1)S \qquad (3)$$

$$= S + F(\Sigma S - S) \qquad (4)$$

$$= S\left[1 + (N-1)F\right] \qquad (4a)$$

where ΣS means the sum of the loudnesses of all the bands. If the bands are of unequal loudness, Stevens reasons that the greatest contribution to total loudness will be by the loudest band, S_m, all the others contributing the F fraction of their sum, and he rewrites equation (4) as follows:

$$S_t = S_m + F\,(\Sigma S - S_m) \qquad (5)$$

or,

$$= (1-F)\,S_m + F\,\Sigma S \qquad (6)$$

Stevens conducted numerous experiments and concluded that, for octave bands of noise the factor F was = 0.27, but he rounded this to 0.30 because of better fit with subsequent experimental data. If the bands are 1/3 octave wide, instead of 1 octave, F turns out to be about 0.15. The partial loudnesses S are shown as "Loudness Indexes" in Fig. 7.

Another method of loudness calculation has been proposed by Zwicker of the Institut fur Nachrichtentechnik in Stuttgart[8]. Zwicker offers the further refinement of taking into account assumed differences in inhibition acting upward from lower to higher frequency bands as a function of the relative level of the bands.

While the methods of Stevens and Zwicker reportedly have served well for the calculation of the loudness of a variety of sounds, they have not been universally successful. For example, recently E.L.R. Corlis and G. E. Winzer of the National Bureau of Standards[9] employed these methods to calculate the loudness of footsteps, and pointed out a substantial disagreement between the calculated loudness and subjective loudness balance measurements.

A number of workers in the field of loudness measurement have suggested using the principles described by Stevens and Zwicker to perform loudness calculations with electronic circuits which, by definition, would constitute a loudness meter. We are not aware of the status of these developments, nor do we feel that these principles are best adapted to an engineering solution of the problem at hand.

---

[8] Acustica; 8, Akust Beih. 1, 237-258 (1958)

[9] Journal of A.S.A. Vol. 38 No. 3 p 424-428, Sept. 1965.

7. Hypothesis on Loudness Summation

One of the propositions examined in our work was the hypothesis that it might be possible to do the summing of electrical signals, stemming from any frequency division of the sound being measured, prior to conversion into the loudness function. In other words, instead of converting sound pressures to phons and then to sones prior to summation we preferred to perform the summations on the sound pressure side of the equation. Considerable simplification in the circuitry of the meter was expected from such an approach.

Let us clarify this by an example. Stevens maintains that if N adjacent equally loud octave bands of sounds are present, then assuming that the first one contributes a unit of loudness, the second one will contribute 0.3 units of loudness, and so forth. Thus, beginning with the first band, and adding successive bands, loudness grows in a progression of 1 : 1.3 : 1.6 : 1.9 ... But we know that loudness also varies approximately as the 0.6 power of sound pressure and sound pressure in an octave band can be represented by a voltage. Suppose we normalize the voltages, as with an appropriate frequency network, so that octave bands of unit loudness produce unit voltage outputs from the octave band filters. These voltage outputs are then rectified so that they can be added in a linear fashion. Now suppose we take the voltage corresponding to the first octave band, and raise it to 0.6 power. The output still is unity since one to any power is one. Next, we add a fraction R of the outputs of the succeeding voltages, and raise the sum to the 0.6 power. We select R so as to closely approach the growth of loudness predicted by Stevens. For example, for octave bands assume that R is 0.64. The resulting "reading" obtained by using the method of "Loudness Index" summation of Stevens, and of 0.6-power "Voltage Summation" is shown in Table I.

TABLE I

No. of Octave Bands N	Stevens Loudness Summation $1 + 0.3(N-1)$	0.6-Power Voltage Summation $[1 + 0.64(N-1)]^{0.6}$
1	1	1
2	1.3	1.34
3	1.6	1.64
4	1.9	1.90
5	2.2	2.13
6	2.5	2.36
7	2.8	2.58
8	3.1	2.78

It is seen that the six-tenth power voltage summation produces a growth function which is very close to that predicted by the Stevens method of addition of loudness indexes. The tremendous advantage of the former method when applied to an electrical circuit is that, a single power function device is required (and this can be the calibration of a meter), whereas to obtain loudness indexes each band has to be operated upon by its own non-linear function. Since the Stevens equation, in itself, is only approximate, it is a matter of experiment to determine which of the two methods is in better conformity with actual experience. In the general case of unequal voltages, the applicable expression would be in the form of $\left[E_m + 0.64(\Sigma E_n - E_m)\right]^{0.6}$, where E_{ns}' are the normalized voltages and E_m is the maximum normalized voltage.

As a matter of fact, there is really no reason to assert that an R = 0.64 and the exponent 0.6 are optimum in adding the normalized voltages. We can experiment, for example, with R = 1 and the exponent = 0.5. The predicted form of loudness growth using this method compared to that of Stevens is shown in Table II. The similarity is worth noting.

TABLE II

No. of Bands N	Stevens Loudness Summation $1 + 0.3(N-1)$	Square-Root Voltage Summation $N^{0.5}$
1	1	1
2	1.3	1.41
3	1.6	1.73
4	1.9	2.00
5	2.2	2.24
6	2.5	2.45
7	2.8	2.65
8	3.1	2.82

From these tables one can hypothesize that a simple square-root voltage summation can be in useable agreement with the more complex methods of loudness summation at least for a limited range of loudness levels. A relationship which suggests itself at once with respect to Loudness-Level summation stems from the fact that the near-doubling of loudness as calculated by Stevens for four equal-loudness bands should correspond to about 10 dB increase in loudness level, whereas the increase of voltage level by direct addition of the rectified voltages of the four bands is $20\text{Log}4 = 12$ dB. Furthermore, we had noted repeatedly that the level of four adjacent octave bands measured by loudness balance methods had to be lowered not by 10 but by about 12-13 dB to balance against the sensation of loudness of a single band. On basis of these considerations, we conducted a number of experiments in which the loudness level of octave bands of noise added in different combinations was compared with the electrical voltage level obtained by simple addition of the normalized voltages.

In Fig. 13, shown in solid line, is the attenuation required to balance the loudness level of varying numbers of bands of noise against a 70-phon 1000-Hz 1/3-octave band of noise. The number N varies from 1 to 8. The level of the arithmetic addition of the voltage bands, calculated on basis of Level = 20 log N is shown in dash line. The agreement is mostly within 1-1/2 dB which is close to the limit of accuracy of our experiments.

The next question we asked ourselves, was: "How does this principle work for summation of bands of unequal loudness levels?" We started out with 70-phon octave bands of noise in groups of adjacent four bands. The lowest frequency group spanned the range of 125 - 2,000 Hz. The middle-frequency group extended from 250 - 4,000 Hz; the High-frequency group covered 500 - 8,000 Hz. We took this occasion to answer a question which has troubled us for some time: Is the inhibition symmetrical or dissymmetrical? In other words, if we compare the loudness of a group of bands with progressively diminishing levels toward the high frequency end with a similar group in which the band level diminishes progressively toward the low frequency end, what will be their relative loudness level?

The results are shown in Fig. 14. The abscissa shows the incremental attenuation per band. The ordinate is the attenuation of the group to match a 70-phon band. It is seen that for the two upper-frequency sets of bands, the direction of attenuation does not matter. The overall attenuation required to equalize the loudness of the sets against a 70-phon comparison tone follows the curve of 20 log the sum of normalized voltages, within 1 - 1-1/2 dB. With the set including the lowest frequency, the direction of attenuation does make a difference. As expected, forward inhibition (or masking of low level high frequency tones by high level low frequency tones), is predominant. This is a factor to be considered in future development work of a Loudness Level Meter.

It is interesting to note that all equally-loud four-octave band sets employed in our tests required that their level be attenuated 13 dB to be equally loud compared with a single octave band.

8. Projecting a Loudness Level Meter

We now have sufficient data at hand to project a sensory loudness-level meter. Our immediate objective is to measure the relative loudness level in the 60-80 phon range. The first step is to provide a set of octave-band filters. Then, the 70 dB equal loudness contour is selected as the design objective for an input network to normalize the filter outputs, so that bands of sound of equal loudness provide output voltages of equal voltage. The filter outputs are rectified and operated on by a summing network to carry out the appropriate mode of addition of the individual voltages. The resultant is displayed on a meter quite similar to a VU meter, but with suitable calibration and endowed with suitable ballistics. *
In block diagram the meter is shown in Fig. 15.

*The term "suitable ballistics" is intended here to denote the ability of the pointer of the meter to respond to short impulsive sounds, repetitive impulsive sounds, etc. in a manner conforming to that of the human ear.

9. Meter Ballistics

The development of meter with suitable ballistics appears to be the remaining key problem in the development of a meter suitable for measurements of loudness levels of speech and music.

Data as to how the ear perceives short pulses of sound is available, but scattered. We thought it best to obtain it with our psychoacoustic team.

The increase in level necessary to maintain equal loudness of octave bands as a function of time, is shown in Fig. 16. For a pulse as short as 30 ms the level, compared with a 1 - sec. long tone, must be increased some 7 dB. This is true regardless of frequency band being tested, in the range 125 - 8,000 Hz.

We were curious to know how did this time constant compare with that of a VU meter. The results are shown in Fig. 16 in dash line. It is seen that the VU meter follows the ballistics of the ear pretty well above 150 ms. but for shorter durations it produces a substantial error, which at 30 ms reaches 10 dB. Investigation of meter ballistics, to conform with subjective measurement of sensory loudness level, is continuing at CBS Laboratories.

Conclusion

The researches aimed at the measurement of loudness level, at CBS Laboratories, have now reached the stage where loudness levels of continuous bands of noise in the 60 - 80 phon range can be rapidly and reliably measured. The adaptation of the method to speech and music and to other discontinuous and impulsive sounds must await further developments. Our present efforts are directed to the measurement of loudness of speech sounds and to the development of ballistics that will agree with the judgment of loudness level of the psychoacoustic test team. Considerable additional testing and circuit adaptation work remains, but we look confidently toward completion of this final phase in the not-too-distant future.

Acknowledgment

The authors acknowledge the invaluable assistance of Mr. Allan J. Rosenheck, who directed the psychoacoustic team, and of Messrs. Richard G. Allen and Henry W. Mahler, who contributed ideas and efforts directed to electronic design. The guidance of Messrs. Ogden L. Prestholdt and Davidson Vorhes of CBS Radio, and of Messrs. Howard A. Chinn, Richard O'Brien, James Parker of CBS Television Network, and Joseph L. Stern of CBS Television Stations, is gratefully acknowledged.

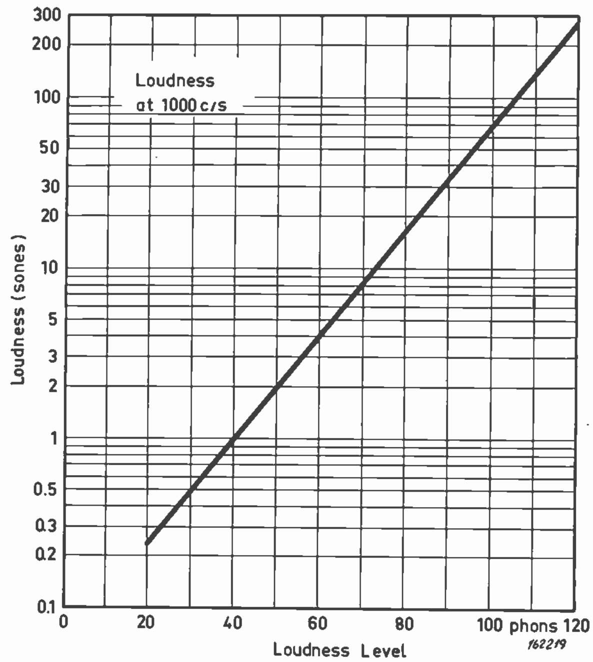


Fig. 1. The Relationship Between the Loudness in Sones and the Loudness Level in Phons

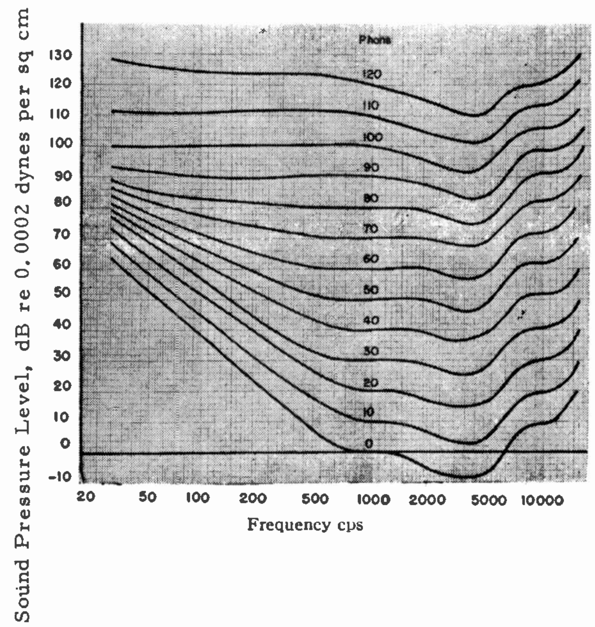


Fig. 2. Equal-Loudness Contours (Fletcher and Munson)

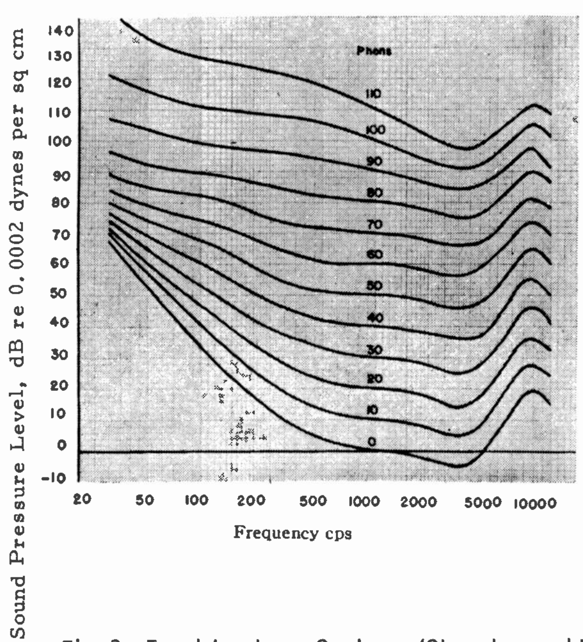


Fig. 3. Equal-Loudness Contours (Churcher and King)

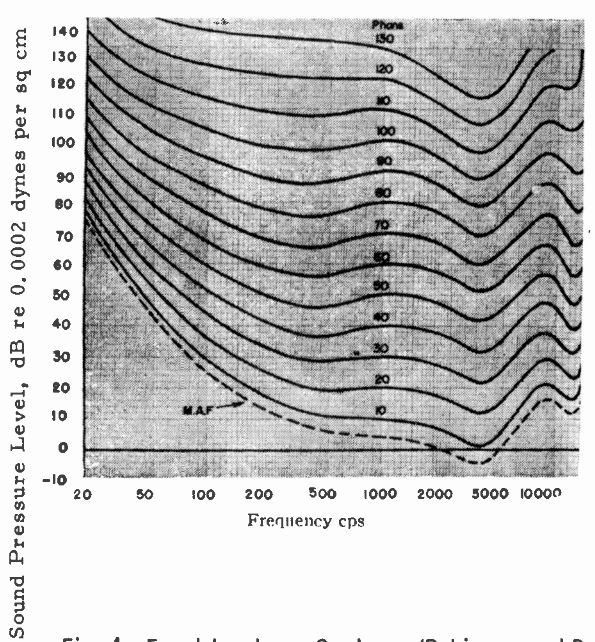


Fig. 4. Equal-Loudness Contours (Robinson and Dadson)

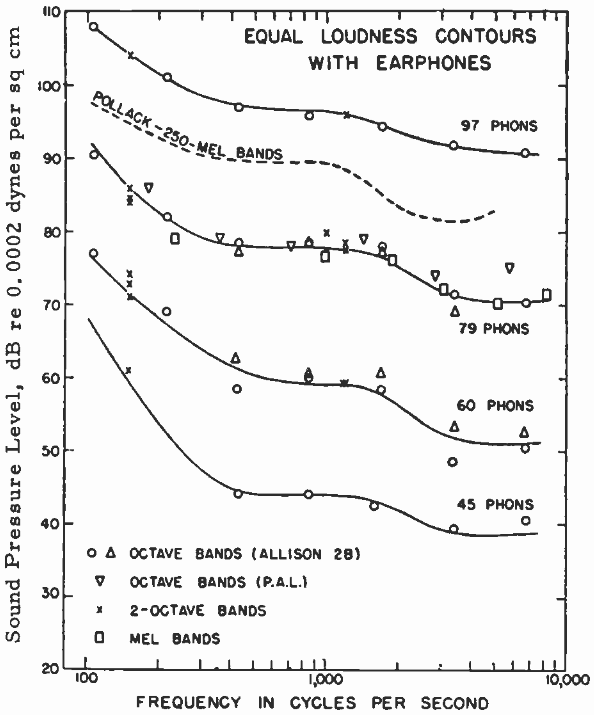


Fig. 5. Equal-Loudness Contours for Bands of Noise with PDR-10S Earphones (Stevens)

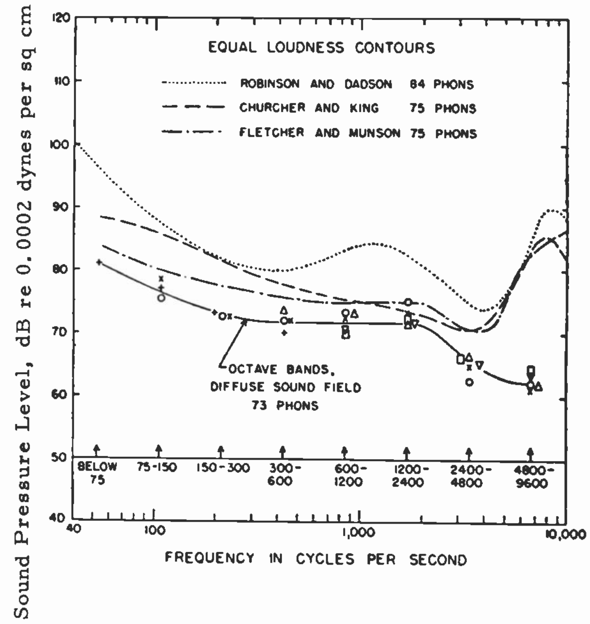


Fig. 6. Equal-Loudness Contour of Stevens Shown by the Solid Curve. The Other Curves Show the Form of the Equal-Loudness Contours for Pure Tones Determined in a Free Field

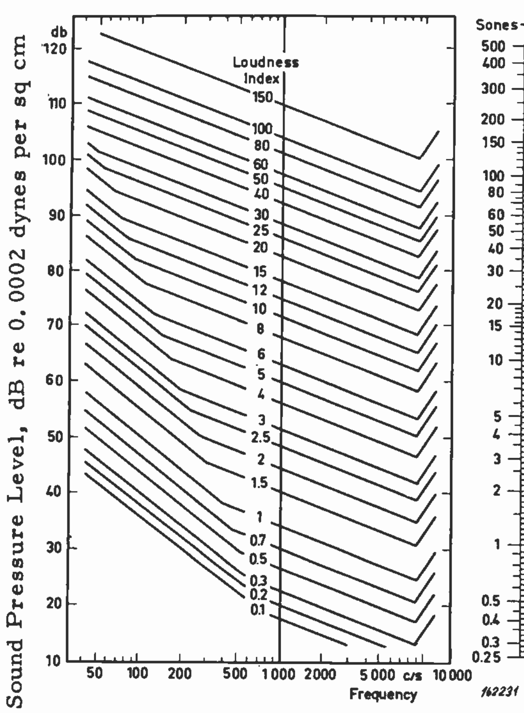


Fig. 7. Loudness-Index Contours (Stevens)

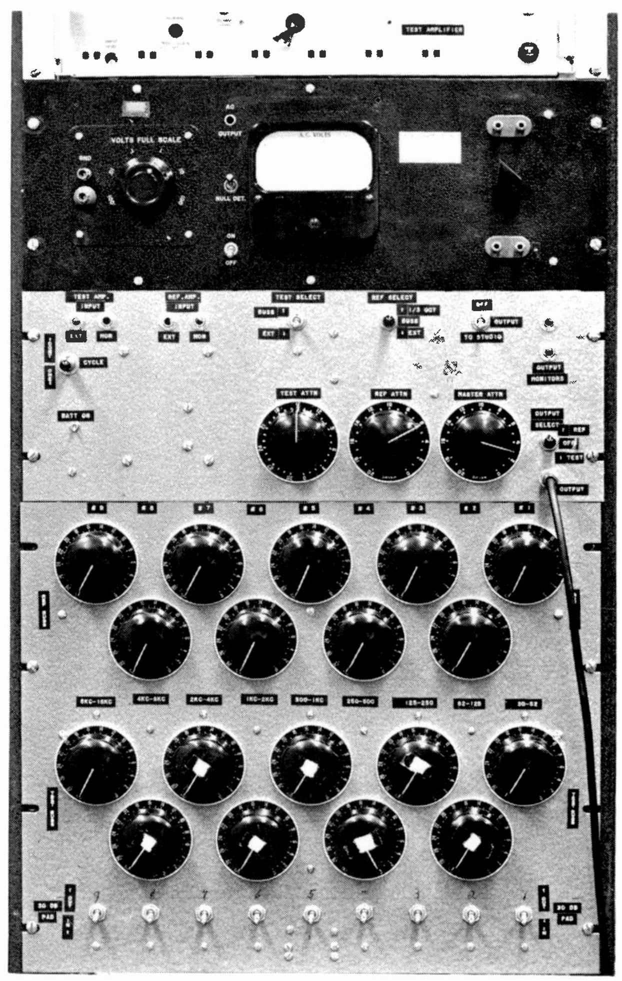


Fig. 8. Loudness-Balance Testing Equipment Control Panel

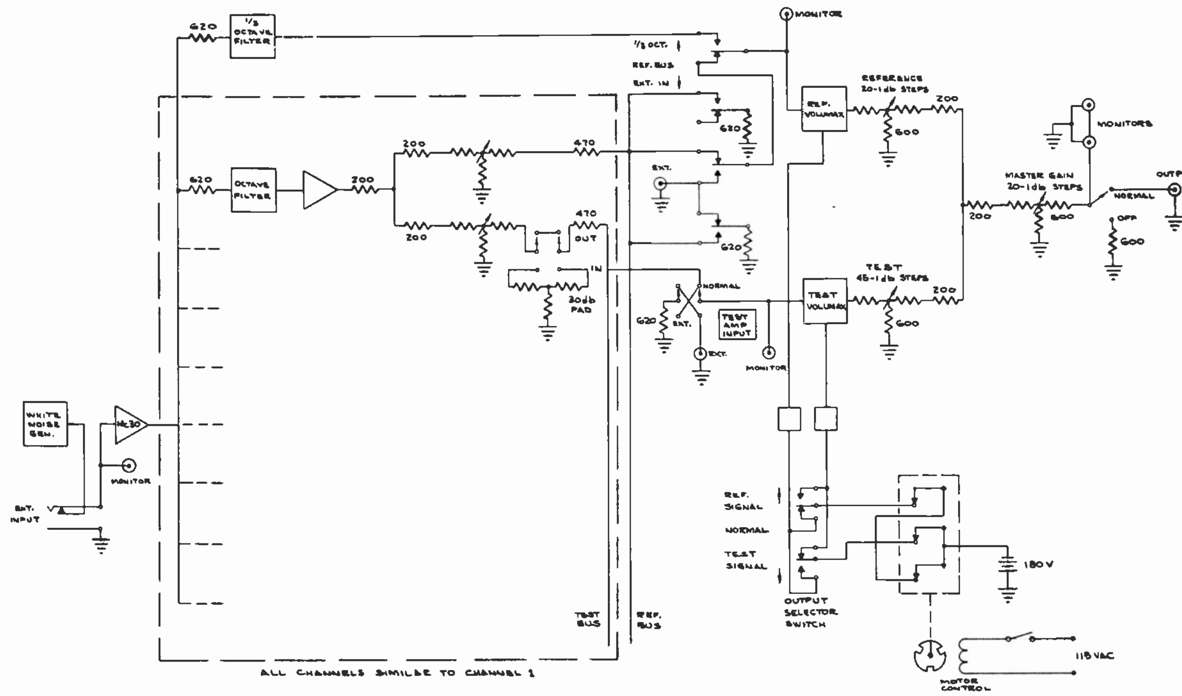


Fig. 9. Block Diagram, Loudness-Balance Testing Equipment

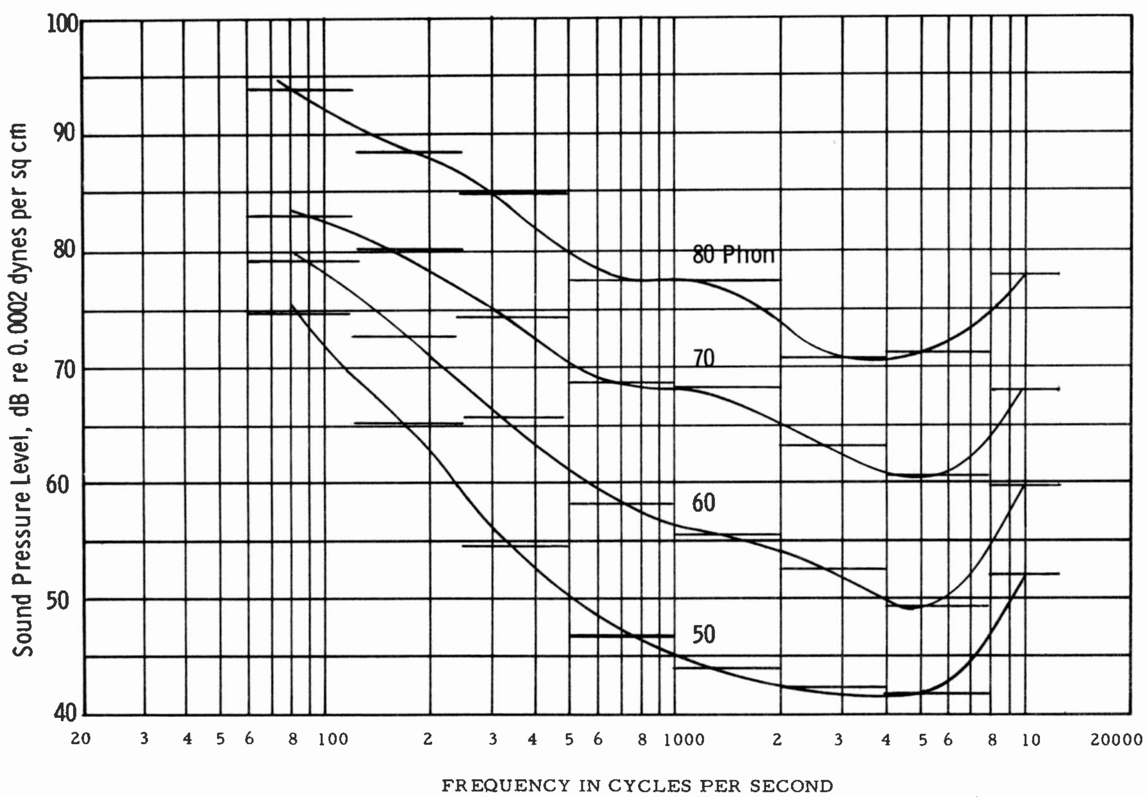


Fig. 10. CBS Laboratories Equal Loudness Contour (Female Observers)

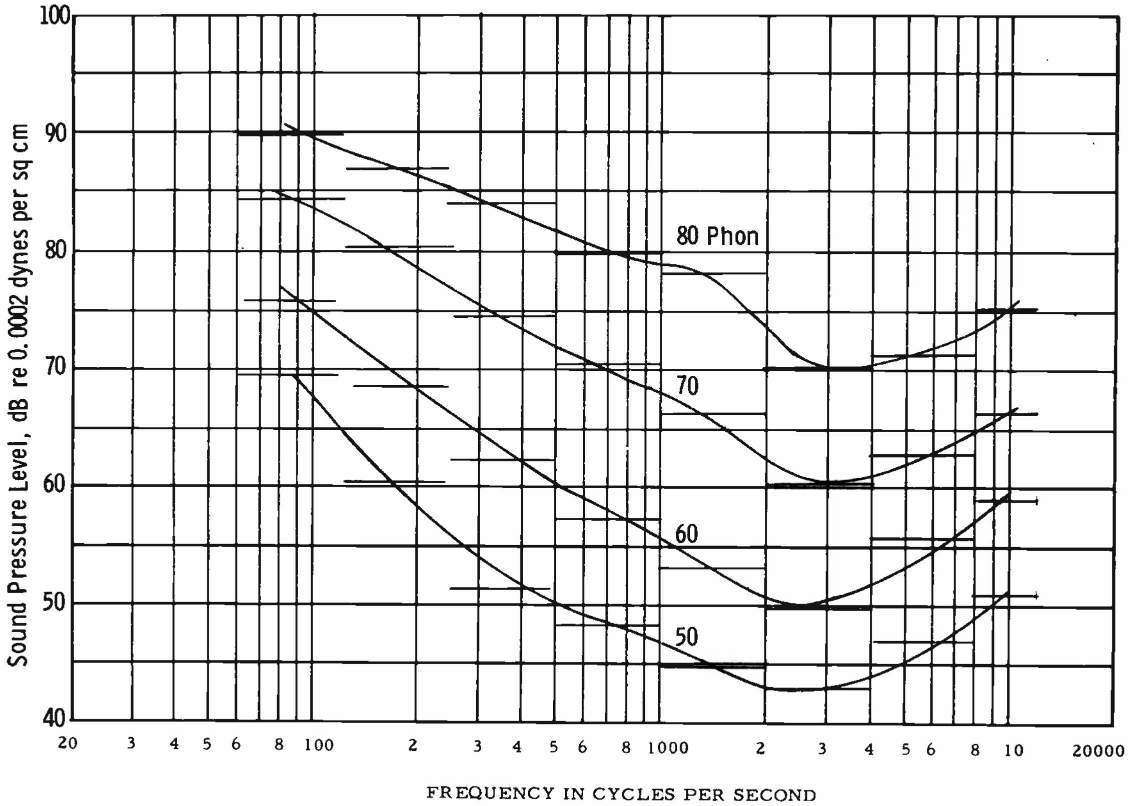


Fig. 11. CBS Laboratories Equal Loudness Contours (Male Observers)

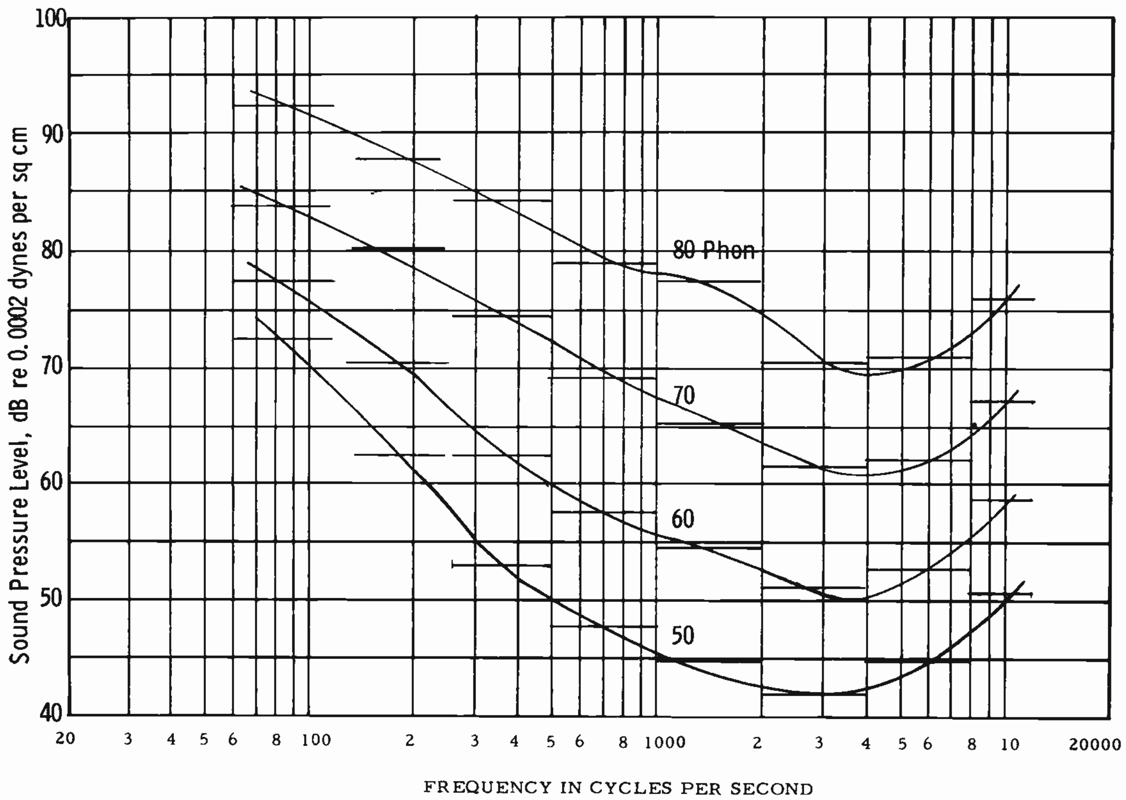


Fig. 12. CBS Laboratories Equal Loudness Contours (Composite)

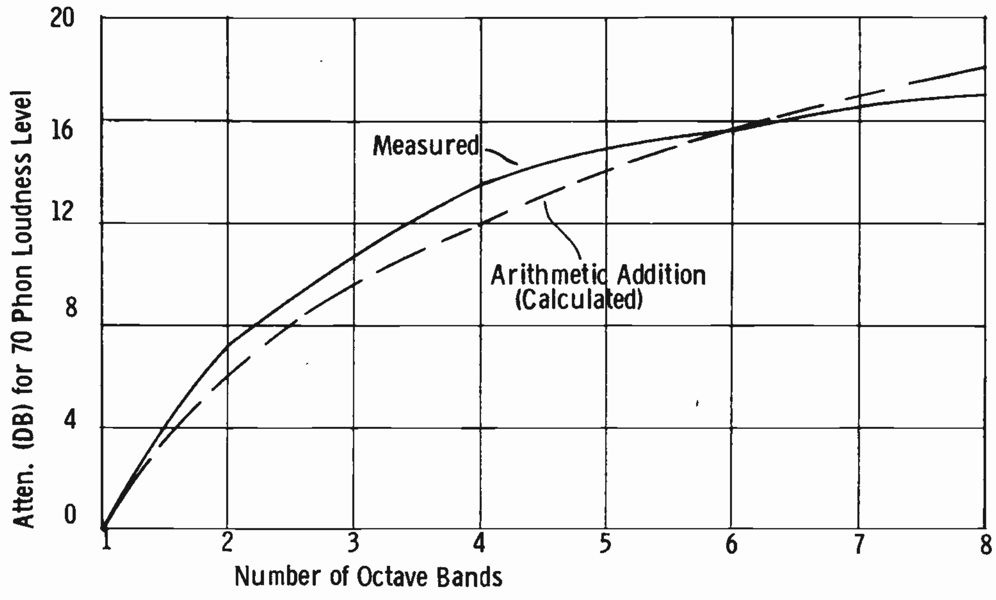


Fig. 13. Combined Bands of Noise (Equal Level)

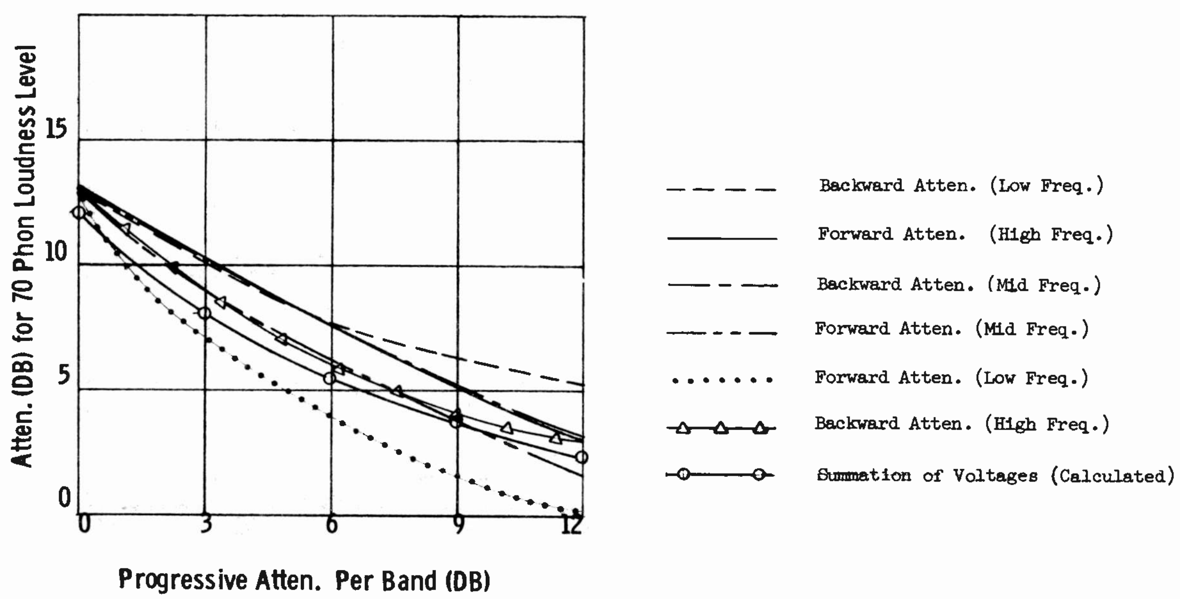


Fig. 14. Combined Bands of Noise (Unequal Levels)

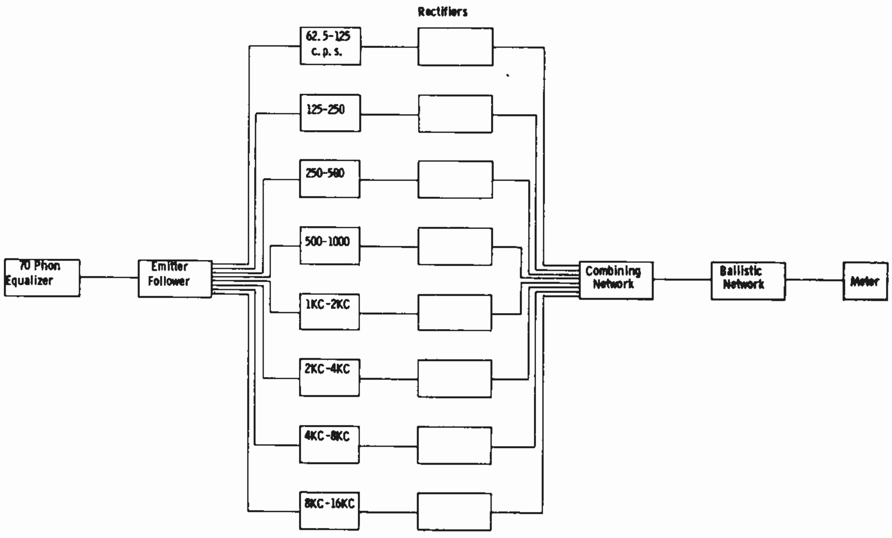


Fig. 15. Block Diagram, Proposed Loudness Meter

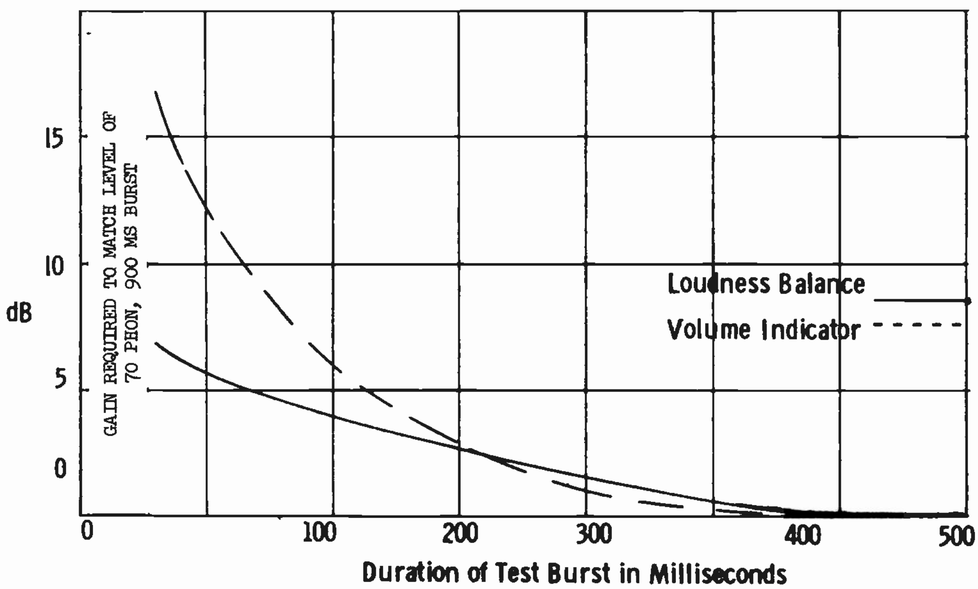


Fig. 16. Power Level of 70 dB Loudness Level Octave-Band Tone Bursts

APPENDIX I

Loudness Level in phons, P, of any sound is given by the following relation:

$$P = 20 \log (p_c/p_r) \qquad (1)$$

where, p_c is the sound pressure of the comparison tone, (1000 Hz), in dynes per sq. cm. equal in loudness to the given sound, and

p_r is the reference level, 0.0002 dynes per sq. cm.

Taking any two sounds having loudness S_1 and S_2, we can write,

$$S_1/S_2 = 2^{(P_1-40)/10} / 2^{(P_2 - 40)/10} \qquad (2)$$

$$= 2^{(P_1 - P_2)/10}$$

Substituting Eq. 1, into Eq. 2

$$S_1/S_2 = 2^{(20 \log (p_{c1}/p_r) - 20 \log (p_{c2}/p_r))/10}$$

or $$S_1/S_2 = 2^{2 \log (p_{c1}/p_{c2})} \qquad (3)$$

Taking logarithms of both sides of Eq. (3)

$$\log (S_1/S_2) = 2 \log (p_{c1}/p_{c2}) \times \log 2$$

$$= 0.6 \log (p_{c1}/p_{c2})$$

$$= \log (p_{c1}/p_{c2})^{0.6} \qquad (4)$$

Consequently,

$$S_1/S_2 = (p_{c1}/p_{c2})^{0.6} \qquad (5)$$

In the region where the equal-loudness contours curves are parallel to each other, in the decibel - frequency scale, the relationship in eq.(5) may be considered to hold for sound pressures of any frequency.

It may be shown immediately that Eq.(5) signifies that loudness in sones doubles for 10 db increase in sound-pressure level: If $S_1/S_2 = 2$, $p_{c1}/p_{c2} = 2^{1/0.6} = 3.16$, corresponding to level difference of 10 db.

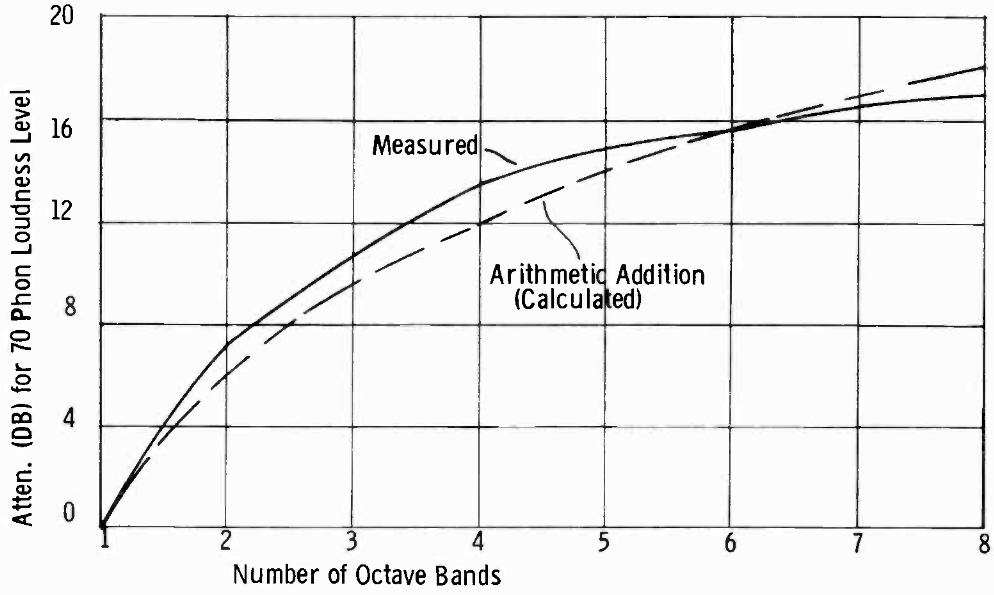


Fig. 13. Combined Bands of Noise (Equal Level)

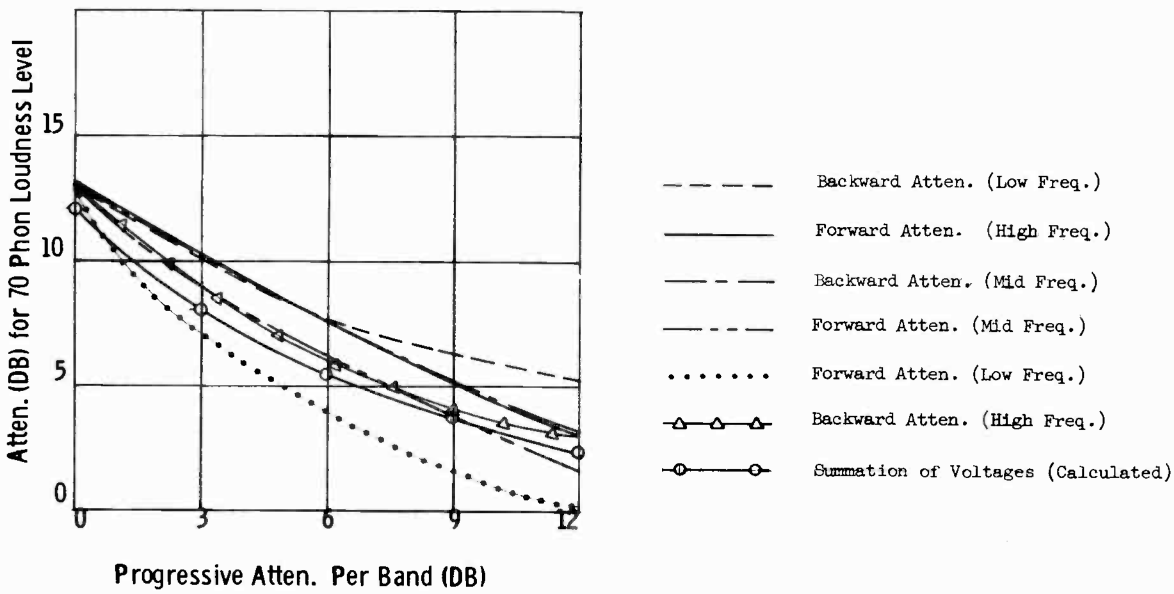


Fig. 14. Combined Bands of Noise (Unequal Levels)

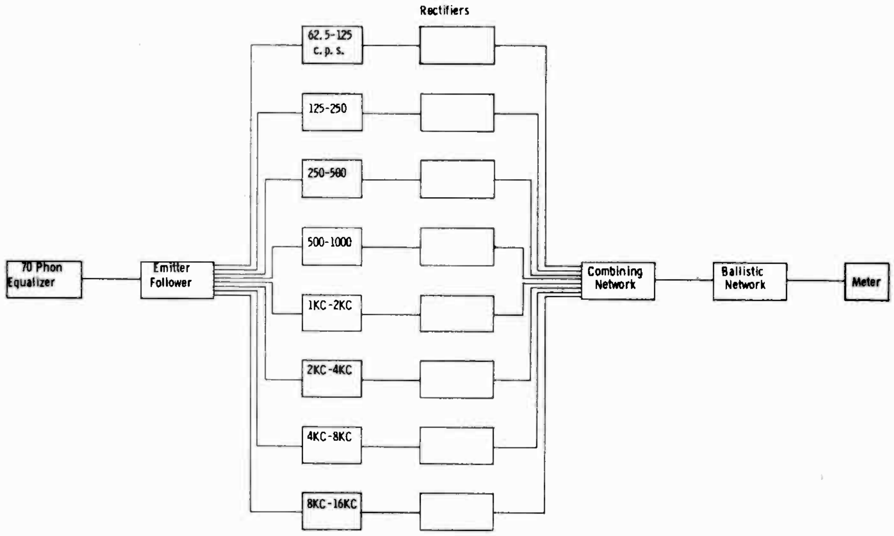


Fig. 15. Block Diagram, Proposed Loudness Meter

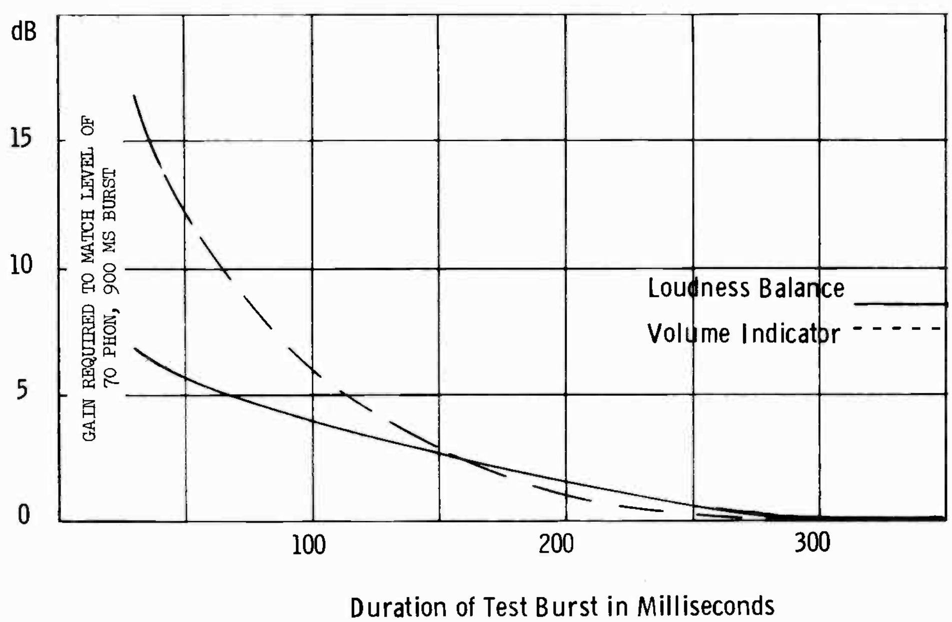


Fig. 16. Power Level of 70 dB Loudness Level Octave-Band Tone Bursts

REVISED

NAB ENGINEERING ADVISORY COMMITTEE REPORT

by

Clyde M. Hunt (Chairman, Engineering Advisory Committee)
Vice President for Engineering
Post-Newsweek Stations
Washington, D. C.
March 28, 1966

Good afternoon, gentlemen of the NAB Engineering Conference. As chairman of the 1966 NAB Engineering Advisory Committee, I am pleased to bring you this informal status report on the committee's activities during the past year.

As you can see from the time limitations of our program this afternoon, it must be very brief and sketchy. It is intended to cover just the high lights of the more important aspects of the work of this committee for the past year. I have, of necessity, had to cut out much interesting detail.

First, I would like to express my appreciation for the assistance which has been given me by the members of this committee -- a group of dedicated engineers, working quietly and efficiently behind the scenes acting as liaison between you, the NAB, the industry, the FCC, and other governmental agencies. Those serving on the committee this year are: William S. Duttera of the National Broadcasting Company; James D. Parker of the CBS Television Network; Leslie S. Learned of the Mutual Broadcasting System; Clure Owen of the American Broadcasting Company; J. D. Bloom, WWL, New Orleans, La.; Virgil Duncan, WRAL, Raleigh, N. C.; John T. Wilner of the Hearst Corporation; and William B. Honeycutt of KRLD, Dallas Texas.

The year 1965 and to date in 1966, have been very busy periods for the advisory committee. One of the outstanding problems which we still have not satisfactorily answered is this matter of objectionable loudness. No doubt you have all heard of FCC's Docket #14904.

This is an extremely complex subject. You have just heard Mr. Bauer present his excellent scientific paper on "Researches in Loudness Measurements." My remarks on the subject of loudness are related primarily to the loudness problem viewed as an industry.

In addition to Mr. Bauer's "his and hers" meters, we need an "FCC" meter. Loudness is a problem and we in broadcasting must come up with a practical answer to it, whether it is scientifically good or bad. If it satisfies our regulatory requirements for the time being, then that is good.

Briefly and rather specifically, this regulatory requirement relates to the apparent loudness of some commercial material when compared to adjacent program material.

It is recognized, that the standard VU meter which is widely used throughout our industry as a level indicating device, does not always reflect the relative loudness of material being broadcast. This is most frequently true of material subjected to excessive volume compression or other electrical processing devices, such as filters, attenuators, or reverberation units, and when voice commercials are presented in the FCC's terms of "a rapid fire, loud and strident manner."

In July of 1965, the Commission issued a report and order in this proceeding which now permits the licensee to reduce the percentage of modulation below the heretofore minimum of 85% in an effort to help stations in their efforts to control commercial loudness.

At the same time, the Commission issued a "Statement of Policy Concerning Loud Commericals" in which it outlined six guidelines for broadcasters to follow in order to avoid loud commercials. The Commission also recognized that the NAB is studying this problem at the engineering level to possibly effect a solution.

To investigate the matter of loudness, we appointed a subcommittee under the chairmanship of Robert Morris of the American Broadcasting Company. The subcommittee consists of the following members:

John T. Wilner, Hearst Broadcasting Company
William S. Duttera, National Broadcasting Company
James D. Parker, CBS Television Network
Carl Lee, Fetzer Broadcasting Company
Clyde Hunt, Post-Newsweek Stations

The subcommittee has explored several different aspects of the problem and is now developing guidelines which will assist the licensee in implementing the Commission's policy statement in the matter of pre-screening commercials.

The subcommittee has spent considerable time and effort looking into the possibility of developing a new measuring device which will give a more accurate indication of loudness, and of the development of automatic control systems which would automatically control loudness.

As a second part of this project, we have established and are maintaining liaison with the various production facilities which record commercials for advertising agencies, in the hope that through such cooperative efforts additional steps may be taken to control this problem.

The control of loudness is not going to be accomplished by any simple, single development -- certainly none that we know of today. It will require the cooperation of all parties concerned, coupled with a step-by-step engineering program working toward the development of new instrumentation and techniques. We all hope that the ultimate solution will be forthcoming within the near future.

TV remote control -- FCC Docket #16202 -- is another big problem. We have been working for the past several years on a project designed to test the practicality of controlling a large VHF television transmitting installation by remote control. The project was initiated in 1963 with the installation of four remote control systems at four VHF television stations; two radio controlled systems and two wire line systems. The tests were conducted at station KKTV, Colorado Springs, Colorado; WGEM-TV, Quincy, Illinois; KFMB-TV, San Diego, California; and WABI-TV, Bangor Maine. As has been previously reported and documented, these control systems were outstandingly successful.

After the filing of a petition by the NAB on February 14, 1965, the FCC issued a Notice of Proposed Rulemaking looking toward the amendment of its rules to authorize the remote control of VHF television transmitters. Although the Commission proposed basically the same changes in the rules which were suggested by NAB, it did add a requirement that out-of-band radiation detecting devices be installed and the observations be periodically made by personnel on duty at the remote control point.

Over 50 television stations and three television networks participated in this proceeding and virtually all took exception to the out-of-band monitoring requirement which the Commission proposed. The NAB in its Comments and Reply Comments, opposed this provision and it is hoped that it will be deleted from the rules when finalized. The record in this proceeding will be closed as of Friday, April 1, and it is hoped that favorable and expeditious action will be taken in this matter.

FCC Docket #15398 concerns the feasibility of sharing the VHF television channels with the land mobile services. As we all know, the demand for spectrum space is a continuing struggle. One of the latest proposals was made by the land mobile services in FCC filings by the Joint Technical Advisory Committee, the land mobile subcommittee of the Electronic Industries Association and the National Association of Manufacturers.

This proposal is to share our VHF television channels! Quite simple they say! The Joint Technical Advisory Committee and the land mobile subcommittee of the Electronic Industries Association have both filed extensive engineering documents with the Commission attesting to the feasibility of such sharing. The NAB Engineering Advisory Committee appointed a land mobile subcommittee, under the chairmanship of Mr. William S. Duttera of the National Broadcasting Company, to investigate the JTAC and EIA filings. This subcommittee after extensive investigation and study, concluded that the sharing of channels 2 - 13, by the land mobile services was not feasible, and indeed, would create destructive interference.

The NAB filed comments in this matter, reflecting the subcommittee's findings, and further pointed out that more efficient use of the presently allocated mobile frequencies could be made by those services. The subcommittee is continuing to study this matter.

The antenna farm problem -- FCC Docket #16030 -- has been with us for the past ten years with first one proposal then another. The most recent is a proposal by the Commission to amend Part 17, of the rules which would establish antenna farms in each and every community in the United States. Adoption of the proposal would require all new tall towers to be placed in a farm area.

For many years the NAB has consistently supported the antenna farm concept, and has worked toward its adoption and implementation. However, this most recent proposal would vest veto power in the Federal Aviation Agency over the designation of a particular farm area. It has been the Association's position that the authority to make the final determination concerning the establishment of the antenna farm must rest with the FCC, and not with FAA.

After carefully studying this very involved and highly complicated proposal, the Association filed comments supporting the farm concept but opposing the veto power for the Federal Aviation Agency.

As Vince (Vincent T. Wasilewski, NAB President) mentioned in his welcoming remarks, one of the most interesting and successful undertakings by this Engineering Advisory Committee in 1965 was the establishment of an Engineering Management Seminar which was held at Purdue University, West Lafayette, Indiana, for one week last November.

A specialized course of instruction was attended by 48 engineers from 23 states and one foreign country. This was the maximum number that could be accommodated. The course was oversubscribed one week after it was announced, and enrollment had to be closed three months before it was scheduled to start.

The course was designed to improve the engineers' understanding of management, and was devoted solely to non-technical subjects. It was under the over-all direction of the School for Continuing Education and Technology at Purdue University, and was implemented by nearly a dozen of the university's most outstanding faculty members.

All students were housed at the University and were afforded all the privileges of full-time students. It was truly a "back-to-school" venture.

The course will be repeated again in November of 1966, and I strongly recommend that you attend if you can make it. It is the finest exercise in management one could be exposed to. Complete details can be obtained from the NAB Engineering Department later this year.

We have, of course, been involved in several other matters which I shall not try to report to you in detail, because of the limited time we have, but only mention by FCC titles.

You may recall new field strength curves for FM and TV stations; FM and TV overmodulation; changes in the NEOV concept; and our own new project -- revisions for a new NAB Engineering Handbook.

In closing I would like to remind you that the Engineering Advisory Committee is your engineering committee. It was established not only to advise the NAB Board of Directors in all technical matters, but also to make your feelings known to all areas of engineering.

If you have technical problems which affect the industry as a whole, make it known to your NAB Engineering Advisory Committee. It will help us to be an effective voice in representing you. Let us hear from you.

I hope that our past efforts here have met with your approval. Thank you.

XXX

A ONE-MAN-PORTABLE
TELEVISION RECORDING CAMERA

by

William H. Butler

Westel Company
298 Fuller Street
Redwood City, California

NAB Convention
March, 1966
Chicago, Illinois

A television station cameraman went out on a most unusual assignment. In two days' time he took pictures of a new addition to the Aquarium - and of another addition in the Zoo. He recorded the Mayor's weekly press conference. He took pictures from a helicopter . . . from the top of a "skyscraper" . . . from an excursion boat in the harbor, and of surfers riding the breakers.

He recorded a ride from the front seat of a rollercoaster - took pictures from an open convertible . . . and from the glass elevator on the outside of a hotel.

He traveled in a patrol car and took pictures of the police in action - at night with no special lighting. A fashion show and a night club were snaps.

He also managed to sandwich in coverage of the arrival of a celebrity at the airport.

And if he had had a mind to, he could have recorded his jumping with the local parachute club - but, somewhat cautious in nature, he chose instead to follow several pros around a local golf course recording their putting techniques.

This cameraman easily traveled by bus, cab, car, and on foot. He was unassisted at all times. He had no movie camera, nor did he have with him a TV recorder as you know them to be.

He required no line power connections at any time.

Yet all of the pictures he took were broadcastable - complete with sound - and they required no processing. Most were taken, as you heard, in situations where only an essentially unencumbered person could move and act.

This man was using the first self-contained, light-weight television recording camera - a new development that quite literally makes it possible to provide professional quality television coverage anywhere, any time - and under the most adverse conditions.

As revolutionary as the camera is, it is, however, the bi-product of a new studio record/playback machine, which in turn was made possible by a remarkable new magnetic recording system and the technical description of this system, named "Coniscan", is the subject of this paper.

Let me start though by first briefly describing the recorder and the recording camera since I think you'll find the engineering details will then be more meaningful and you'll see how each development contributed to the entire system.

The Westel* Television Recording Camera is a self-contained, self-powered video recording system that can be carried and operated by one man without assistance or additional equipment. Designed to produce tapes that meet all broadcast standards, it permits a completely new degree of freedom and flexibility in news coverage, documentary programming, and on-location production of commercial spots. With it, a cameraman quite literally becomes a self-contained, self-powered video cruiser.

The unit consists of a record-only module that weighs 23 pounds complete with tape and rechargeable nickel-cadmium batteries, and an integrated, cable-connected vidicon camera head that weighs less than 7 pounds. With one loading of batteries and tape it will record 33 minutes of video and sound. There is sufficient extra battery capacity to permit an additional 30 minutes of preview operation, plus 60 minutes of standby operation. It may also be powered by an external 12-volt DC source such as automotive batteries.

The camera head includes an active CRT viewfinder that may be switched to operate as an A-scope. All operating controls and indicators are located on the back of the camera head for convenient operation. The camera will acept any standard C-mount lens.

The Westel Television Recording Camera uses the same proprietary Coniscan* recording system used in the Westel* Television Recorder, including a sync generator, the same scanning assembly, drum servo and signal processing electronics. Tapes made on the Recording Camera can be played back on any Westel Recorder and meet essentially the same performance standards as tapes made on the studio recorder.

In the interest of light weight and low power consumption, Rewind and Fast Forward functions are not provided in the Recording Camera and there is only one audio channel.

As noted earlier, this Recording Camera was actually made possible by the development of the Westel Television Recorder, a professional broadcasting quality machine that meets all standards of the television industry for picture quality and time base stability. This recorder will, without auxiliary equipment, record and playback full-band monochrome signals of the 525-line, 60 field standard U.S. broadcast system, and is adaptable for use on other common line-standard systems. It can be used with a variety of power sources. With the addition of the Westel* Color Module, it will record and playback standard NTSC color signals. Two high-quality audio tracks are provided. Electronic Editing capability is also built-in.

The Recorder uses the unique proprietary Coniscan* video recording system that permits the use of a single recording head with attendant

*TM

Simplification, compactness, low initial cost and operating economy - and it is the Coniscan system that is the real subject of this paper.

There were three factors that contributed greatly to the success of the development program. The first of these was the lack of commitment to prior design. This put the engineers in the enviable position of not being restricted by such things as investments in tooling, or established market positions. The other two factors were the extensive general development of electronics theory and technology in the last 10 years, sponsored to a great extent by the military and aerospace programs - and finally, the recent availability of advanced components.

The development program had as its objective a new video recording system, which would in turn lead to the production of "hardware" offering . . . .

1. Broadcast quality and broadcast stability.
2. Mechanical and electronic simplicity.
3. Low initial price and operating economy.

The first objective, it goes without saying, is a requirement for any professional video recorder.

Simplicity of design and construction, sought in Number 2, was, in fact, the basis for achieving the 3rd objective of reliability and low operating cost.

Given the three stated design objectives, it became immediately apparent that a single rotating head would seem to yield the best opportunities for basic mechanical and electrical simplicity. Thus, you might say we started with a concept of the ultimate hardware, and worked "backwards" to develop the system that would make it possible. The single head approach can yield great advantages, particularly in eliminating head switching requirements and the electrical and mechanical problems of matching multiple heads, and in general offers basic simplicity, and hence reliability, which was one of the primary design objectives. And we also realized that the single head approach would make color signal processing far easier.

Although this scanning approach has obvious advantages, certain mechanical difficulties have to be overcome if basic stability is to be achieved, and the principal ones of these are:

1. Head dropout, caused when the head crosses over from one edge of the tape to the other.

2. Signal degradation due to lack of support for the tape at its edges.

3. Need for an edge of the tape free of video signals to allow for control and audio track recording.

4. Irregular tape tension and stretch due to friction drag around the scanning assembly.

5. Tape stiction - irregularity of motion - due to varying co-efficients of friction of the scanning surface and of the tape surface itself, irregularities that vary also with environmental conditions.

Overcoming these difficulties therefore required the development of a radically new scanning system, subsequently named Coniscan, which is symbolically represented in Figure 1. As you will see, the geometry is such as to eliminate the problems listed above.

The scanning method is really the "key" to the Coniscan system. But in order to have a truly stable "platform" it is also necessary to move tape through the scanning assembly in a very precise manner. This requires that tape be handled gently, so as not to introduce errors due to tape stretch or deformation. It also requires that tape movement through the scanning assembly be carefully controlled, not only in terms of average motion, but also in terms of its position at any moment. This is, of course, an extremely important consideration in a recorder where total head/tape motion includes a substantial longitudinal component.

The relative merits of the so-called open-loop and closed-loop capstan systems have long been argued by designers. In actuality, it must be admitted that each tape drive system has both advantages and disadvantages. The approach used in the Coniscan system is neither open nor closed-loop, but offers the advantages of both, but without their shortcomings and limitations. Two independent capstans are used, each having its own servoed motor and motor driver. The average speed of both capstans is referenced to vertical sync frequency to establish average tape speed. In addition, the instantaneous relative speed of each capstan is separately controlled, referenced to horizontal sync frequency, so that tape tension within the scanning area can be varied as required. In this way each pulse on the tape is controlled, not only as to its instantaneous position and average motion, but also to the correct average time between pulses.

To round out the mechanical tape path, a word of description should be added here on the reel system. In order to permit the capstan/scanning system to accomplish its proper functions, the tape must be free to respond to rapid changes in motion. A technique for reel control to accomplish this was developed, similar to that used in computer-type transports, which also require very rapid changes in tape motion without introducing time base errors due to varying tape stretch. Both reels in the Coniscan system are independently motor driven and are under active control of position sensing servo systems. The tape passes over spring loaded compliance arms which accommodate very rapid changes in demand for tape, at the same time maintaining constant tape tension into and out of the capstan/scanning area.

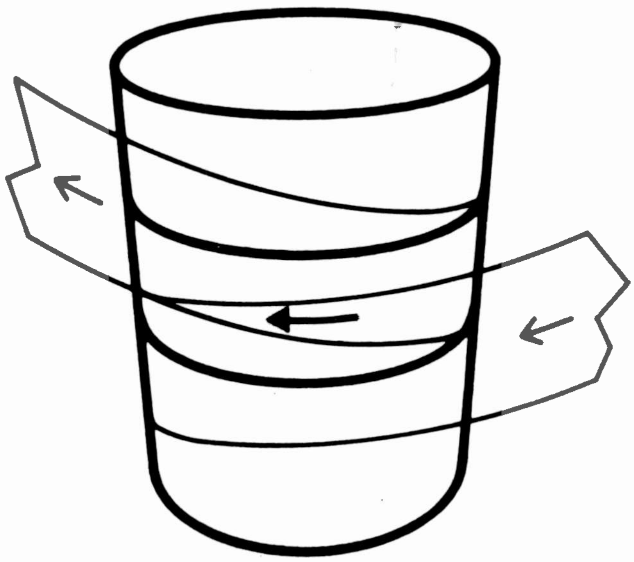


Figure 1.

The mechanical system, briefly described here, achieves the design goal of simplicity associated with a single head approach. At the same time a "platform" is established which has inherent time base stability, providing of course that the capstan and rotating head section can be appropriately driven and rapidly controlled. This leads then to a description of the motors and associated servo systems.

Each of the driven parts - the two reels, the two capstans, and the rotating head section - are driven by identical DC motors with identical constant current drivers. The five motors used are of the printed circuit type. These motors, when properly driven, exhibit very high torque-to-inertia ratios, but do not exhibit the cogging effect usually associated with DC motors. The use of independent DC drive for the various elements also eliminates the need for mechanical brakes, solenoids, and other mechanical linkage, and is therefore a major step towards the objective of simplicity and reliability.

The servo systems for both the capstan and rotating head section are simply described as a "sample/hold" system. This approach yields the advantages of a digital "go - no-go" system. Again this is in compliance with the objective of simplicity, permitting a very fast response system with very low noise characteristics. Digital techniques, of course, are by their nature inherently stable, being independent of fluctuating reference sources, such as voltage, phase, etc. As was mentioned earlier, the capstans are controlled by a two-loop servo system. This is also true of the rotating head section, whose average speed is referenced to vertical sync frequency, while instantaneous speed corrections are dictated by the horizontal sync frequency.

The Coniscan recording system, so briefly described here, results in an inherently stable, reliable "platform", permitting very broad corrective action in the playback mode. The transport servo electronics are based on a digital approach which, when used with the printed circuit type motors, permits very accurate and rapid control. The use of digital type electronics eliminates the need for operator adjustment of transport functions.

The objectives of designing for simplicity and inherent stability also led to development of signal electronics,which are unique in that they too require no operator adjustment, while yielding bandpass and signal to noise performance well within the range commonly accepted as "broadcast quality". The same basic attributes permit electronic editing, which in turn adds to the usefulness of remote recording.

As you can now see, the principles of the Coniscan recording system made possible the development of the recording camera, described in the introduction of this paper.

So far the subject of color, one of great interest at this time in the industry, has had only passing mention. However, I'm sure that you are now aware that the Coniscan recording system has certain inherent qualities which are significant in any discussion of color capabilities. The first of these is that the system is based on a single rotating head. This obviously eliminates the problem of color banding, the result of unmatched multiple video heads and/or associated electronics. Secondly, the inherent electro-mechanical stability of the transport system has resulted in a residual time base error well within the range of simple, electronic correction. The basic machine, therefore, is inherently color compatible and has permitted the development of a new and greatly simplified approach to color recovery.

This paper has described a new system of magnetically recording video information. The recording system is based on a number of innovations, made possible to a great extent by recent developments in circuit components and design techniques. The new recording system, called Coniscan, has resulted in a very stable, reliable approach to video recording, making improved and simplified color recording a reality, and permitting highly mobile field operation.

MODERN EQUIPMENT FOR

MEASURING TELEVISION TRANSMISSION SYSTEMS

---

by

Dr. Herbert Mangold

ROHDE & SCHWARZ, Munich, Western Germany

Paper presented to the NAB Broadcast Engineering Conference

Chicago 27 - 30 March 1966

by ROHDE & SCHWARZ Sales Co. (USA) Inc., 111 Lexington Ave,
Pasaic, New Jersey

Printed in Western Germany

(A) Television is said to be part of entertainment electronics in a slightly deprecatory sense. Its technique, however, embraces nearly the entire field of communication electronics together with optics, mechanics and chemistry.

The general purpose of developing better measuring instruments is to improve the quality of television for several reasons:

1) in TV the same process as in audio-engineering is likely to occur: from background noise to high fidelity listening, or respectively from pass-time to high quality viewing.

2) successful color TV transmission requires a perfect technique especially in the case of the NTSC-color TV system.

3) ET (educational TV) is only possible with very good equipment because of the high definition and resolution necessary in transmitting drawings, experiments, works of art and other information to students and pupils.

The methods of measurement and the instruments presented here are not suitable for service shops for TV sets but are primarily intended for the following customers:

communication laboratories for radio links and transmission lines including satellites;

manufacturers of TV transmitters;

scientific institutions;

authorities such as the Bureau of Standards or the Federal Communication Commission;

central laboratories of broadcasting companies;

laboratories of TV home receiver industries.

The subject of this paper is not the generation of TV signals in cameras, scanners, videotapes and their switching and distributing problems, rather it is restricted to transmission systems. Their characteristics are described by three typical quantities:

1. Linear distortions (transfer constant)

1.1 amplitude-frequency response

1.2 phase or group delay frequency response

1.3 transient response

2. Non-linear distortions

2.1 nonlinearity

2.2 harmonic distortion

2.3 intermodulation distortion

2.4 differential gain

2.5 differential phase

3. Signal-to-noise ratio

3.1 peak-to-peak value of noise

3.2 rms value of noise

3.3 weighted noise

3.4 intercarrier interference

Additional quantities to be measured:

rf power up to 50 kW at 1000 MHz,
impedances, VSWR,
field strength,
gain and radiation patterns of antennas.

Remark. The main problem in TV measuring techniques consists in the unwanted presence of blanking and synchronising components in a composite video signal (pix). Their spectra, harmonics of the line frequency accompanied by lower and upper sideband oscillations spaced at multiples of field frequency, are the cause of serious errors in precision measurements, especially within the vf range below one MHz (Fig. 1). According to the theorem of Merz and Gray, the main information content of a TV signal is found in this frequency range. On the other hand, sync and blanking intervals are necessary in most transmission systems for stabilizing the operating conditions of amplifier or modulator stages. Therefore it is necessary to eliminate the energy of blanking and sync pulses from measuring signals by

frequency)
amplitude) selection.
or time)

(B) Methods of measurement and equipment

A complete TV transmission system (Fig. 2) is simulated by:

a vestigial sideband transmitter with 0.5 W sync power output and 0.1 W fm sound output, Type SBTF

and

a Nyquist demodulator of high precision with 2 vf outputs and fm intercarrier demodulator output, Type AMF.

The two equipments are connected by an attenuator and a magic T for correct VHF input levels.

A TV transmitter test assembly, Type UMVF, is used for all measurements except envelope delay, which is carried out by the external group-delay measuring equipment, Type LFM. A color bar generator and a color and a monochrome monitor complete the system.

The vestigial sideband transmitter Type SBTF (Fig. 3) is of the if modulated type both for picture and sound. The modulated if signal is shaped by only one filter.

This signal may be converted by a common local oscillator in each TV channel. Group-delay equalization is accomplished within the vf input circuit.

The Nyquist demodulator Type AMF (Fig. 4) is of highest possible quality with very close tolerances specially in the Nyquist slope. Its differential gain is better than 0.5 dB, including the demodulation process and the differential phase of less than $\pm 1^{\circ}$. For better performance, group-delay equalization is located in the if section, efficient on both sideband signals. An intercarrier fm demodulator circuit with a separate demodulator diode is included for sound demodulation.

The TV transmitter test assembly, (Fig. 5) Type UMVF, consists of the following instruments mounted in a castered rack:

video noise meter	Type UMVF
video sweep generator	Type SWOF
precision oscilloscope	Type OMTF

sideband adapter	BN 424103
control unit	BN 19372
video test signal generator	Type SPF
differential gain/phase meter (space reserved)	Type PVF
blower and power switch panel with dust filter	

General views of the test assembly are shown in Fig. 6 and Fig. 7. The big plug unit at the bottom incorporates in one cable of 17 ft all connections between the visual transmitter and test rack:

1 vhf/uhf tube
2 vf tubes
96 control wires
2 power supply wires
1 ground wire

The main cabling of the TV transmitter test assembly Type UMVF is presented in Fig. 8. It may be remarked that the control unit BN 19372 includes a vf cross-bar switching system, allowing the simultaneous connection of two of the four indicating instruments either to the vf test-signal output of the assembly or to the vf signal coming from the equipment under test. Every check point of the transmitter in the vf, if, vhf or uhf range can be switched to the assembly by push-button command in the control unit through the 96 control wires. This saves a lot of time in the checking procedure because all test cables may remain permanently installed.

1. Linear distortion measurements

1.1 Amplitude-frequency response

This is one of the most important procedures (Fig. 2) for quality checking of TV transmitters, for example, according to FCC Rules & Regulations with a double sideband demodulator (DSBD), Fig. 9. The method is not quite satisfactory because one cannot separate the lower and upper sideband characteristics. This has been done by calculating according to Fig. 10, assuming that no phase shift between the lower and upper sideband oscillations exists. A much more precise specification is given by the EIA document RS 240, Fig. 11, which is very similar to those of the ARD and of the West German Post Office. The latter documents both have a very close overall tolerance with respect to color TV. The reference point is not 0.2 MHz but 1.5 MHz outside the range of vestigial sideband transmission.

The Videoskop, a novel swept-frequency visual display unit, block diagram in Fig. 12, comprising a selective receiving section, permits the measurement of video frequency responses between 50 kHz and 20 MHz in the gaps between the lines of the spectrum of sync and blanking components regardless of the generation of any harmonics in the test item or noise voltages. The sweep is proportional to time, the sweep speed may be adjusted to suit the steepness of the amplitude responses to be measured.

A sideband adapter, block diagram Fig. 13, in conjunction with the Videoskop permits the sideband characteristic to be determined at both sides of the carrier at a minimum spacing of 50 kHz. In spite of high blanking-interval amplitudes the sideband characteristic is very clearly visible (Fig. 14 to 16).

The amplitude-response measurement is also important in checking the Nyquist slope of a television demodulator, which is mostly used for monitoring television transmitters. Single-sideband modulation of small depth is simulated by means of two signal generators. The difference-frequency amplitude is measured with a selective level meter in the video-frequency range.

As a makeshift solution, one signal generator may be replaced by the television transmitter itself and the selective level meter by a broadband instrument. This test method is also used for checking domestic receivers.

1.2 Frequency response of phase constant and group delay time

The aim of the measurement is, in all cases, to know the delay time differences in the transmitted frequency range. In Fig. 17 the FCC tolerances of the envelope delay characteristic of a visual transmitter for color TV are shown. The needed equipment is fairly elaborate; for this reason phase characteristics or group delay times are not normally covered by routine measurements or in monitoring but generally in precise measurements on the transmission systems or in acceptance tests, Fig. 2.

Incidentally, the group delay time measurement yields the differential quotient of the phase constant; in case of doubt it should be checked by integration whether the phase tolerances are observed. The group-delay measuring equipment Type LFM, block diagram Fig. 18, is based on the gap-frequency (20 kHz) method, allowing measurements in the presence of line sync and blanking pulses with an accuracy of ±1 nsec by using frequency selection. Another advantage of group delay measuring methods is that they are possible in open loops.

1.3 Transient response with standardized test signals

In contrast with amplitude-response measurements, the phase and group delay measurements, especially on programme lines, require rather elaborate equipment since a reference phase signal must be made available. Standardized test signals, e.g. CCIR Rec. 421, signals nos. 1 and 2, in the form of time functions such as step and pulse have therefore been adopted in television measurements; they approach very closely the actual conditions of operation and give information on amplitude response via rise time and pulse width and on the delay time characteristics via overshoot. Although the theoretical calculation of the transfer constant is very complicated on this basis, the method is of great practical importance since it only requires a test pattern generator and an oscilloscope and, on the other hand, sync pulses and blanking intervals have no disturbing effect in the oscilloscopic evaluation and the result is very instructive. For this reason, this method is particularly suitable for monitoring.

A test signal generator Type SPF, whose block diagram is shown in Fig. 19, is included in the test assembly. Internally it is driven by an auxiliary sync signal generator only in line frequency, but it can be switched to a standard sync signal generator. The test signals are well known, interference and hum may be simulated. Furthermore a module is prepared for the modified pulse and bar test signal. It consists of a 2 T sine-squared pulse Fig. 20, combined with another sine-squared pulse of ten times half-amplitude duration (20 T) but modulating a color subcarrier signal. Fig. 21 shows the generation of this special pulse and Fig. 22 the spectra of the

bar (step function),
2 T pulse and
20 T pulse.

The special advantage of this combined signal is its close simulation of normal TV signals even in color as a consequence of its high energy density at the upper limit of the vf range. This new signal is very sensitive to slight deviations in frequency (1 dB) or group delay (100 nsec) response. A paper was recently published by P. Wolf of IRT Munich in the "Journal of the SMPTE" 75/1966/1/15-19.

2. Non-linear distortions

The linearity of the modulation characteristic of amplifiers or transmitters is mainly determined by measuring the relative slope with a sawtooth and superimposed RF signal. (CCIR test signal no. 3). In transmission systems for NTSC color signals the differential phase of the color subcarrier must be measured additionally. One uses the same test signals as for linearity measurement, only adding a reference phase, for example, at the level of the blanking interval. A new equipment, the differential phase/gain meter Type PVF, is being prepared; it will be located in the test assembly Fig. 2 below the vf test signal generator. Its accuracy will be $\pm 0.2^{\circ}$, which is believed to be necessary in the case of color TV systems sensitive to non-linearity in phase transmission, e.g. the NTSC system.

3. Signal-to-noise ratio measurements

3.1 Peak-to-peak value of noise

The peak-to-peak value method is said to give too uncertain a result (approx. ± 2 dB or more) because of the differences in subjective observation. Moreover, only oscilloscopes which are immune to overdrive and use DC coupling can be used with success. These conditions are fulfilled by the new precision oscilloscope Type OMTF in the test assembly.

3.2 rms value of noise

Measurements of spurious voltages in the picture signal range are generally not possible with rms responsive meters since in contrast with the oscilloscopic display the meter does not distinguish the unimportant sync signals and blanking interval amplitudes from the spurious amplitudes to be measured, which are usually much smaller. By means of horizontal and vertical blanking (Fig. 23) to the average level of the spurious voltage in the time function of the signal and by making use of the integration over time accomplished in the meter, the measurement becomes possible if the absence of the spurious energy in the intervals is taken into account for the calibration of the meter. The blanking process must not produce any new spurious pulses of appreciable energy, therefore it is carried out twice in series by the video noise meter Type UPSF according to the block diagram Fig. 24. As the two blanking stages of the instrument can be switched off, the original input signal can be checked at the output of the instrument with an oscilloscope, e.g. a videotape signal "black" with V-time base in Fig. 25. Fig. 26 shows the same signal after processing. With all unwanted signals suppressed, the residual noise voltage may be measured objectively by a pointer meter. (Note the differences in noise voltages generated by the four divisions of the magnetic head wheel.)

3.3 Weighted noise

With the instrument Type UPSF it is also possible to measure weighted noise in rms values according to CCIR Rec 421 with a special filter inserted into the signal path within the noise meter.

Another example of noise measuring is the triangular noise in fm systems with pre-emphasis. Here the highly selective receiver of the video sweep generator Type SWOF is used. The result in investigating a simulated satellite communication TV channel according to Fig. 27 is shown in Fig. 28, from which the triangular law is to be seen.

3.4 Intercarrier interference

These spurious signals caused by an unwanted phase modulation of the TV visual transmitter (differential phase), are measured in the audio circuit of the demodulator with a lf noise meter of suitable characteristics.

(C) Conclusion

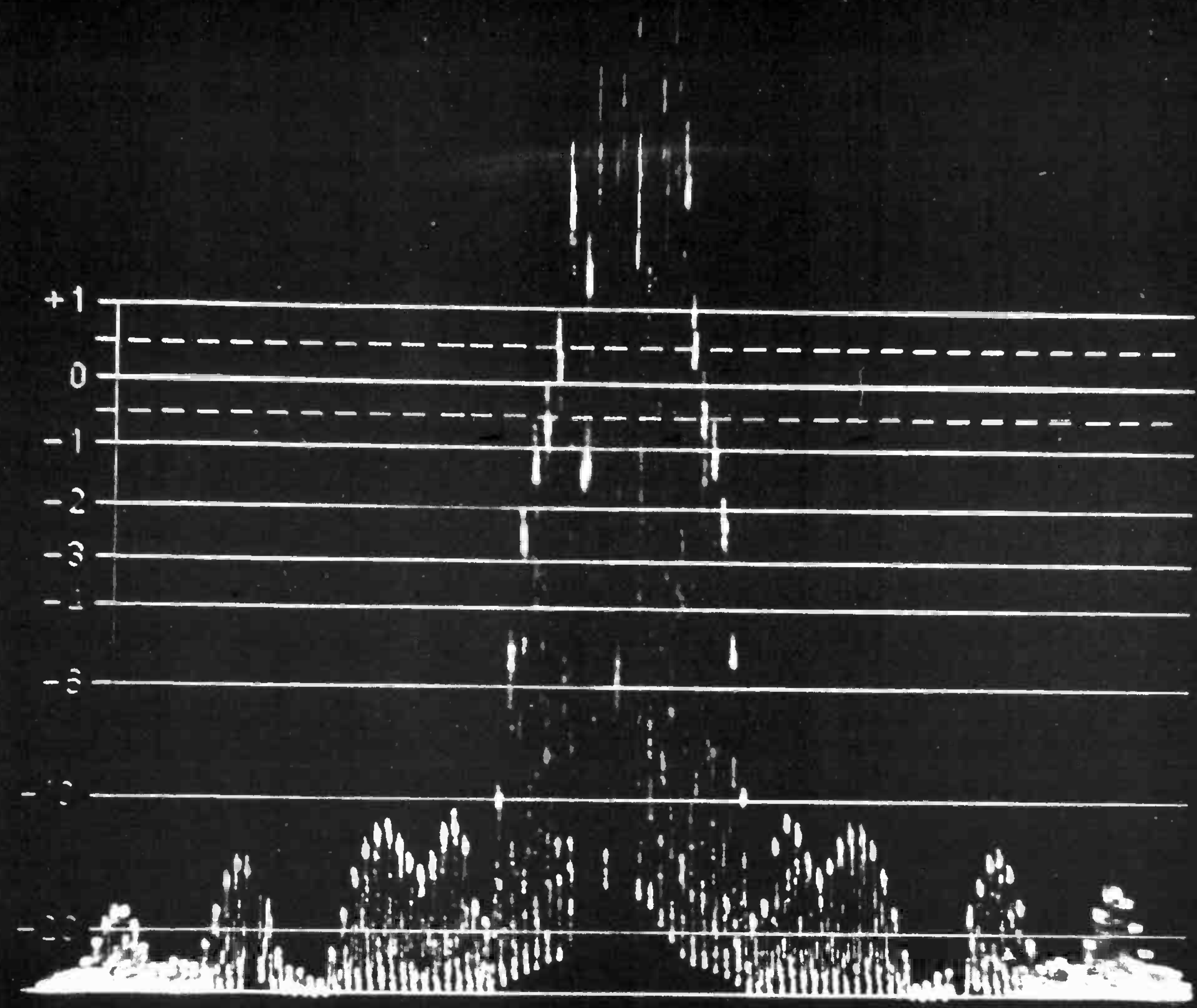
The competition between communication and measuring equipment with respect to tolerances extends also to the field of television. On principle, a measuring instrument should be more accurate by at least 1/2 order of magnitude than the values to be measured.

List of figures

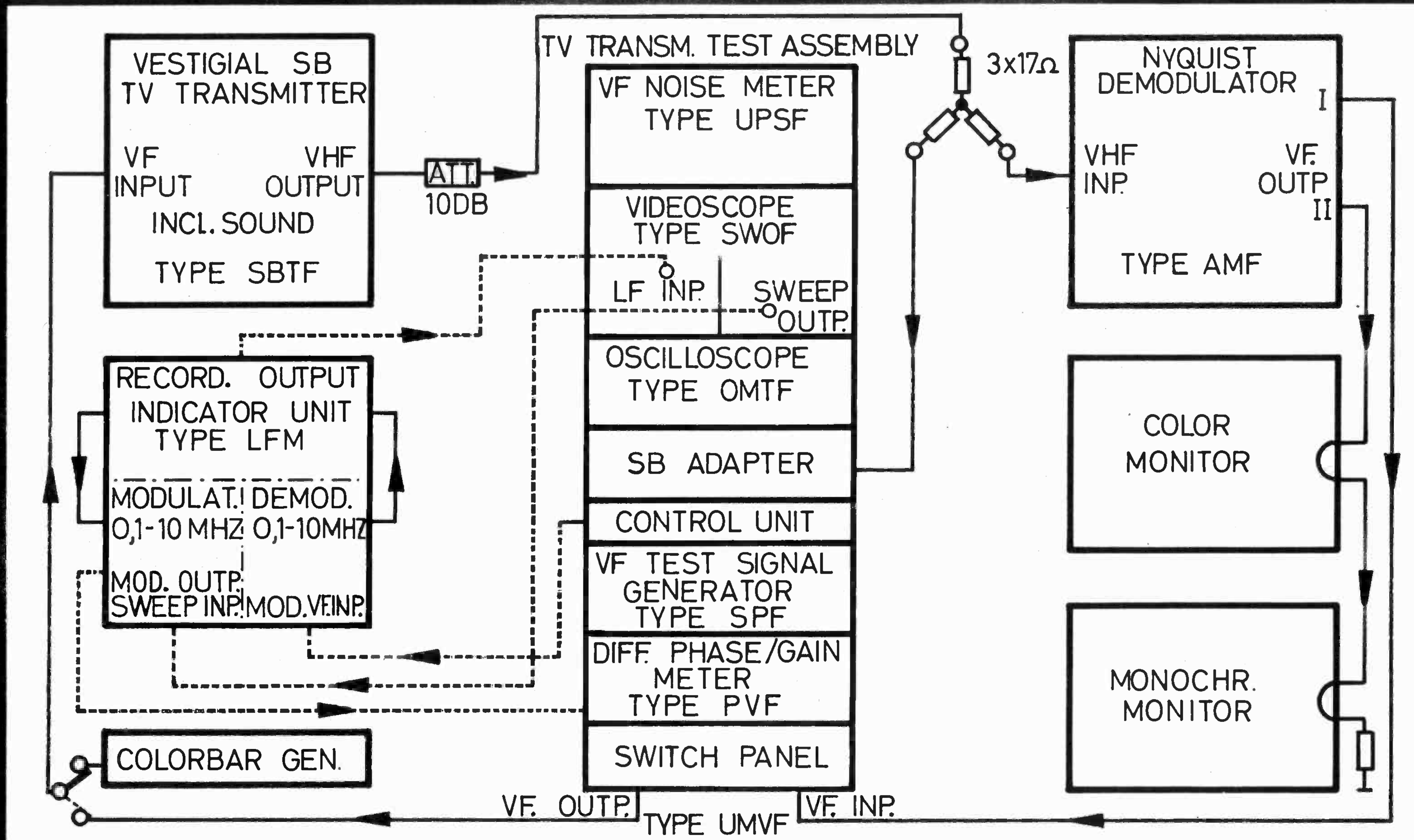
List of figures

<u>Fig. 12</u> WF 14610	Video wobulator Type SWOF, block diagram
<u>Fig. 13</u> WF 14609	Sideband adapter BN 424102 to wobulator Type SWOF, block diagram
<u>Fig. 14</u> WF 11364	Vestigial sideband characteristic of tv transmitter Type SBTF, modulated by wobulating signal 10-70 % rf amplitude of sync peak value, m = 75 %
<u>Fig. 15</u> WF 11365	Vestigial sideband characteristic of tv transmitter Type SBTF, but modulation 60-70 % rf amplitude of sync peak value, m = 7,7 %
<u>Fig. 16</u> WF 11366	Vestigial sideband characteristic of tv transmitter Type SBTF, but modulation 10-20 % rf amplitude of sync peak value, m = 33,3 %
<u>Fig. 17</u> EL1/18	FCC tolerances for envelope delay frequency response of tv visual transmitters
<u>Fig. 18</u> EL2S/26	Block diagram of group-delay measuring equipment Type LFM
<u>Fig. 19</u> EL1/21	Video test-signal generator Type SPF, block diagram
<u>Fig. 20</u> IRT/M/267/D	Modified pulse and bar test-signal 2T/20T pulses
<u>Fig. 21</u> IRT/M/197/D	Generation of the modulated 20T pulse
<u>Fig. 22</u> IRT/M/257/D	Spectrum of the modified pulse and bar test-signal

<u>Fig. 23</u> WF 12217	Principle of compensation of sync and blanking intervals (time selection)
<u>Fig. 24</u> WF 12583	Video noise meter type UPSF, block diagram
<u>Fig. 25</u> WF 62/1	Original videotape signal "black", V-time base
<u>Fig. 26</u> WF 62/4	Processed videotape signal "black", V-time base
<u>Fig. 27</u> BP	Video noise measuring circuit via "Early Bird" satellite communication system at Raisting/Obbay.
<u>Fig. 28</u> BP	Video noise spectrum of "Early Bird" satellite communication system measured with SWOF at bandwidth of 3 kHz



R&S	Impulsspektrum bei Tastung des SBTF mit H-und H- Austastlücken 5% Schwarzabhebung Frequenzbereich ±1MHz	Fig. 1 11370

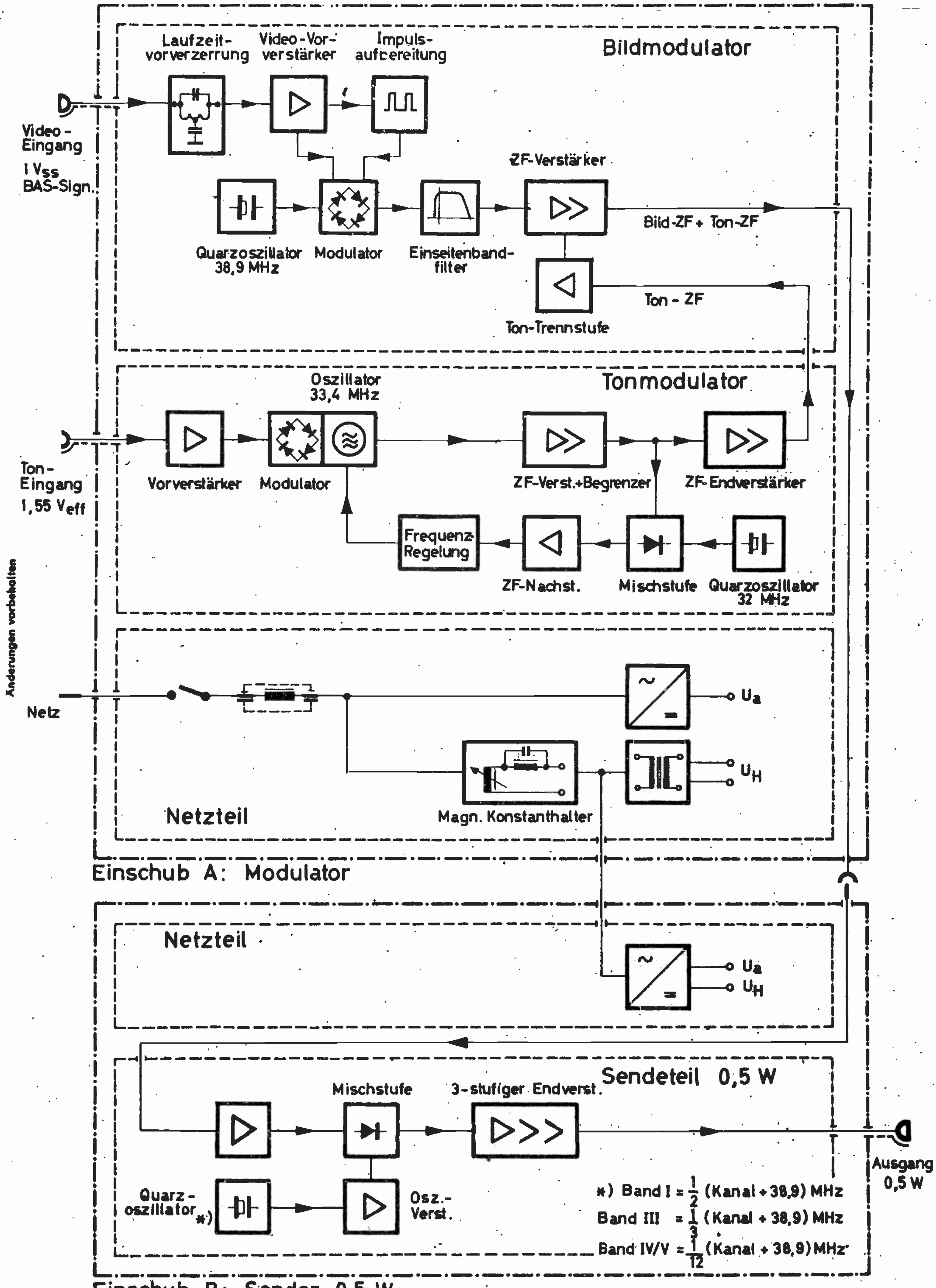


BLOCK DIAGRAM OF COMPL. TV TRANSMISSION TEST CIRCUIT FOR VEST. SB RESP., GROUP DEL., DIFF. PHASE/GAIN, NOISE, TRANSIENTS

EL1/22

Fig. 2

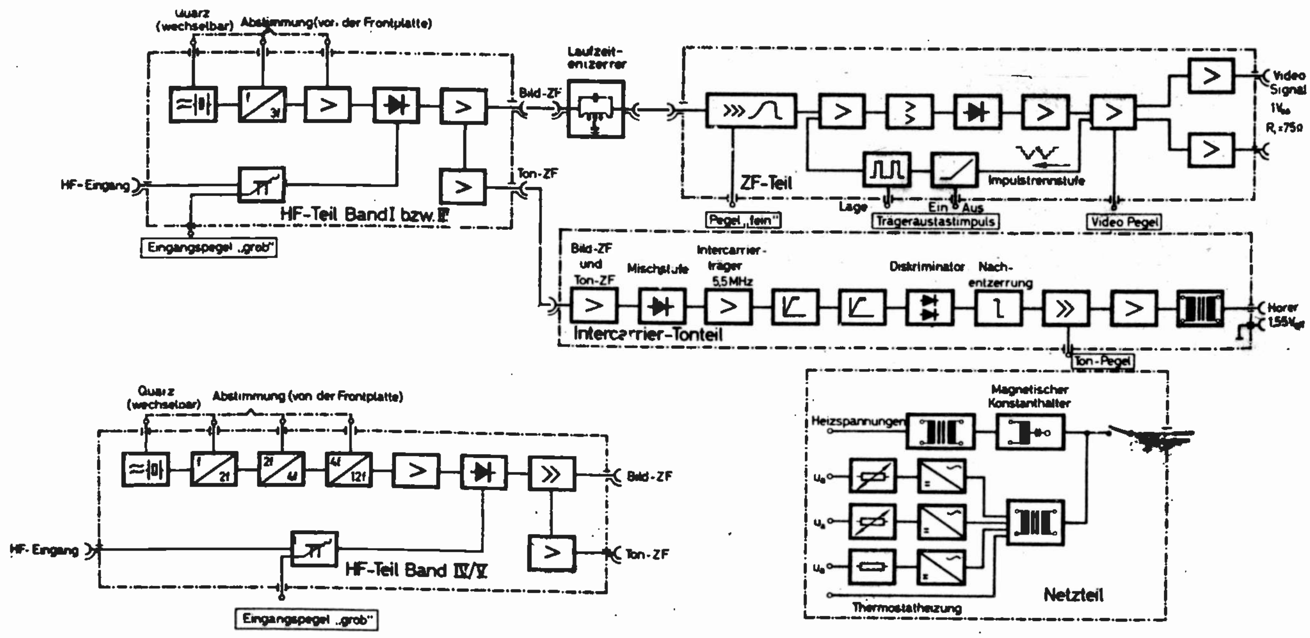
BLOCKSCHEMA Fernseh-Kanalmeßsender SBTF



0762 9

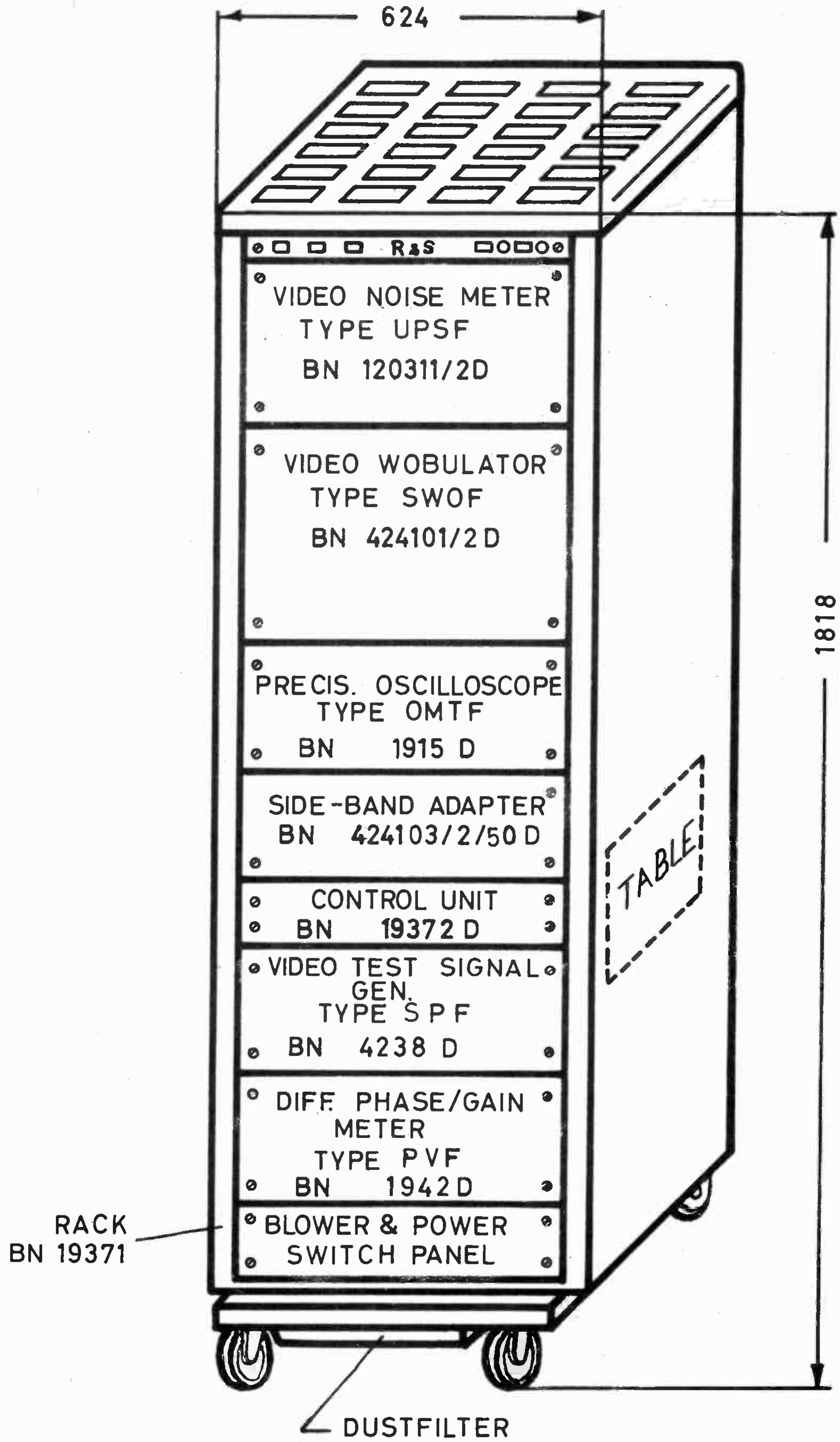
EL2/ELS

Fig. 3



Blockschaltbild des Fernsehmeßdemodulators Type AMF

Fig. 4



1270 VA

TV TRANSMITTER TEST ASSEMBLY
TYPE UMVF BN 1937

EL 1/19

Fig. 5

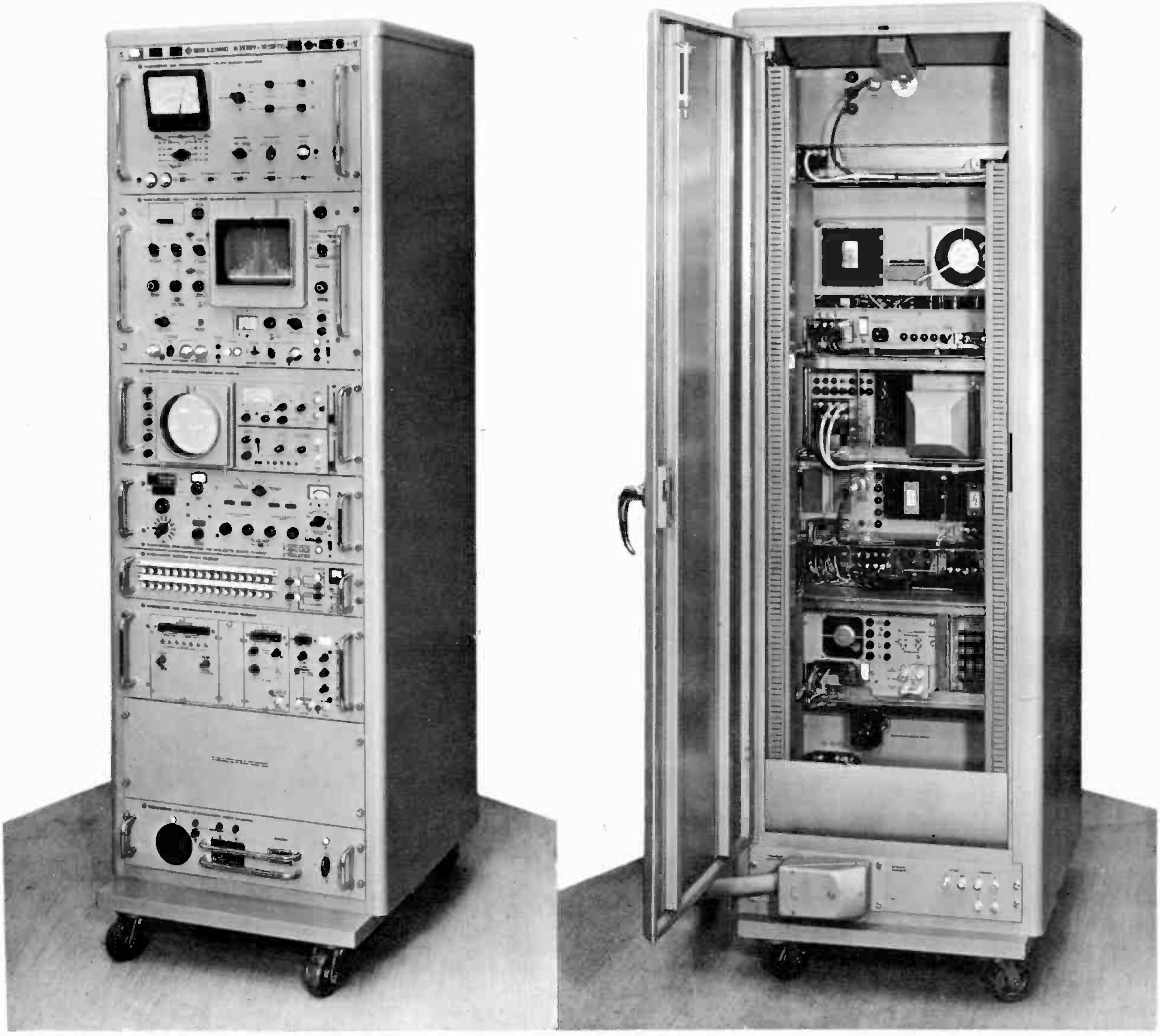
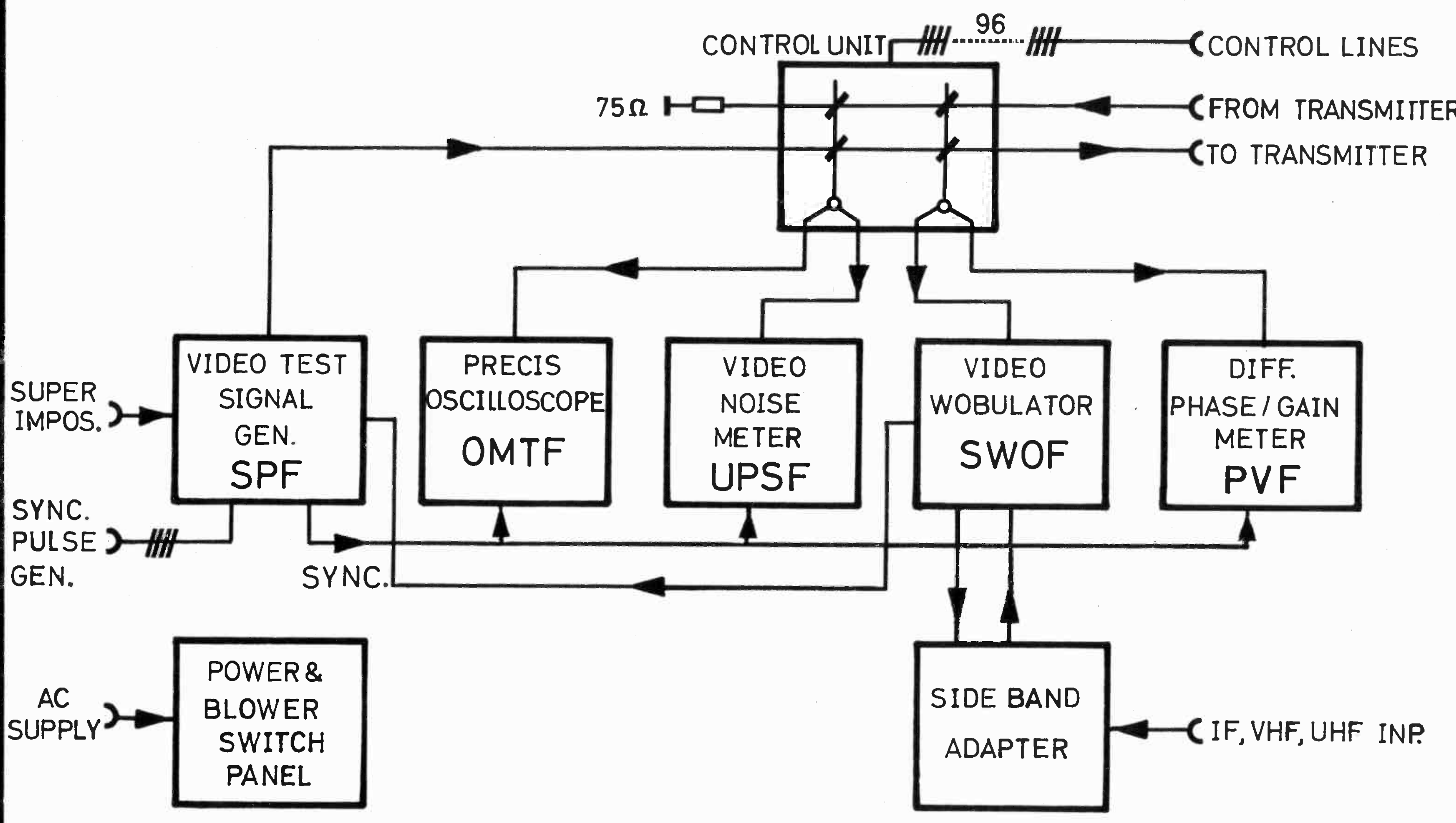


Fig.6/7

Zeichenvordruck für Diapositive 5x5 cm, Nutzformat 23x35 mm

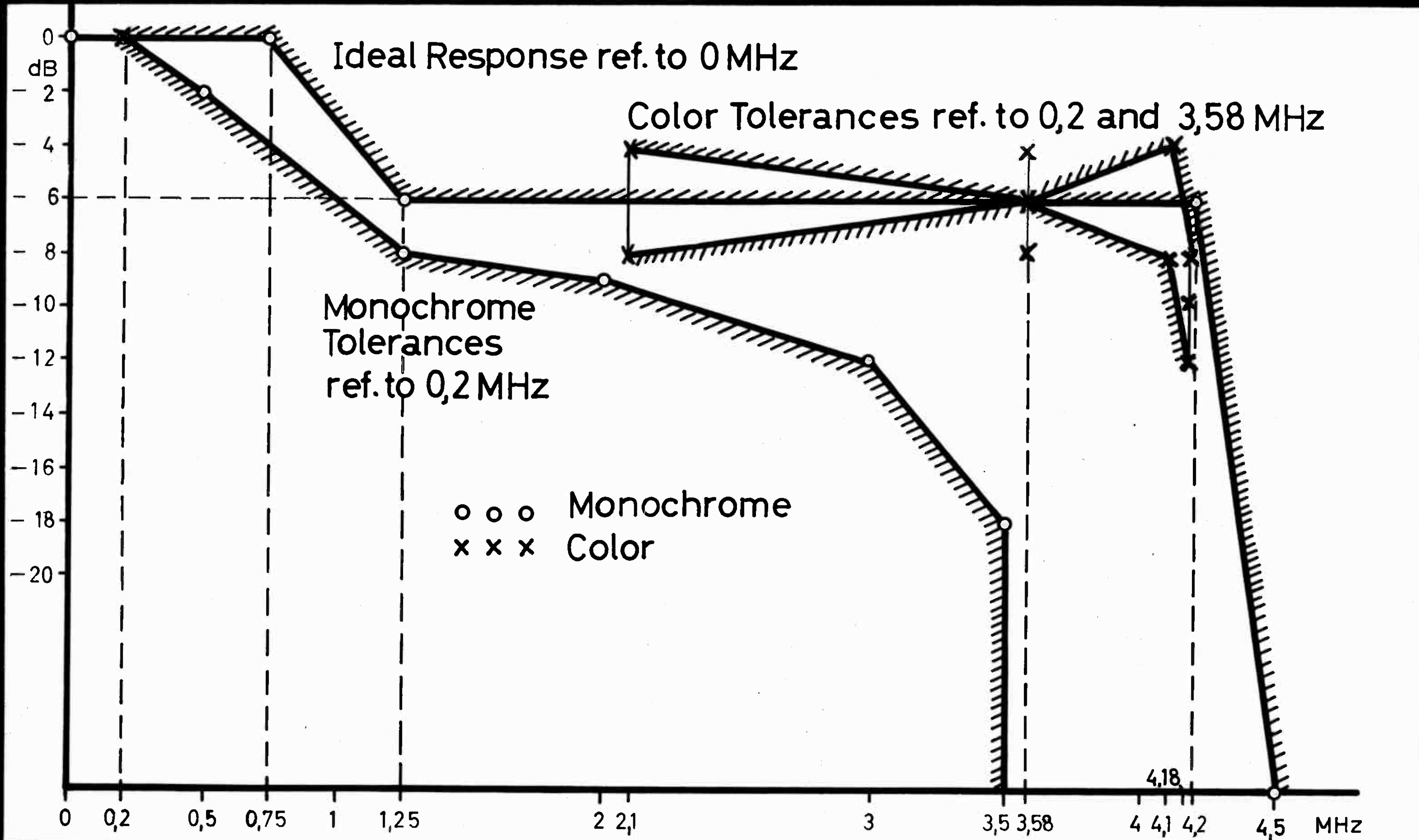
Nur Querformat. Schriftgrößen: Hervorzuhebende Teile 7 mm, Hauptteile 6 mm, Nebenteile 5 mm. Schriftdicken: 1 mm; 0,8 mm; 0,5 mm. Kleinster Linienzwischenraum 1 mm. Prüfabstand der Zeichnung 1,8 m

Einstellmaß 35 mm



TV TRANSMITTER TEST ASSEMBLY TYPE UMVF
BLOCK DIAGRAM

EL1/20 Fig.8



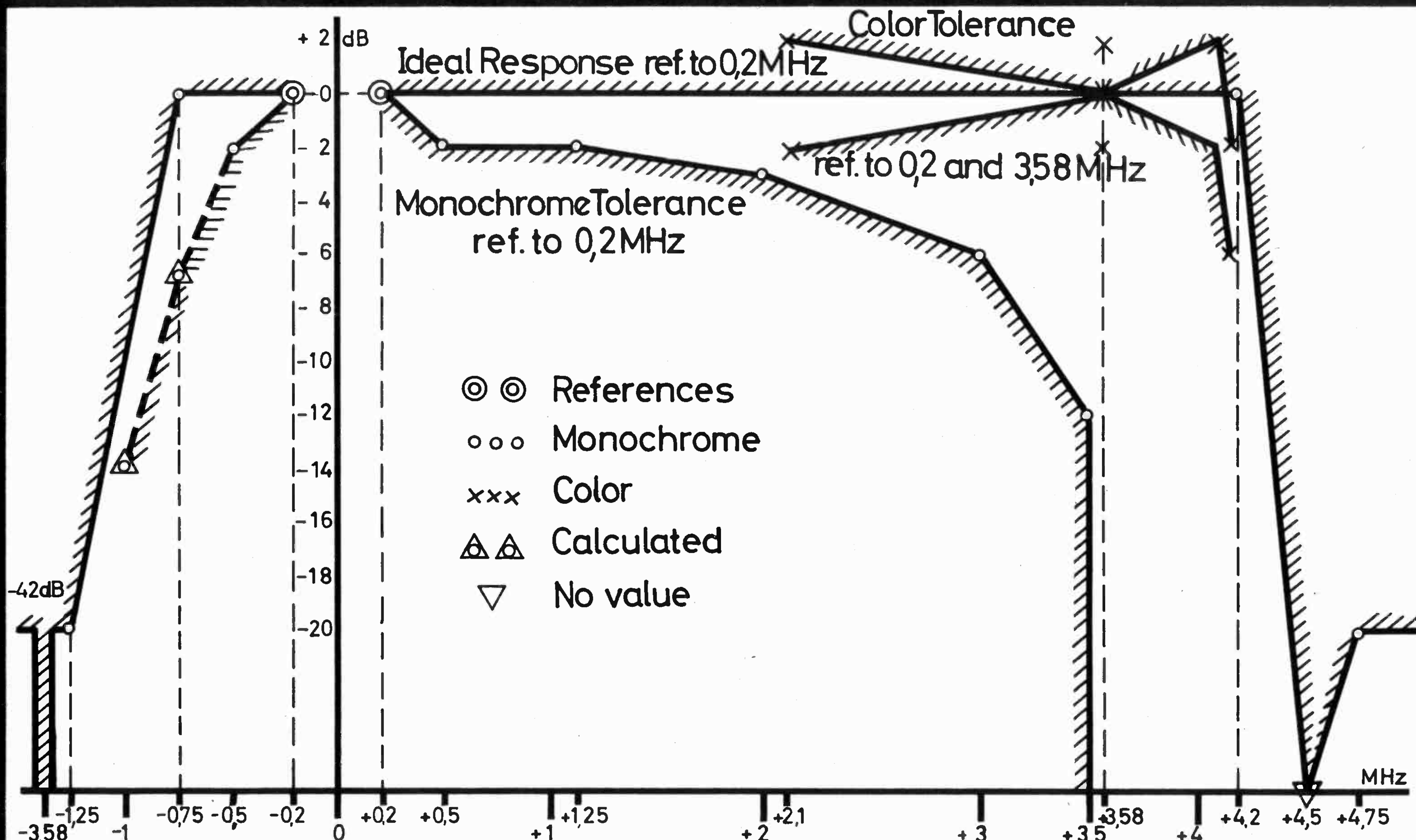
FCC-R.a.Reg. § 73687 (a)(1)-(2), § 73699 Fig.11
Ampl.-Frequ.Response of TV-Pict. Transm.with DSBD

EL1/15 Fig. 9

Zeichenvordruck für Diapositive 5x5 cm, Nutzformat 23 x 35 mm

Nur Querformat. Schriftgrößen: Hervorzuhebende Teile 7 mm, Hauptteile 6 mm, Nebenteile 5 mm. Schriftdicken: 1 mm; 0,8 mm; 0,5 mm. Kleinster Linienzwischenraum 1 mm. Prüfabstand der Zeichnung 1,8 m

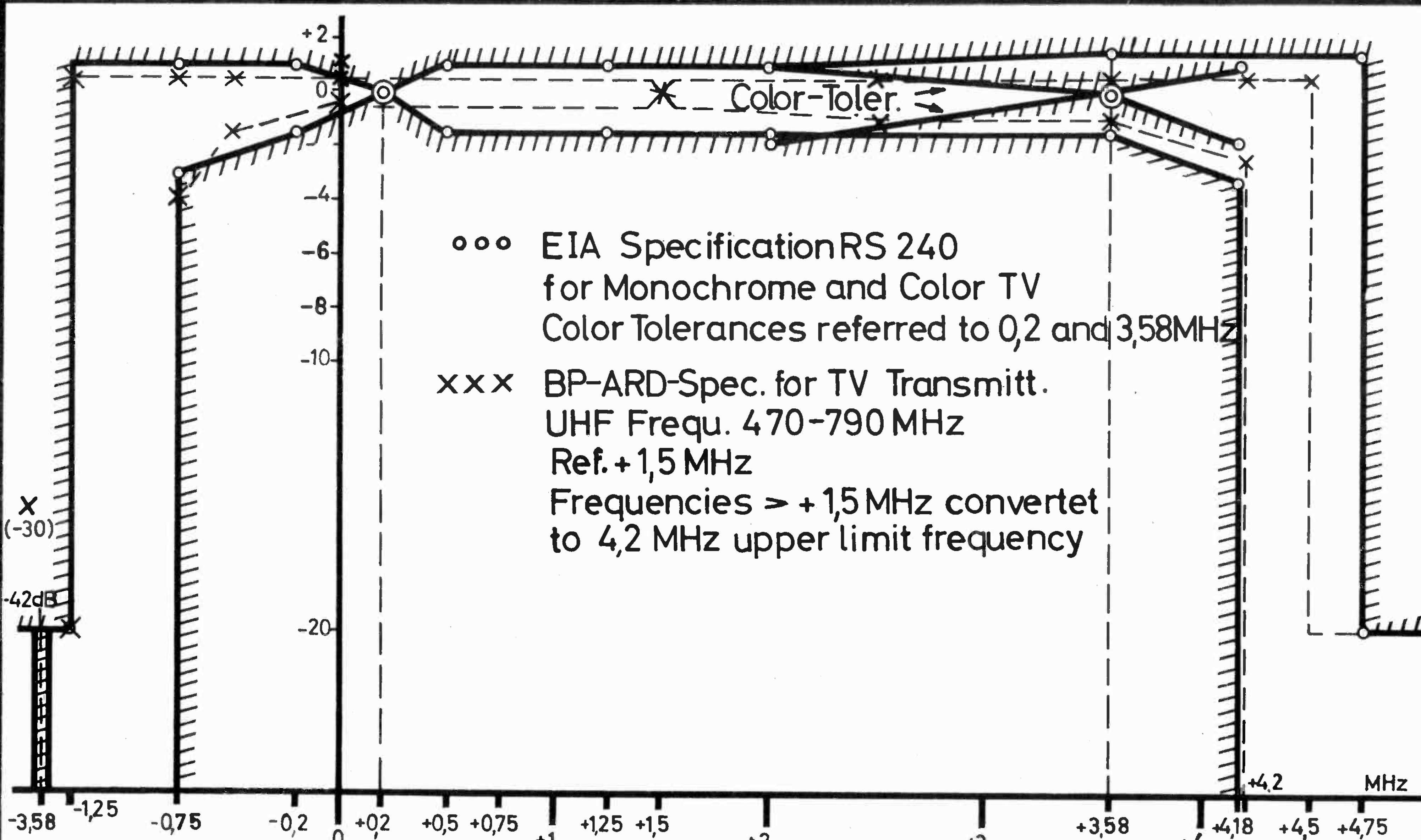
Einstellmaß 35 mm



FCC - R.a.Reg. §73687 (a)(1)-(4), §73699 Fig. 5, Fig 5a, Fig 11
Vestigial Sidebandcharacteristic of TV-Visual-Transmitters

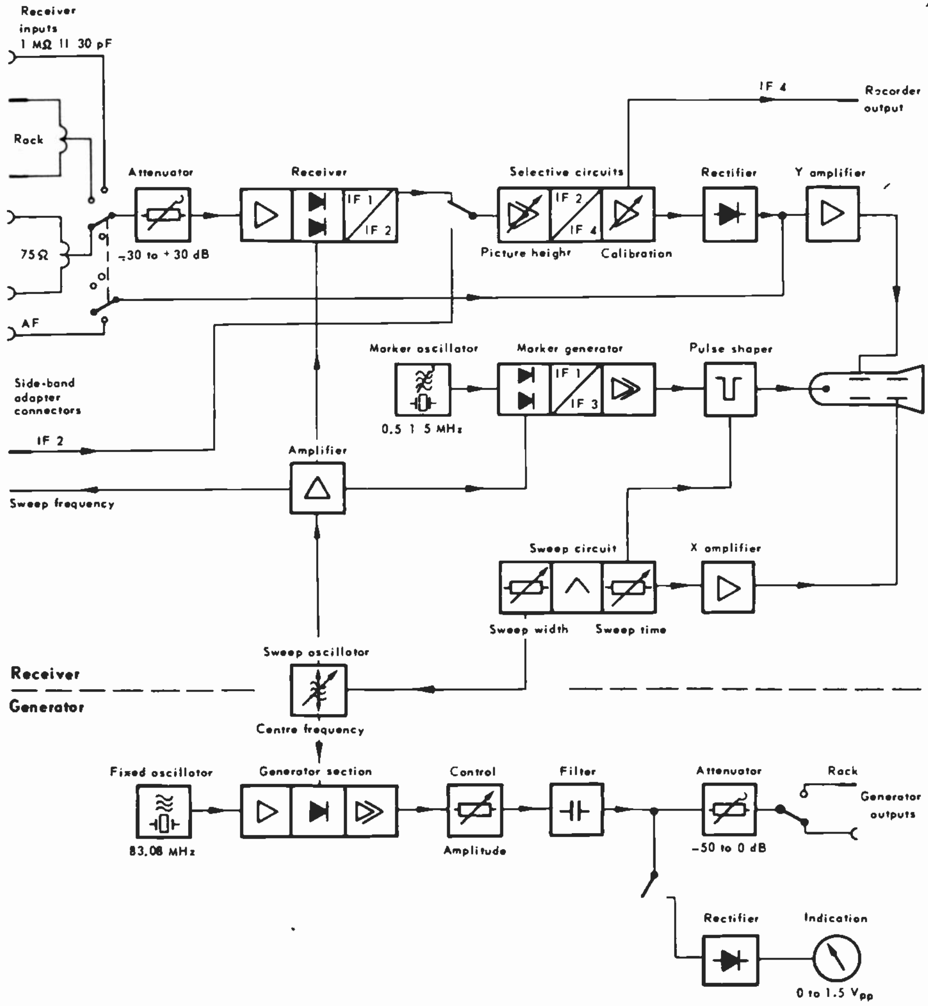
EL 1/16

Fig. 10



EIA Specification RS 240 for Vestig. Sideband-Charact. of TV-Transmitters and Bundespost-Pflichtenheft

EL1/17 Fig. 11


Receiver inputs 1 MΩ II 30 pF
Rack
75Ω
AF
Side-band adapter connectors
IF 2
Sweep frequency
Attenuator
-30 to +30 dB
Receiver
IF 1
IF 2
Selective circuits
IF 2
IF 4
Picture height
Calibration
IF 4
Recorder output
Rectifier
Y amplifier
Marker oscillator
0.5 1 5 MHz
Marker generator
IF 1
IF 3
Pulse shaper
Amplifier
Sweep circuit
Sweep width
Sweep time
X amplifier
Sweep oscillator
Centre frequency
Receiver
Generator
Fixed oscillator
83.08 MHz
Generator section
Control
Amplitude
Filter
Attenuator
-50 to 0 dB
Rack
Generator outputs
Rectifier
Indication
0 to 1.5 Vpp

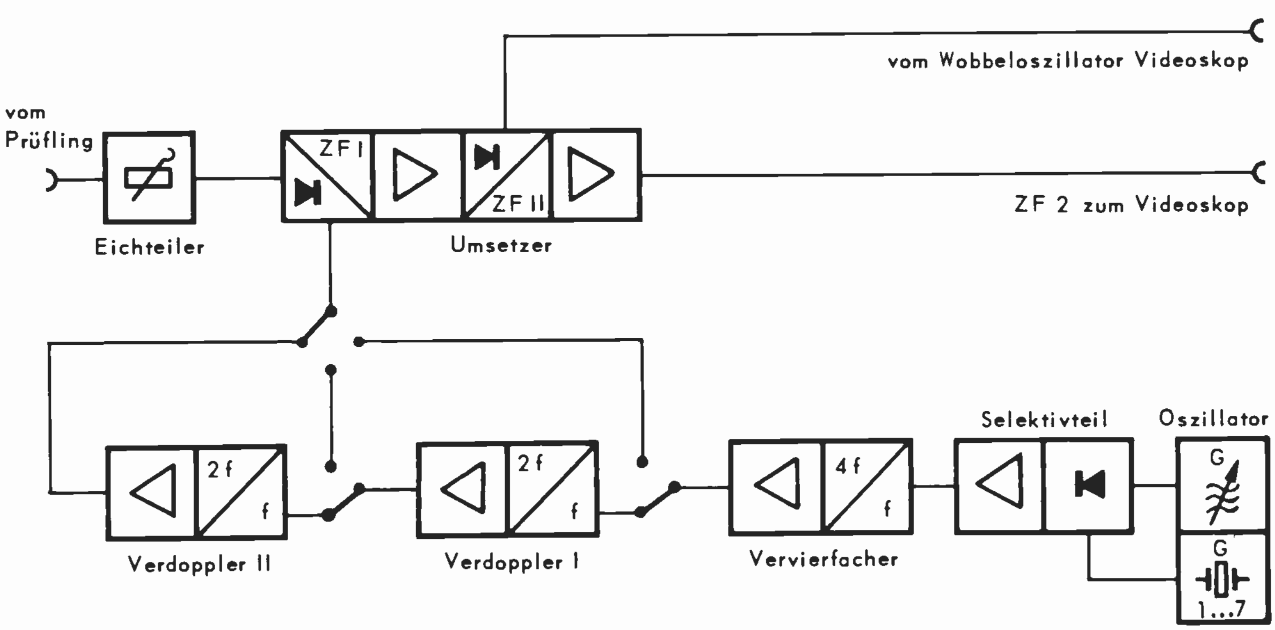
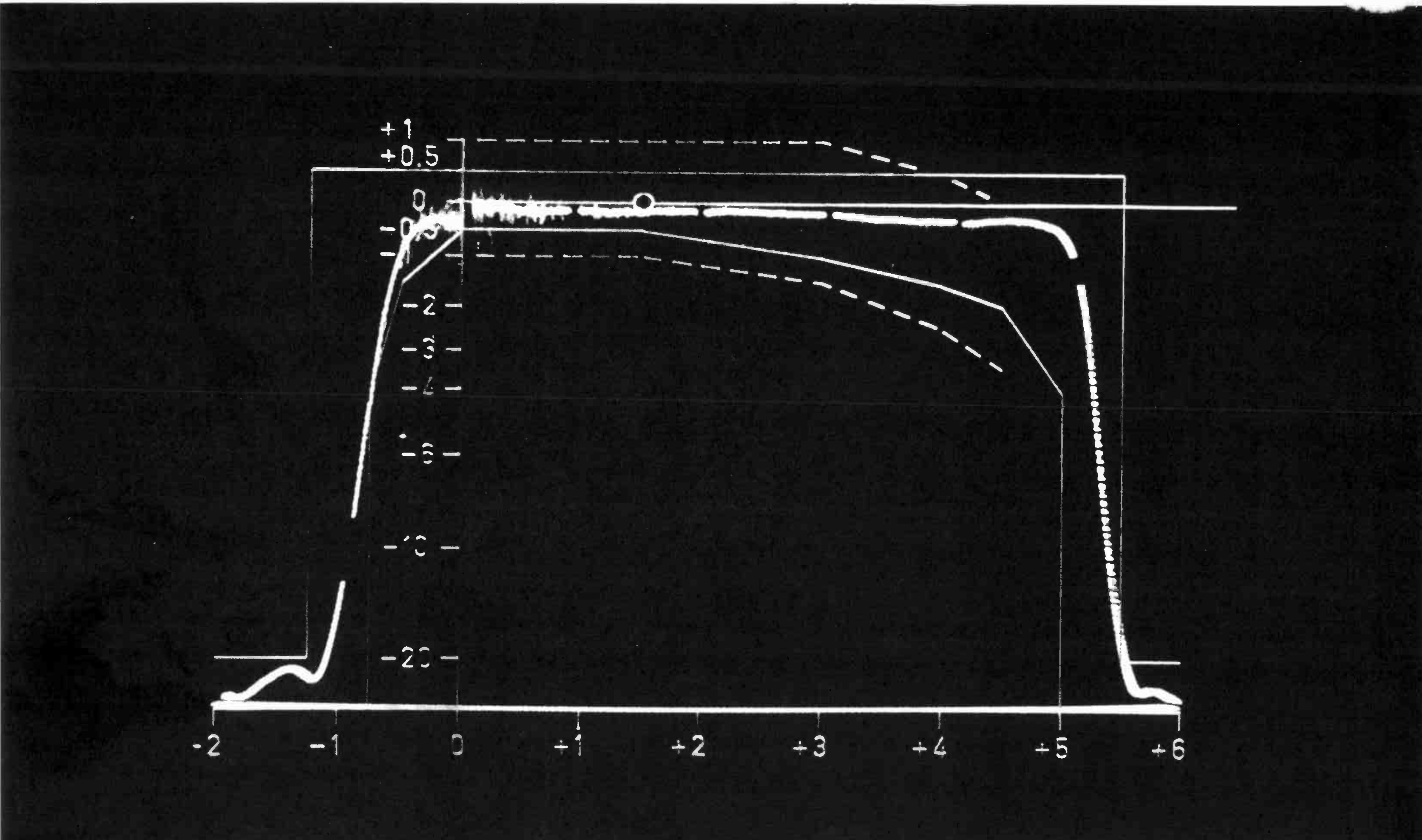

vom Wobbeloszillator Videoskop
vom Prüfling
Eichteiler
ZF I
ZF II
Umsetzer
ZF 2 zum Videoskop
2f
f
Verdoppler II
2f
f
Verdoppler I
4f
f
Vervierfacher
Selektivteil
Oszillator
G
G
1...7

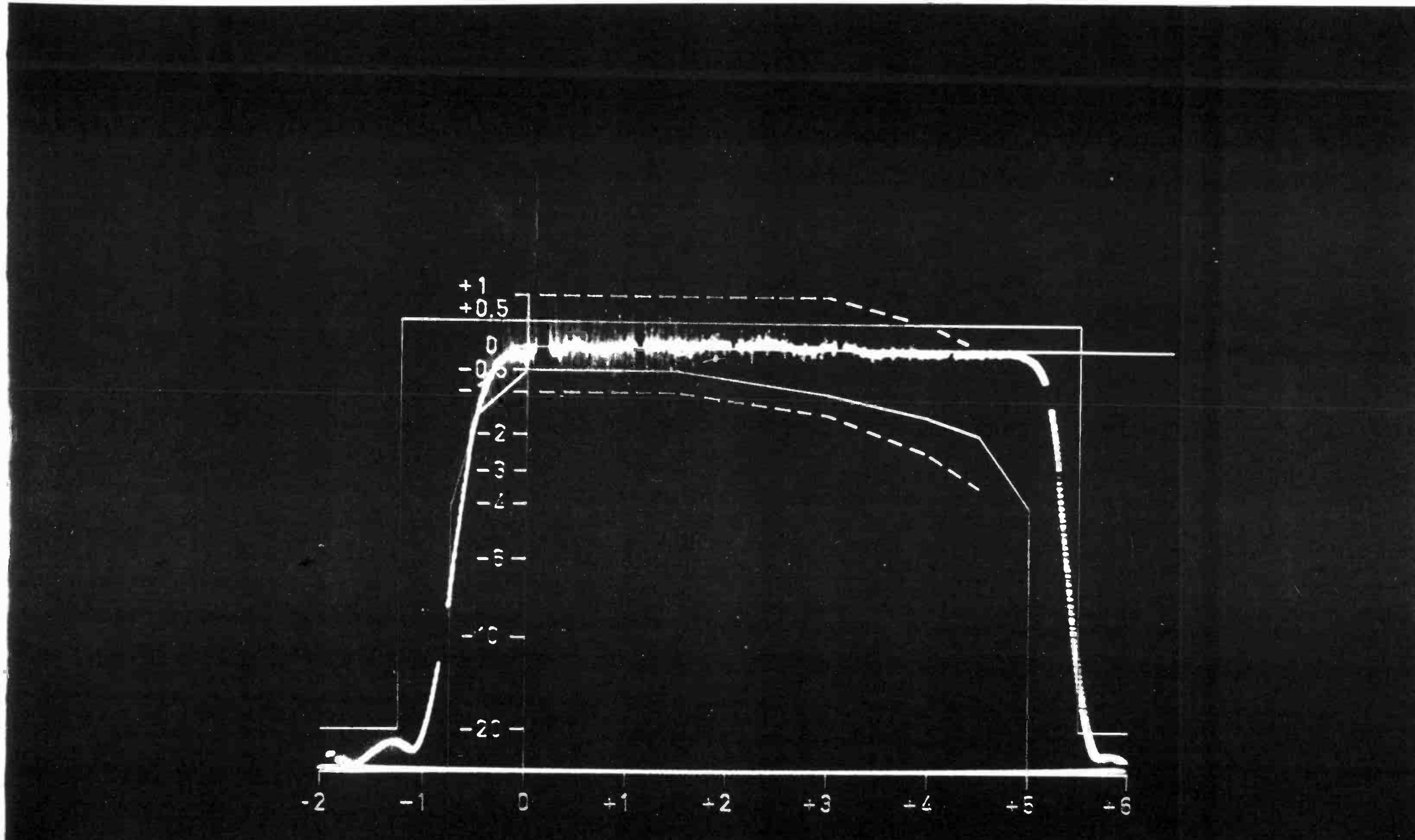
Fig. 12/13



Gewobbelte Seitenbandcharakteristik SBTF
100% B 5% Schwarzabhebung

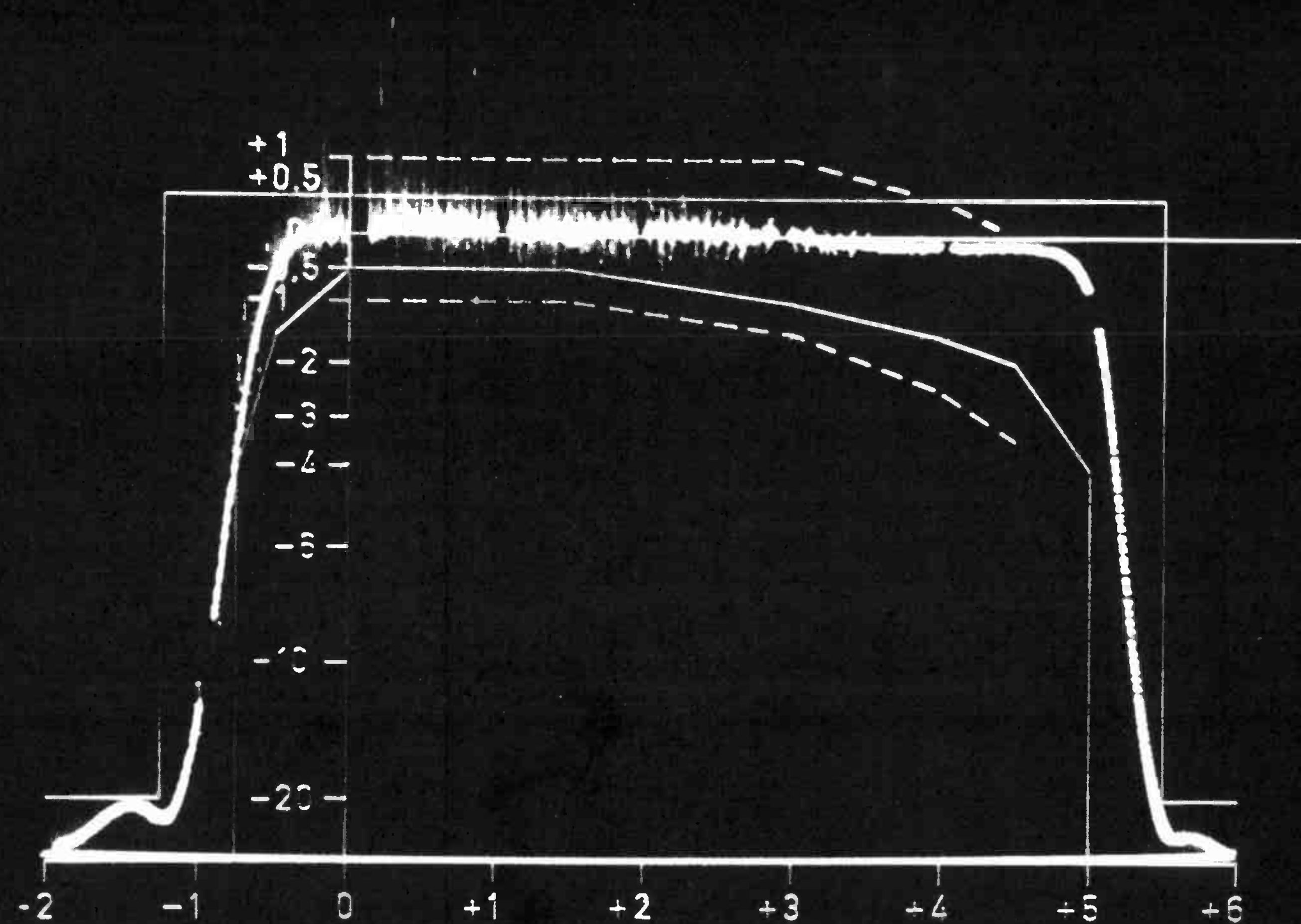
11364

Fig. 14



Gewobbelte Seitenbandcharakteristik SBTF
10% B 5% Schwarzabhebung

11365 Fig. 15



Gewobbelte Seitenbandcharakteristik SBTF
10% B 60% Schwarzabhebung

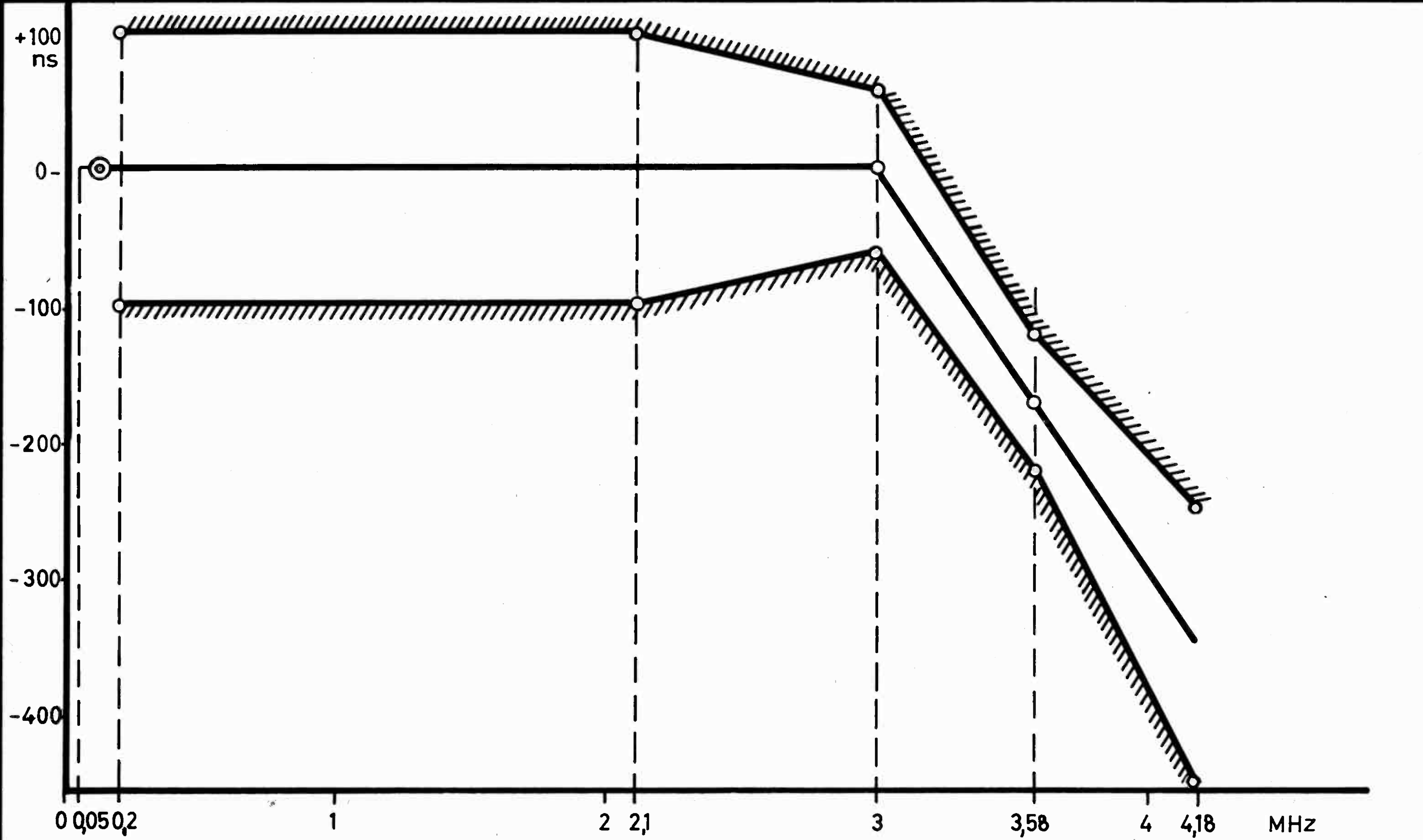
11366

Fig. 16

Zeichenvordruck für Diapositive 5x5cm, Nutzformat 23x35mm

Nur Querformat. Schriftgrößen: Hervorzuhebende Teile 7 mm, Hauptteile 6 mm, Nebenteile 5 mm. Schriftdicken: 1 mm; 0,8 mm; 0,5 mm. Kleinster Linienzwischenraum 1 mm. Prüfabstand der Zeichnung 1,8 m

Einstellmaß 35mm



FCC-R.a.Reg. § 73687(a)(5) Envelope Delay of TV-Visual-Transmitters

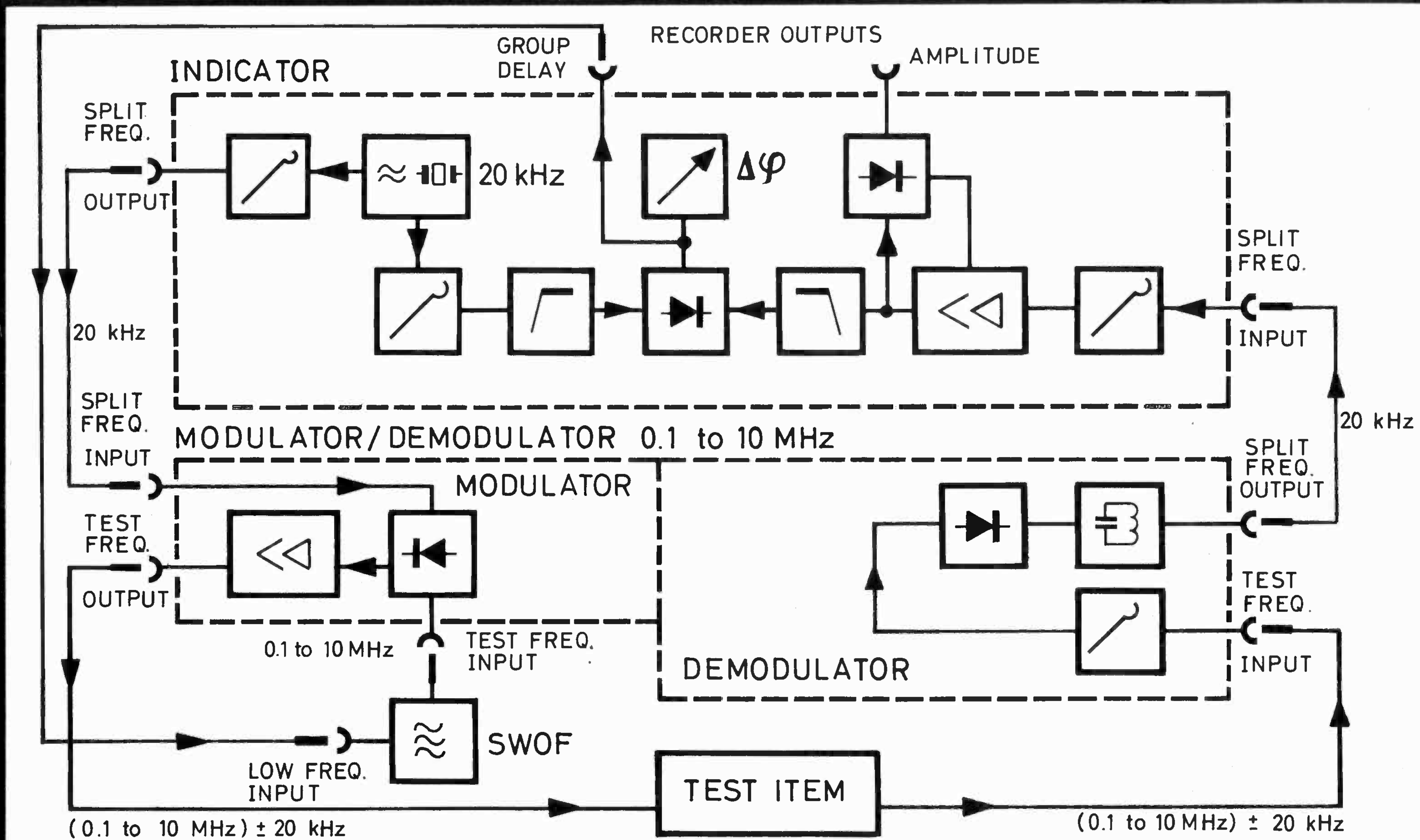
EL1/18

Fig.17

Zeichenvordruck für Diapositive 5x5 cm, Nutzformat 23x35mm

Nur Querformat. Schriftgrößen: Hervorzuhebende Teile 7 mm, Hauptteile 6 mm, Nebenteile 5 mm. Schriftdicken: 1 mm; 0,8 mm; 0,5 mm. Kleinster Linienzwischenraum 1 mm. Prüfabstand der Zeichnung 1,8 m

Einstellmaß 35 mm



BLOCK DIAGRAM OF THE LFM FOR THE DETERMINATION OF THE GROUP-DELAY BEHAVIOUR OF VIDEO AMPLIFIERS AND NETWORKS (0.1 to 10 MHz)

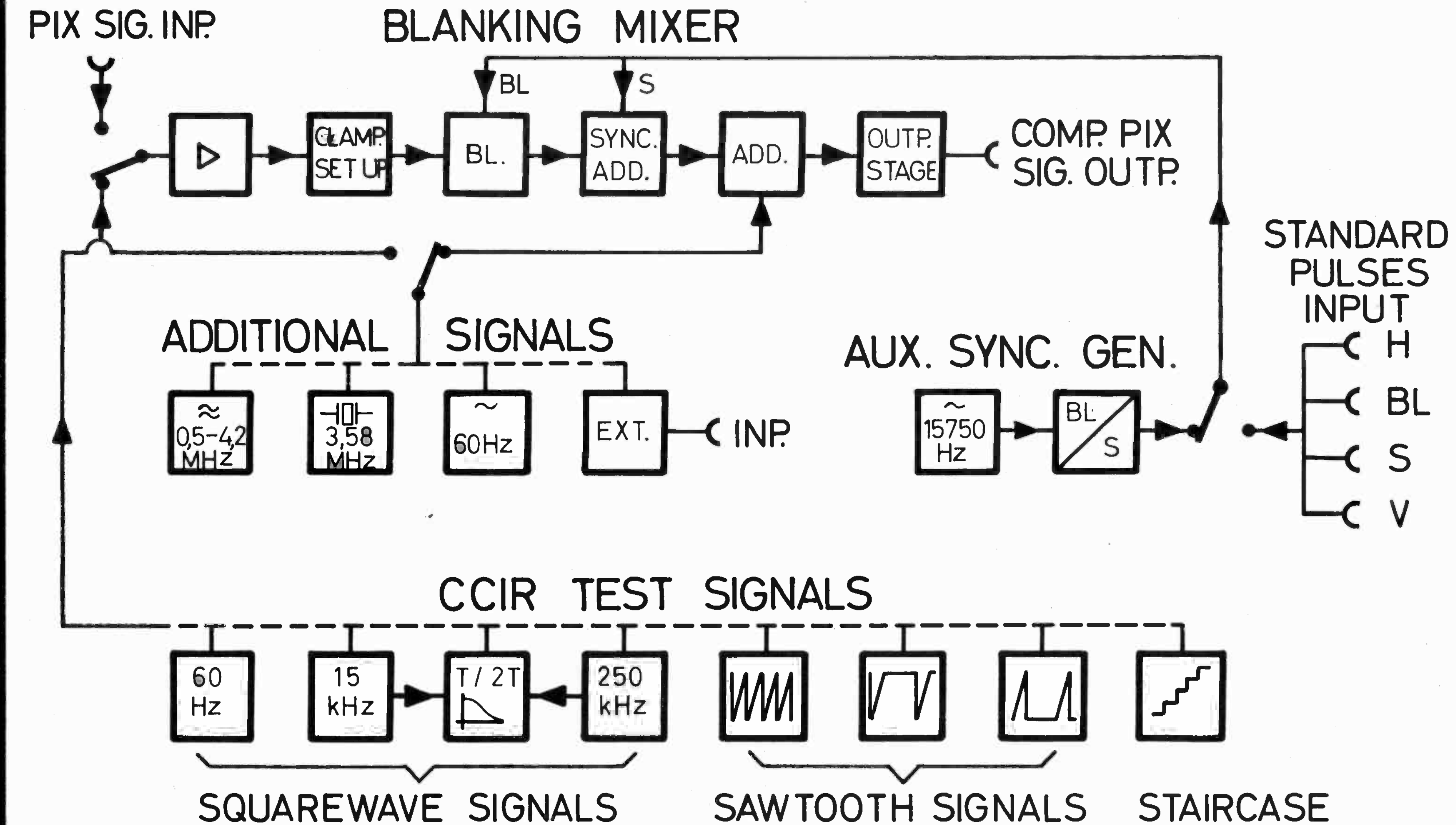
EL2 S/26

Fig.18

Zeichenvordruck für Diapositive 5x5cm, Nutzformat 23x35mm

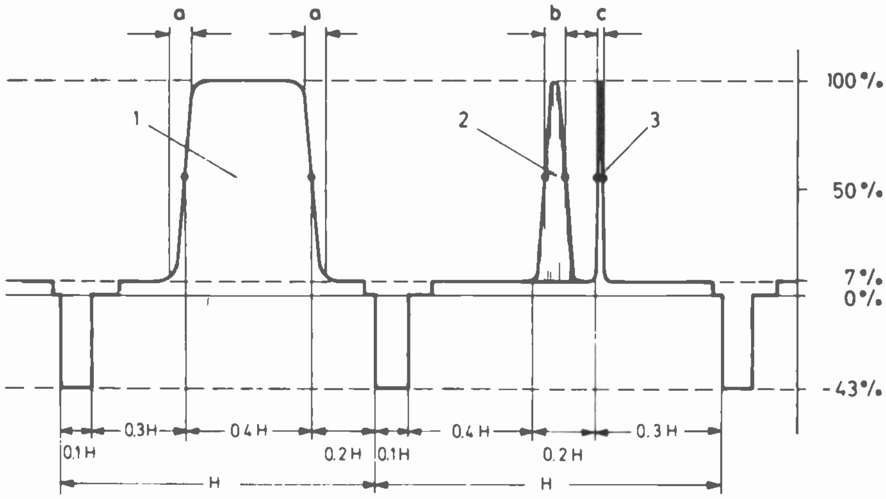
Nur Querformat. Schriftgrößen: Hervorzuhebende Teile 7 mm, Hauptteile 6 mm, Nebenteile 5 mm. Schriftdicken: 1 mm; 0,8 mm; 0,5 mm. Kleinster Linienzwischenraum 1 mm. Prüfabstand der Zeichnung 1,8 m

Einstellmaß 35mm



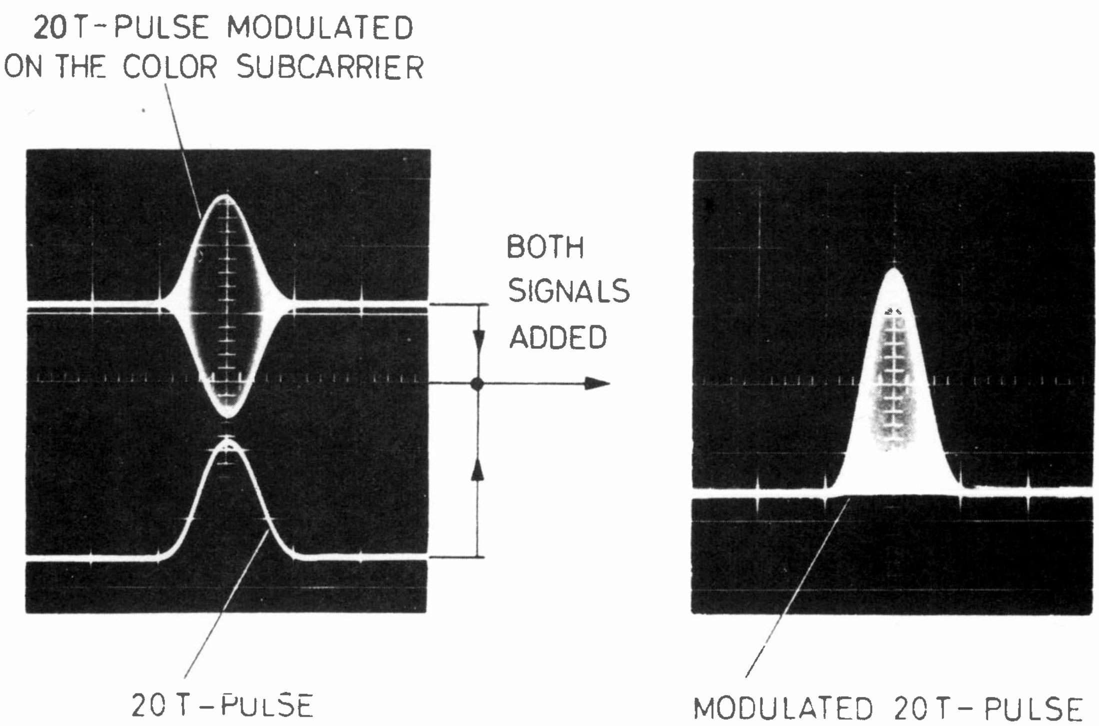
VIDEO TEST SIGNAL GENERATOR TYPE SPF BN 4238
BLOCK DIAGRAM

EL1/21 Fig.19



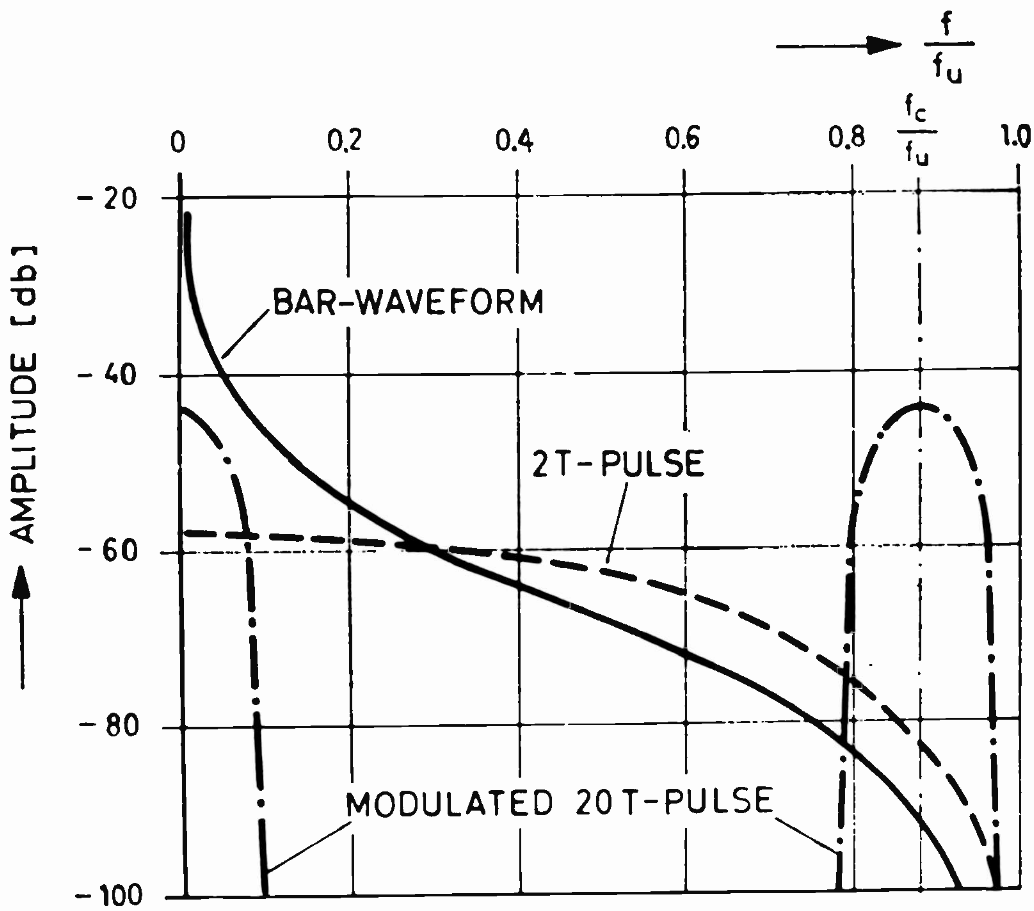
1 = BAR-WAVEFORM, a = RISE - TIME 2T
2 = MODULATED 20T - PULSE, b = HALF-AMPLITUDE DURATION 20T
3 = 2T - PULSE, c = HALF-AMPLITUDE DURATION 2T
$T = \frac{1}{2 f_u}$, f_u = UPPER VIDEO - FREQUENCY LIMIT
f_u = 4 Mc/s → T = 0.125 μs; f = 5 Mc/s → T = 0.100 μs
H = LINE PERIOD

IRT	MODIFIED PULSE-AND-BAR TEST SIGNAL	M/267/D 25.8.65



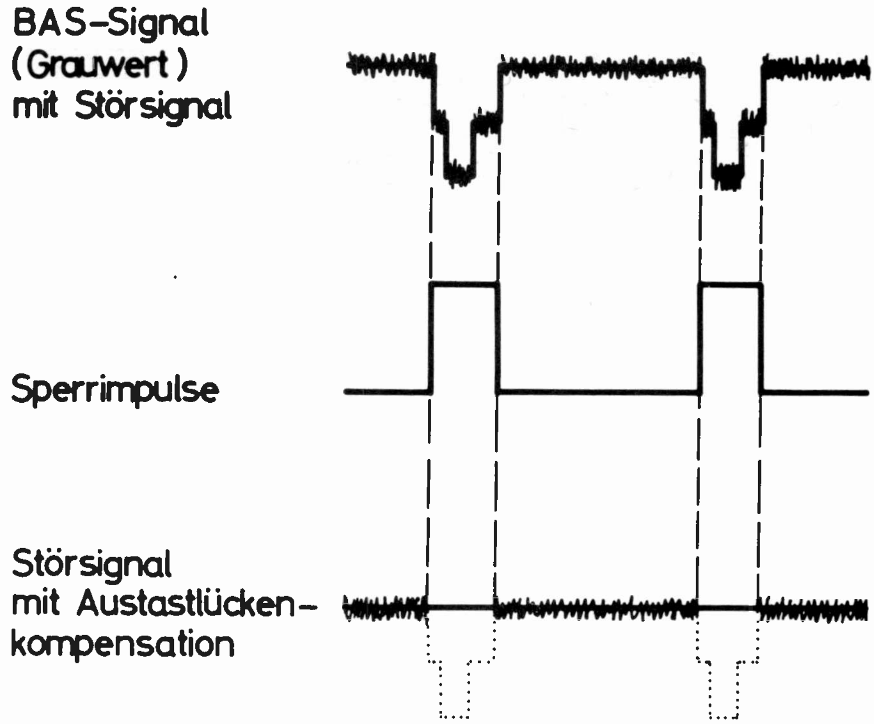
IRT	GENERATION OF THE MODULATED 20T - PULSE	M/197/D 17.8.65

Fig. 20/21



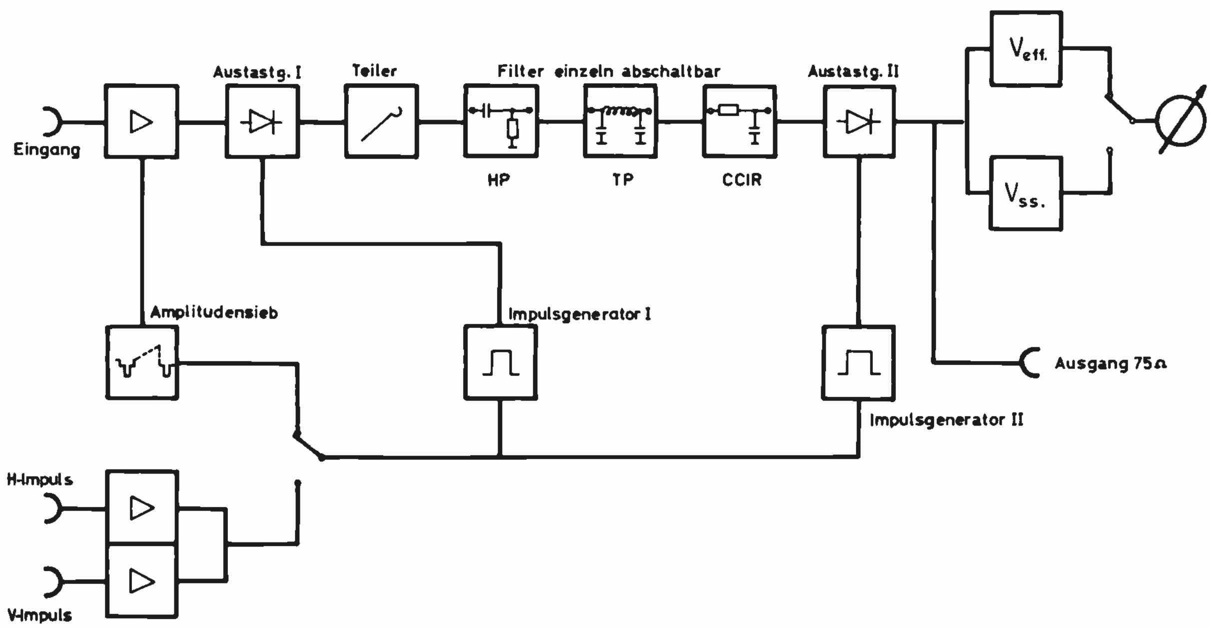
f / f_u
0
0.2
0.4
0.6
0.8
f_c / f_u
1.0
-20
-40
-60
-80
-100
AMPLITUDE [db]
BAR-WAVEFORM
2T-PULSE
MODULATED 20T-PULSE

Fig. 22



Prinzip der Störspannungsmessung
mit H-oder V-Lückenaustastung

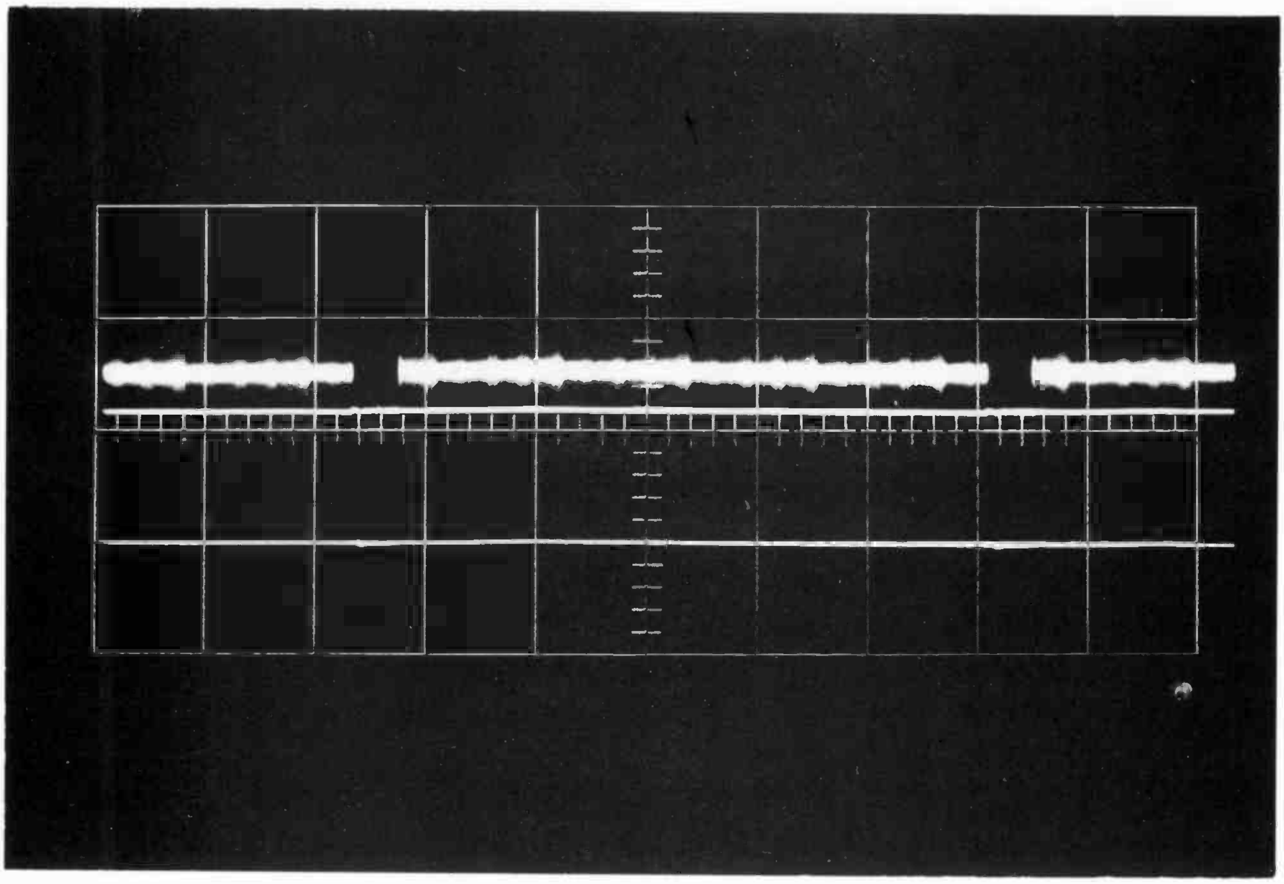
12217



Video-Störspannungsmesser Type UPSF BN120311
Blockschaltbild

12583

Fig. 23/24



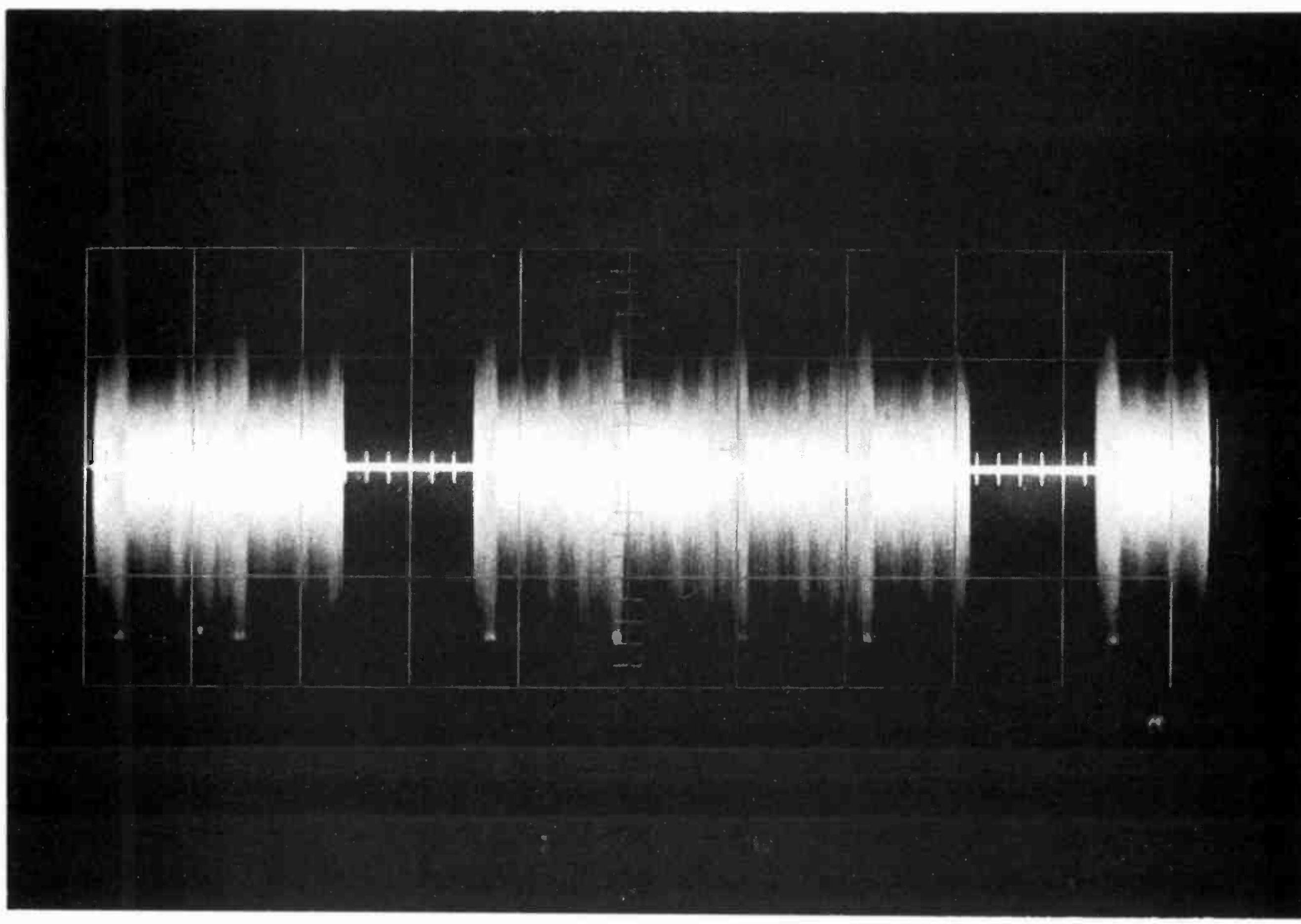
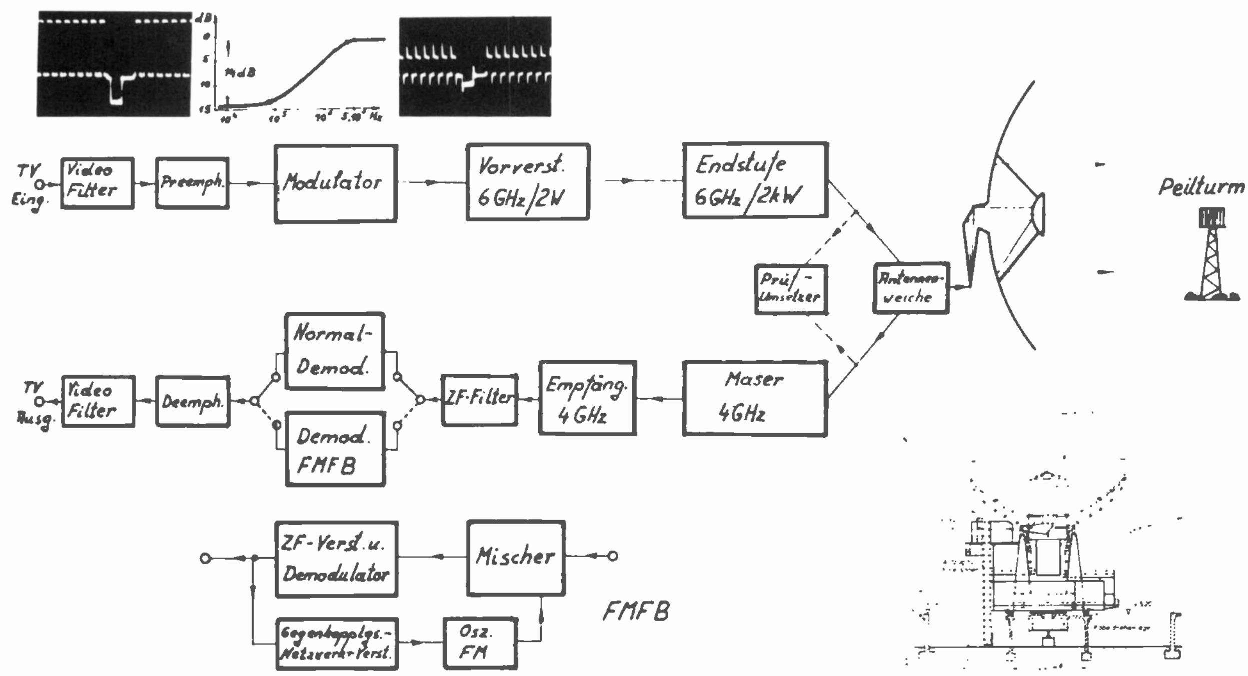


Fig. 25/26



TV Eing.
Video Filter
Preemph.
Modulator
Vorverst. 6 GHz/2W
Endstufe 6 GHz/2kW
Peilturm
Prüf-Umsetzer
Antennen-weiche
TV Ausg.
Video Filter
Deemph.
Normal-Demod.
Demod. FMFB
ZF-Filter
Empfäng. 4 GHz
Maser 4 GHz
ZF-Verst. u. Demodulator
Mischer
Osz. FM
FMFB

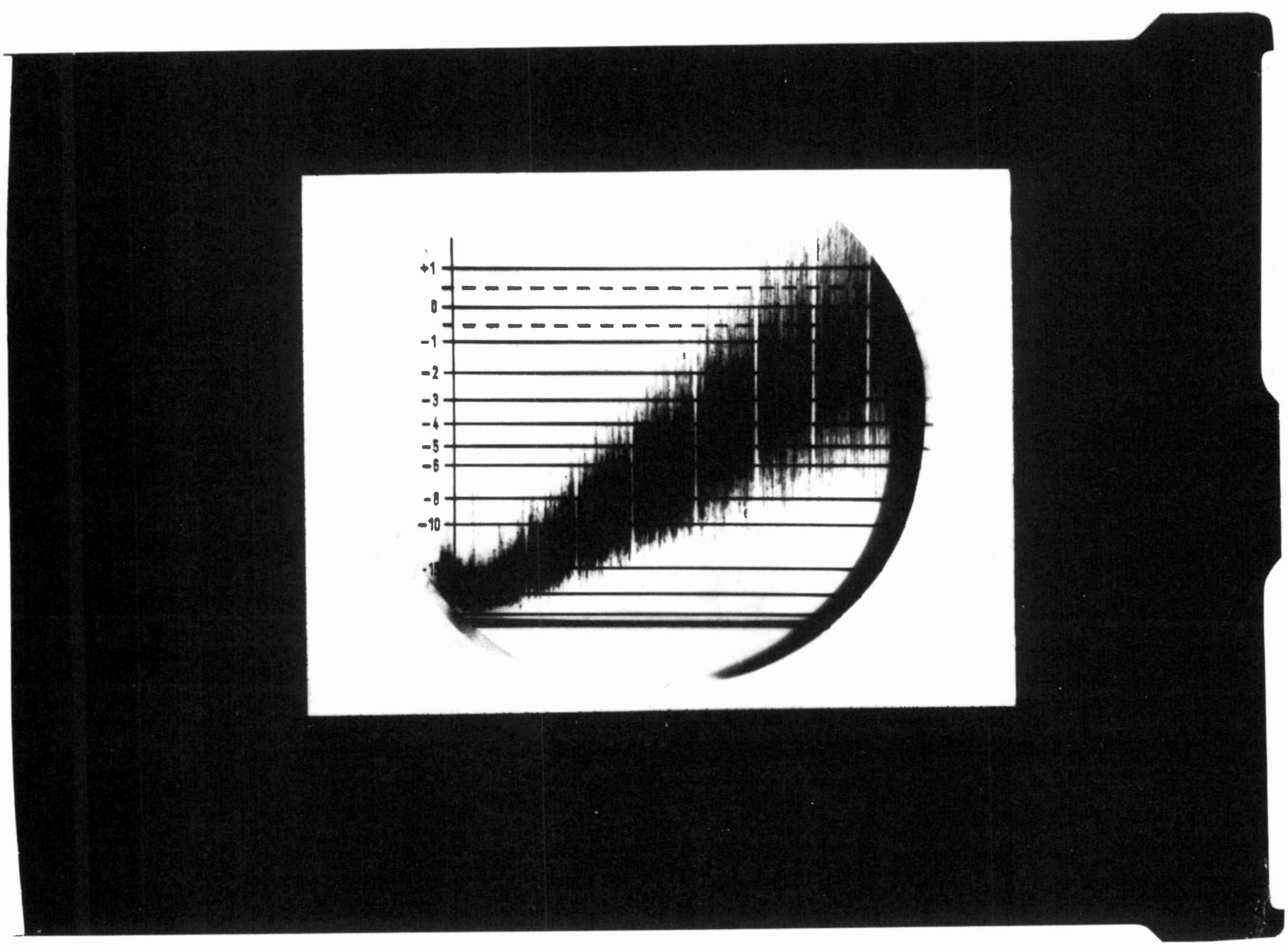


Fig. 27/28

ABC TRANSMITTER CONTROL SYSTEM

Robert M. Morris and Fred L. Zellner

During January of 1961 ABC was in the process of applying remote control to its three 50KW transmitters at WABC New York, WLS Chicago, KGO San Francisco, and to KQV, a 5KW directional station in Pittsburgh. During this transition from manned to remote operation it became apparent that an accurate method of automatic logging of the transmitter operating parameters would further improve our operations. All too often the operating logs showed constant meter readings or a variation of readings associated with a change of operators. Both of the above inconsistencies could be attributed to the operator in attendance, due either to the fact that operator duties were expanded beyond the routine of the transmitter operator, or that readings of important parameters, with which the operator was not familiar, were being improperly interpreted and recorded from the remote meter.

It was then decided that a method of electronic recording of logged data was necessary to see that all Commission requirements were met truly and that if deficiencies occurred, the facts would be available to technical management as well as being brought to the attention of the responsible operator, through the use of an audible alarm system.

On or about the same time, a petition was filed by the National Association of Broadcasters for the use of automatic logging devices for recording of information normally required to be entered in the transmitter operating logs of AM, and FM stations. ABC set about to develop a system of transmitter control and automatic logging to provide for the proper operation of the station and to satisfy Commission requirements.

The ABC Transmitter Control System is more than a system of remote transmitter control with automatic logging. It includes features of sensing for abnormal conditions including, of course, out-of-FCC tolerance operation with provisions for alarm. It includes both automatic and manual control of such things as shift of pattern for a directional antenna system or start of emergency generator in the event of power failure. It also includes automatic sensing and switching in the event of failure of the main transmitter or program circuit.

The ABC Transmitter Control System is a composite system using commercially available modules and units. It is being applied to AM and FM radio transmitters and is suitable for use for TV transmitter remote control. It is designed for maximum reliability of control and automatic control of logging and of emergency switching of lines, transmitters or power sources for continuity of service.

The characteristics of and advantages offered by the ABC Transmitter Control System are as follows:

1. Uses a single control line (in addition to the two program lines) for all functions of control, telemetry and alarm with provisions for maintenance of service in the event of failure of one line.

2. Provides digital recording of transmitter data required by the FCC, at 10 minute intervals, including time from an electronic digital clock.

3. Provides an accuracy of 0.5% on recorded meter readings. This is better than can be done directly by a skilled operator and much better than other broadcast logging systems.

4. Provides an alarm for un-authorized entry in station and for fire.

5. Provides an alarm for conditions of the transmitter which are out of tolerance.

6. Provides an automatic pre-programmed system for switching on the emergency transmitter in the event of failure of the main transmitter.

7. Provides an automatic means of sensing failure of the main program line circuit and of transferring to the emergency program line.

8. Provides automatic protection of service against loss of main commercial power.

9. Where a directional antenna is used, provides automatic means of pattern change at designated times.

10. Uses solid state circuitry and techniques for maximum reliability.

A photo of the transmitter and control system as installed at station KQV Pittsburgh is shown in Fig. 1 - transmitter room. The control equipment is in the rack on the right. This equipment incorporates all the functions and features previously outlined. This includes an RFL telemetry system and tone channels plus a Moore Associates fault alarm, and a Weston out-of-tolerance meter.

Fig. 2 shows a rear view of this equipment including, on the right hand side, a clock and pattern change relays used to shift automatically from day to night antenna pattern.

Fig. 3 is a photo of the studio control point equipment involved in the automatic control system. Here, in addition to this equipment, is the automatic logging equipment. This consists of a Beckman digital voltmeter and printer and automatic sequencer or scanner and a Haydon electronic digital clock which feeds time in digital form to the printer.

It should be made clear that there will be no attempt in this

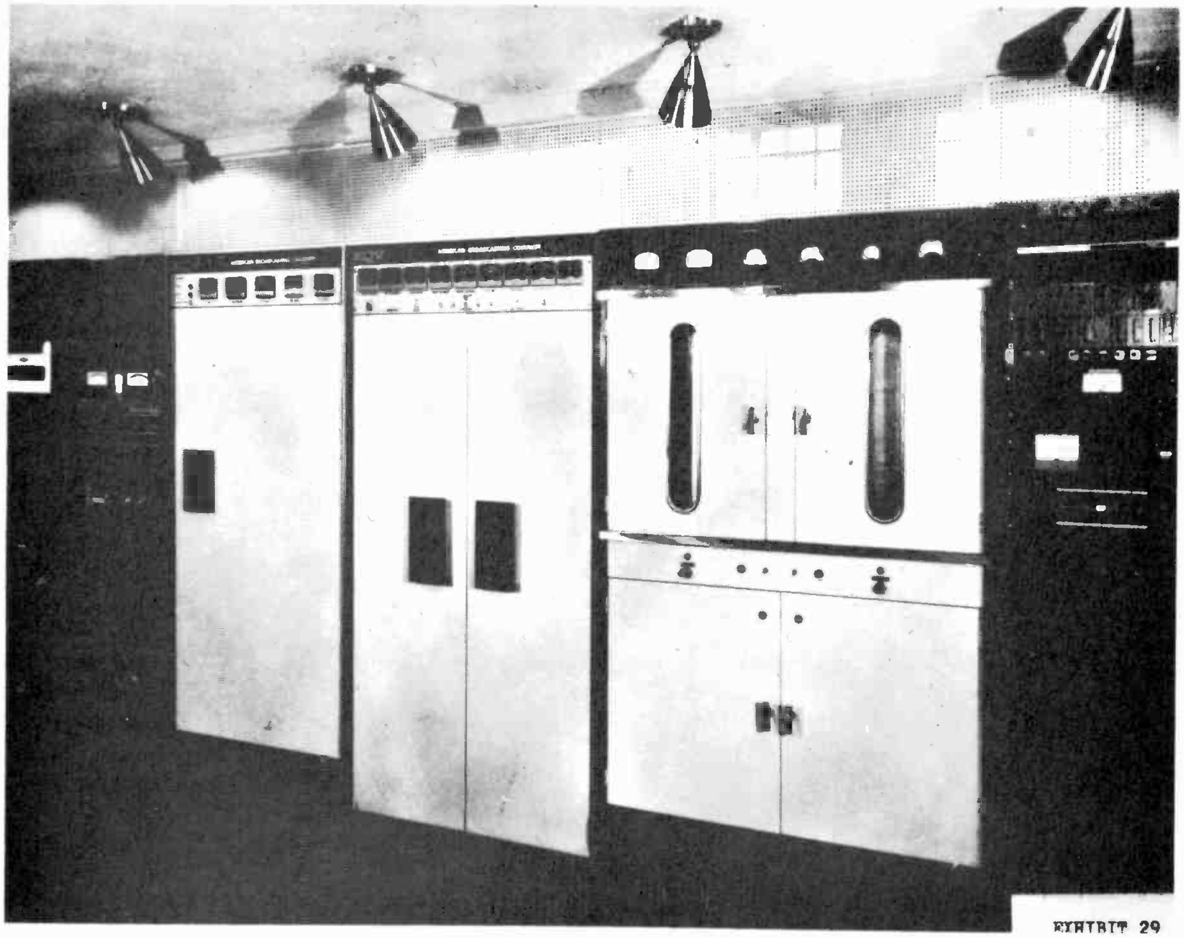
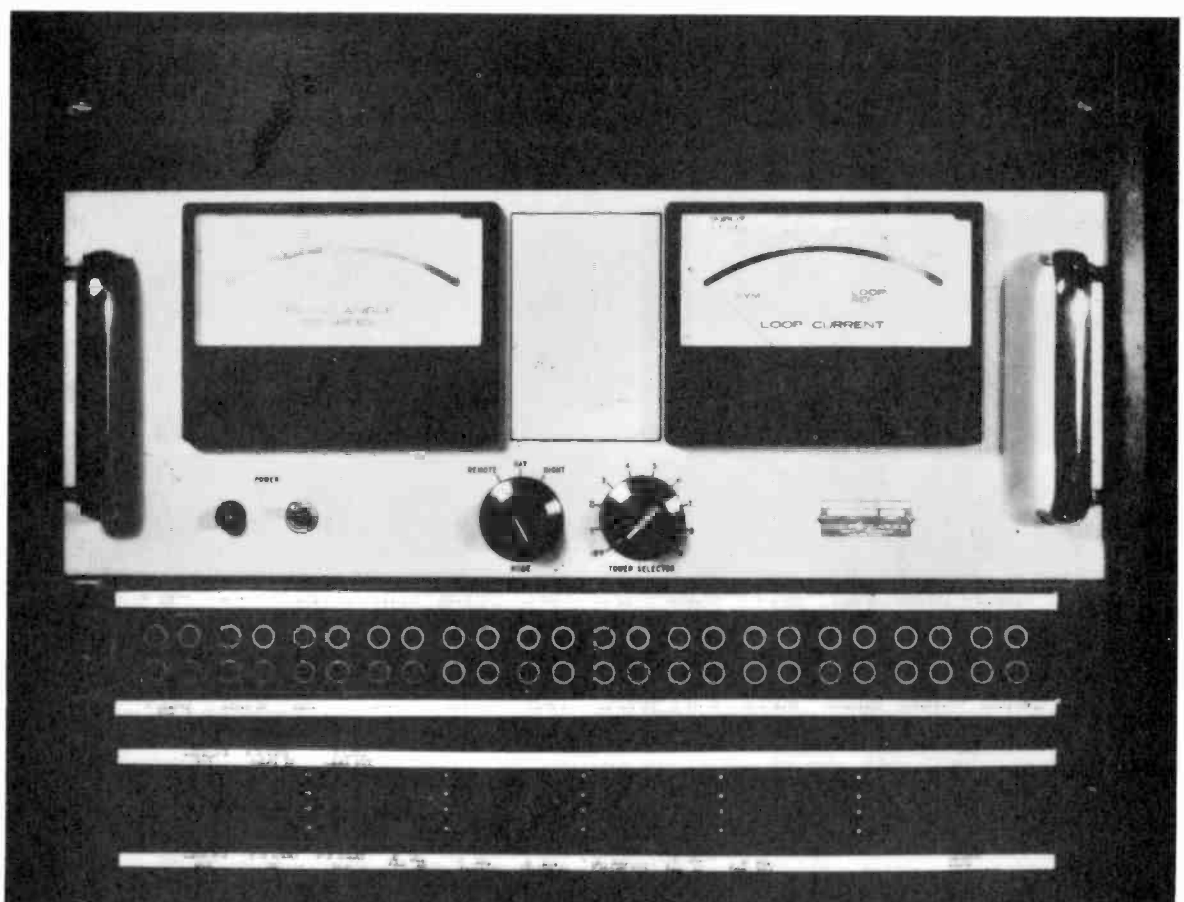


EXHIBIT 29



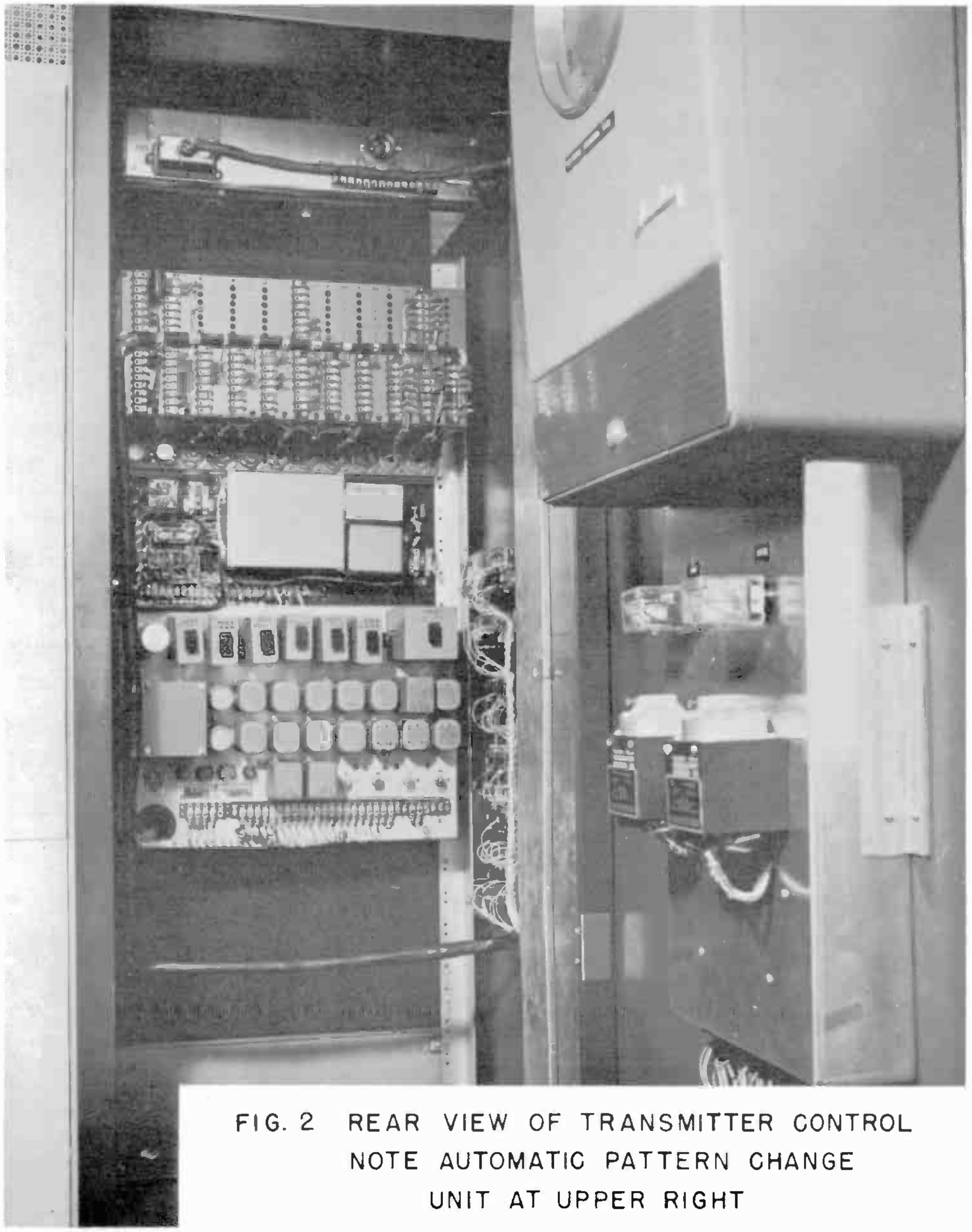


FIG. 2 REAR VIEW OF TRANSMITTER CONTROL
NOTE AUTOMATIC PATTERN CHANGE
UNIT AT UPPER RIGHT

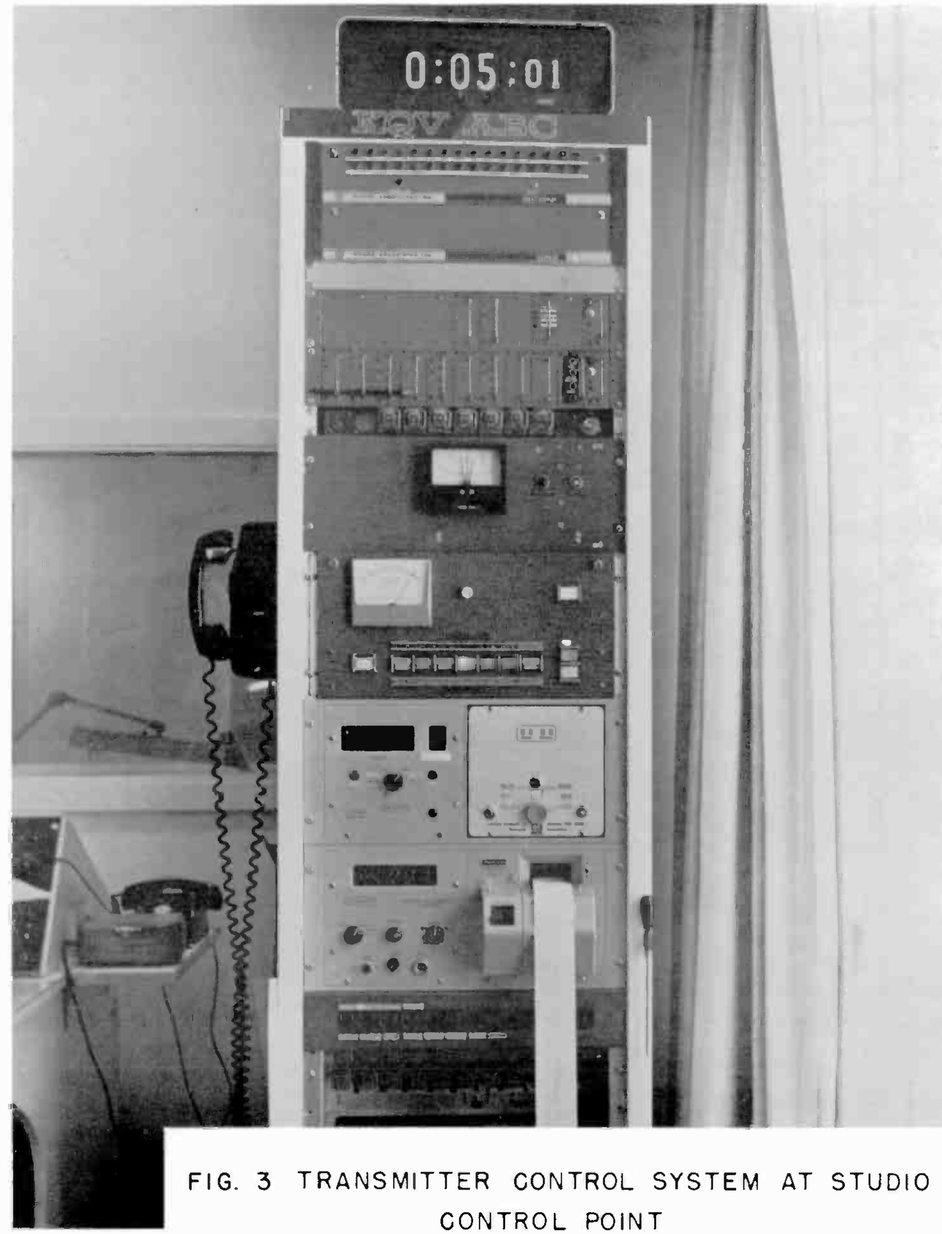


FIG. 3 TRANSMITTER CONTROL SYSTEM AT STUDIO
CONTROL POINT

paper to describe the circuitry or intimate technical details of any specific equipment used in this system. Such information is contained in instruction books of the individual units or components. The system can be composed of any of several different types or makes of equipment. There have been several new units made available since the first system was assembled which have advantages either in performance or price as compared to the original components. The system does, however, have several features of design which are advantageous regardless of the specific components chosen.

It is difficult to select any one element of the system as being a key feature since the design is such that the system advantages are derived from interdependence of elements. For example, one of the most obvious advantages in comparison with other systems of remote control is the improved accuracy of the telemetry system. This is achieved by the combined use of a tone telemetry channel in place of a d.c. metering channel and by a normalized de-normalized system which transmits all telemetry signals at approximately the same level and converts to readings decimally related to the original values before readout for automatic logging. The accurate and stable telemetry signals in turn make possible the use of a digital readout and printer which, without such stability, would not function. The use of the tone system for transmission also makes possible the use of a single control line or, for certain applications, the use of radio or multiplexed control and telemetry.

General Description

Fig. 4. This is a block diagram of the complete transmitter control system as installed at KQV Pittsburgh. It will be noted that only one control circuit is used. This one circuit with the tone control system used, is capable of handling all control telemetry and alarm functions required. However, for reasons of added reliability in the event of circuit failure over a particular cable routing, control tones from the studio to the transmitter are applied on one of the two program circuits between 7000 and 8000 cycles. (Program material is limited to 6000 cycles by means of a filter in the emergency mode of operation). The two program circuits take separate routes from the studio to the transmitter so that it is always possible to have at least one program circuit, even though an accident may have destroyed the other program circuit and the control circuit. Automatic circuit transfer is provided if the program circuit ceases to function at any time.

Automatic operation of the logging function is initiated every 10 minutes by a pulse from the digital clock. This pulse causes the Beckman Scanner to move to position 1 after which scanning and logging through the assigned positions is automatically controlled. A limit can be put on the number of positions scanned, down to one. The scanner closes function relays sequentially on the Automatic Logger Relay Panel.

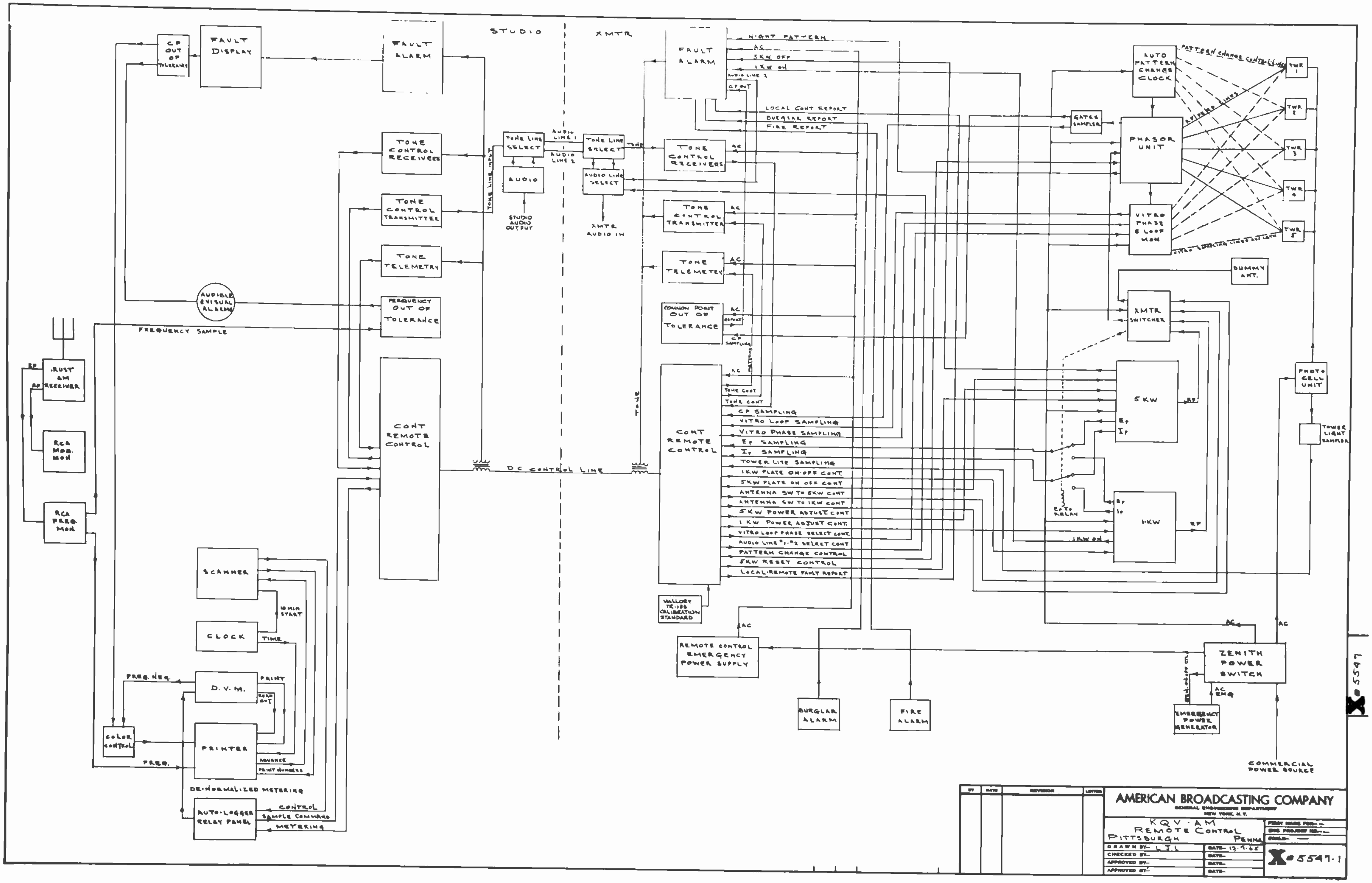

STUDIO
XMTR
FAULT DISPLAY
CP OUT OF TOLERANCE
FAULT ALARM
TONE CONTROL RECEIVERS
TONE CONTROL TRANSMITTER
TONE TELEMETRY
FREQUENCY OUT OF TOLERANCE
CONT REMOTE CONTROL
AUDIBLE & VISUAL ALARM
FREQUENCY SAMPLE
RUST AM RECEIVER
RCA MOD. MON
RCA FREQ. MON
SCANNER
CLOCK
D.V.M.
PRINTER
COLOR CONTROL
AUTO-LOGGER RELAY PANEL
DE-NORMALIZED METERING
CONTROL
SAMPLE COMMAND
METERING
TIME
PRINT
ADVANCE
PRINT NUMBERS
FREQ. NEG.
FREQ.
TONE LINE SELECT
AUDIO
STUDIO AUDIO OUTPUT
AUDIO LINE 1
AUDIO LINE 2
AUDIO LINE SELECT
XMTR AUDIO IN
DC CONTROL LINE
TONE
NIGHT PATTERN
AC
5KW OFF
1KW ON
CP OUT
LOCAL CONT REPORT
BURGLAR REPORT
FIRE REPORT
COMMON POINT OUT OF TOLERANCE
TONE CONT
CP SAMPLING
VITRO LOOP SAMPLING
VITRO PHASE SAMPLING
EP SAMPLING
IP SAMPLING
TOWER LITE SAMPLING
1KW PLATE ON-OFF CONT.
5KW PLATE ON OFF CONT
ANTENNA SW TO 5KW CONT
ANTENNA SW TO 1KW CONT
5KW POWER ADJUST CONT
1KW POWER ADJUST CONT.
VITRO LOOP PHASE SELECT CONT.
AUDIO LINE #1-#2 SELECT CONT
PATTERN CHANGE CONTROL
5KW RESET CONTROL
LOCAL-REMOTE FAULT REPORT
MALLORY TE-186 CALIBRATION STANDARD
REMOTE CONTROL EMERGENCY POWER SUPPLY
BURGLAR ALARM
FIRE ALARM
AUTO PATTERN CHANGE CLOCK
PATTERN CHANGE CONTROL LINES
GATES SAMPLER
PHASOR UNIT
VITRO PHASE & LOOP MON
VITRO SAMPLING LINES
TWR 1
TWR 2
TWR 3
TWR 4
TWR 5
DUMMY ANT.
XMTR SWITCHER
5KW
1KW
RF
EP
IP
EP-IP RELAY
1KW ON
PHOTO CELL UNIT
TOWER LIGHT SAMPLER
ZENITH POWER SWITCH
EMERGENCY POWER GENERATOR
COMMERCIAL POWER SOURCE
AMERICAN BROADCASTING COMPANY
GENERAL ENGINEERING DEPARTMENT
NEW YORK, N.Y.
KQV-AM
REMOTE CONTROL
PITTSBURGH PENNA
DRAWN BY- L.J.L.
DATE- 12-7-65
CHECKED BY-
APPROVED BY-
X 5547-1

FIG. 4

These relays have two functions, one set of contacts pick off the de-normalized voltage from an appropriate voltage divider network and apply it to the input of the digital voltmeter, a second set of contacts apply the correct voltage and polarity to the d.c. control line to cause the desired voltage sampling to be transmitted back from the transmitting station.

The Variable Frequency Telemeter System provides a means of sending back the d.c. sampled voltage as an AC equivalent over an audio tone (usually 900 cycle) carrier, thus eliminating the effect of induced voltages or variations in the DC resistance of the metering line, which can seriously affect accuracy of metering on a d.c. basis.

The desired voltage or current sample from the radio transmitter is selected by d.c. signals over the control line from the studio to the transmitter remote control unit. The sampled voltage is applied as a frequency modulation on the 900 cycle telemeter carrier, transmitted over the control line to the 900 cycle receiver, returned to a d.c. voltage, and indicated as a percentage-of-normal reading at the studio remote control unit. The percentage-of-normal voltage is then sent through a calibrated denormalizing voltage divider and is read by the digital voltmeter (a replica of the original transmitter meter reading) and when the voltage has stabilized for one second a command is sent from the voltmeter to the Beckman Printer which prints out the time of the reading, scanner position number, and the voltage shown by the digital voltmeter. After the reading has been printed, the scanner moves to its next position and the process continues.

If so desired, the Continental Remote Control unit can be used to manually select desired readings for manual logging as a percent of normal. A manual overide is provided to prevent any lash-up with the automatic logger.

In Fig. 5 the reading on the printer tape, as an example, might be 01 500 0000. The first number (or numbers) will be the position or function number of the scanner. The second group of three is the telemetered analogue of the meter reading. The last four digits is the time. All meter readings, except one, are logged by telemeter readings from the transmitter. In the case of transmitter frequency however, the frequency monitor is located at the control point and is operated remotely by means of an antenna and RF monitor amplifier.

In the ABC system, the d.c. control line is used for six purposes:

1. As a d.c. control line for the Continental system.
2. Transmitter to studio fault alarm (660 CPS). (Moore Associates)
3. Transmitter to studio line transfer control (780 CPS)
4. As a Continental select report back (420 CPS)

SAMPLE
LOGGER TAPE

```
22    036
21 .. 098 ....
20 .. 259 .....
19 .. 444 .
18 .. 501 . 0011
17 ..
16 .  011 .....
15 .. 060 ...
14 .  036 .....
13 .. 163 .....
12 .  155  ..
11 .. 056 .....
10 .. 175 ....
.9 .. 575 .
.8 ..
.7 .. 100 .....
 6 .  907
.5  . 545
.4 .. 905
.3 .. 122 .....
.2 .. 507
 1 .  500   0010
22 .  032 . ..
21 .. 094 . ..
20 .  257 .....
19 .. 445
18 .. 501 . 0001
17 ..
16 .. 010   ..
15 .. 061 .....
14 .. 036
13 .  163
12 .. 155 ..
11 .  056 .
10 .. 176 .
.9 .. 577 ...
 8 .
 7    100   ..
.6    913 .....
 5 .  549 .. ..
 4 .. 912 .
 3    123
.2    510
 1    500   0000
```

FIG. 5

IDENTIFICATION
STAMP

SCANNER POSITION	FUNCTION
1	CALIBRATE
2	5 KW/1 KW Plate Volts
3	5 KW/1 KW Plate Amps
4	COMMON POINT
5	#1 LOOP
6	#2 LOOP
7	#3 LOOP
8	SELECT "B"
9	#4 LOOP
10	#5 LOOP
11	#1 PHASE
12	#2 PHASE
13	#4 PHASE
14	#5 PHASE
15	AM TOWER LITES
16	AM FREQUENCY
17	SELECT "A"
18	FM CALIBRATE
19	FM PLATE VOLTS
20	FM Plate Current
21	FM Reflectometer
22	FM FREQUENCY

LOG SHEET LEGEND

Scanner Position	Multiplier	Function
1		AM Calibrate
2	X10	Plate Voltage
3	X.01	Plate Current
4	X.01	Common Point
5	X.1	Loop #1
6	X.1	Loop #2
7	X.1	Loop #3
8		Select
9	X.1	Loop #4
10	X.1	Loop #5
11		Phase #1
12		Phase #2
13		Phase #4
14		Phase #5
15		AM Tower Lites
16	See Chart	AM Frequency
17		Select
18		FM Calibrate
19	X10	FM Plate Voltage
20	X.01	FM Plate Current
21		FM Reflectometer
22	X10	FM Frequency

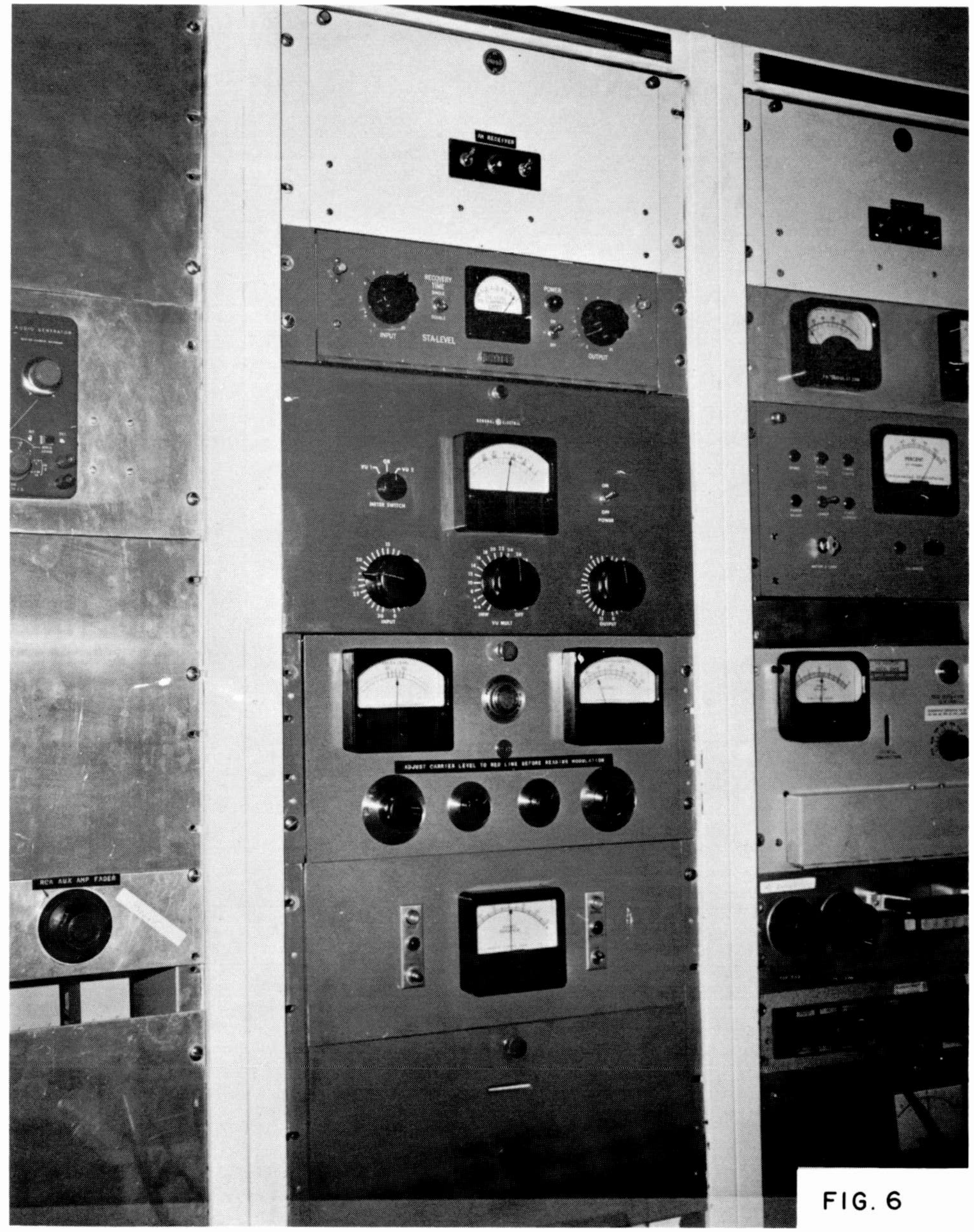


FIG. 6

5. Transmitter to studio telemeter channel (900 CPS)
6. Fault Alarm interrogate and cycling channel (540 CPS) systems using Continental Fault Alarm.

The emergency or #2 broadcast line is used for three purposes:

1. For audio programming as an emergency source.
2. As a studio to transmitter channel for 7800 CPS on/raise, off/lower, emergency line switching and fail-safe signal.
3. For 7400 CPS tone channel for Continental Fault Alarm interrogation and cycling signal. (When the Continental Fault Alarm is used).

The 7400 and 7800 cycle tones are not heard as modulation, should programming switch to #2 broadcast line, (emergency program source) because of two 6KC filters, one in the studio to keep tone from feeding back into regular programming channels and one at the transmitter. If a break should occur in the #2 broadcast line control tones, the tone equipment will automatically switch to the regular broadcast line. The switch is so fast that fail-safe does not operate and control is maintained. If the #1 line is opened under this condition, control is lost and the on-air transmitter will shut down automatically to comply with FCC regulations on remote control fail-safe.

Faulty or improper operation exceeding FCC specified tolerance is controlled independently of the automatic logging system. The entity directly involved in power output is antenna or common point current which is best monitored at the transmitter. Limits on power are specified as plus five percent and minus ten percent, which is plus 2.5% minus 5% approximately of antenna current. A Weston 1075 type meter system connected to the transmitter output or monitoring rectifier and set with its limit contacts 2.5% above and 5% below license reading provides the necessary circuit to function with the fault alarm system which will transmit the indication to the control point. At the control point (see Fig. 3), an audible and visual alarm is provided in case of an out-of-tolerance condition, and the Beckman Printer prints the antenna or common point reading in red until the condition is corrected.

Frequency is monitored at the studio location by an RCA frequency meter (see Fig. 6) which includes a limit meter indicating any frequency excursion in excess of plus or minus 20 cycles. Negative frequency deviation is printed in red, positive deviation in black, and an audible and visual alarm is provided for an out-of-tolerance condition.

A significant advantage of this system as will be noted from Fig. 5 is that the logging system may be used simultaneously to record data from two or more transmitters at different locations and controlled by separate remote control and telemetry systems. The first 17 functions on the KQV log have to do with the AM transmitter. Functions 18 to 22

are the logging positions for KQV-FM. The logger simply connects to and interrogates the separate control system for the FM transmitter for these five functions.

A further advantage of the digital type of logging system is its complete objectivity and accuracy. The telemeter system has a rated maximum error of 0.5%. The digital voltmeter and recorder has a maximum error of 0.3% including the potential 1 unit error in the third decade of the voltmeter. The error of the complete system on any one reading seldom exceeds 0.5%. If one is interested in average values for one hour, the average of six readings is available which reduces the error to about 0.2%. All of these values are mote accurate than the most careful operator could obtain by direct reading of indicating instruments.

Using a base of one reading for each assigned operating parameter, every ten minutes gives a total of 144 readouts per 24 hour period. This type of sample gives a very complete and comprehensive record of transmitter operation, more so, than is possible by manual logging every 30 minutes.

The availability of 144 accurate meter readings per 24 hour day also makes possible statistical analysis of transmitter conditions with still greater precision and sometimes with interesting results. Fig. 7 shows a statistical plot of the distribution of readings of the calibrate voltage during early testing of the digital logger. This was done primarily to determine the accuracy of the system. This distribution plot however, showed two readings which were obvious errors and eight readings which were in two groups significantly outside the normal distribution curve. Consideration of the possible causes together with a study of the circuit and a comparison with similar data for plate voltage gave the impression that the relay contacts associated with this function must be out of adjustment, or otherwise defective. Inspection proved this to be true. Fig. 8 shows the statistical plot made after corrective measures were taken.

It has been found that in some cases a statistical plot of logged data over a period as brief as one day will provide an indication of abnormal operation. A plot of frequency on a probability basis shortly after initial installation of the system gave a lop-sided curve which suggested trouble. Changing to the emergency crystal at the transmitter produced a curve with a maximum at a slightly different frequency but generally of the same improbable shape. Two weeks later, the frequency monitor failed due to a rosin joint in the d.c. metering circuit.

A constant check is kept on the system stability and reading accuracy by means of the calibrate voltage illustrated here graphically. The AM calibrate voltage is the first reading taken on the remote AM log tape. The calibrate battery (4.2 volt mercury battery mallory TR-133) provides a constant voltage source that is sampled at the start of each

logging scan. This reading is sampled in the same manner and follows the same path from the AM transmitter to the remote logger tape as all other readings except AM frequency. The constant sampling of this calibrate voltage provides a means of checking sampling, telemetry, denormalizing voltage dividers, and digital voltmeter stability and reading accuracy. Deviations of less than 0.5% for 90% of these readings over a 24 hour period are usually achieved.

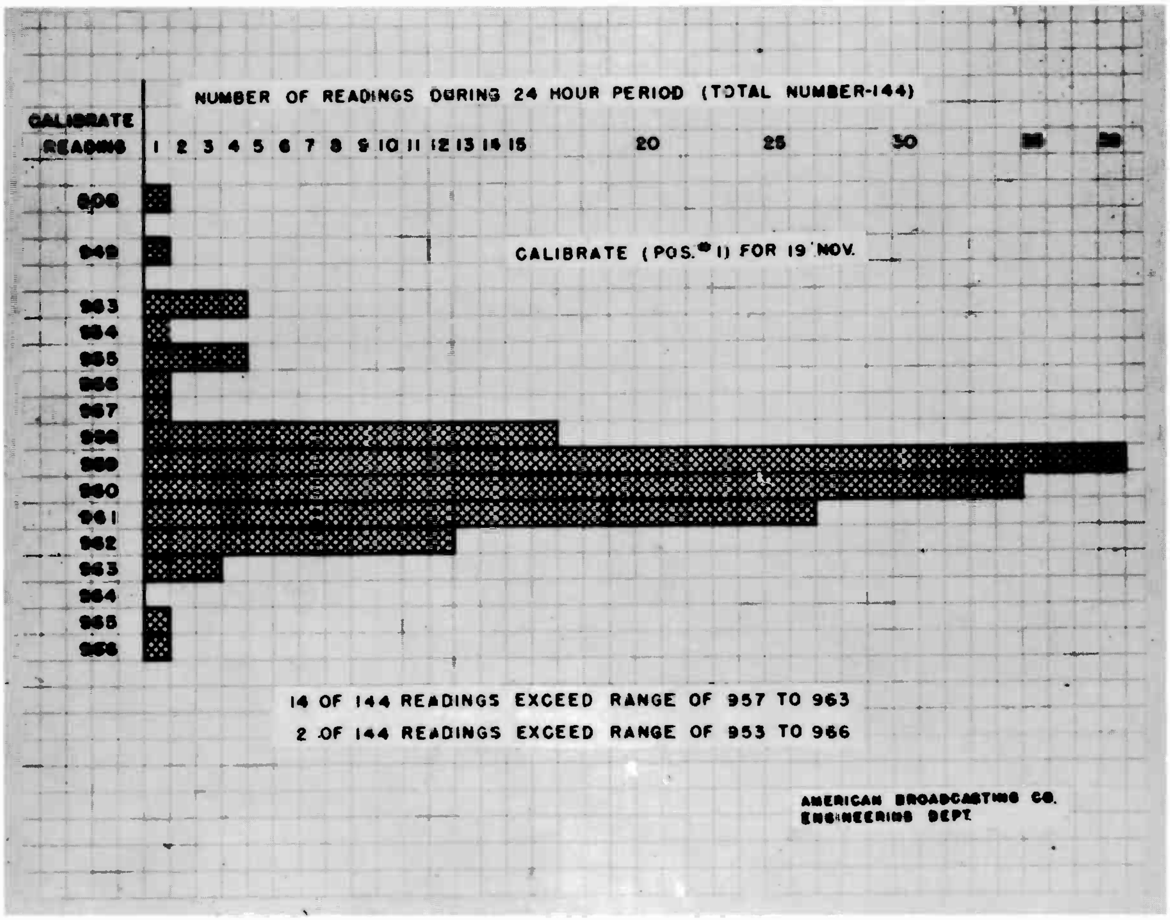
Fig. 9 shows the most recent addition to the automatic control system at KQV. This is the new remote controlled Vitro Phase Monitor by means of which the 5 tower directional array is monitored for phase and current ratios. The readout of sampling current amplitudes is normallized to provide a direct indication of current ratio relative to the reference tower. Phase is readout directly in degrees relative to the reference tower. The monitor is arranged to function conveniently with a digital voltmeter which facilitates its use with the rest of the control and telemetry system and also permits the convenient use of a digital voltmeter near the phaser controls to facilitate adjustment of the array.

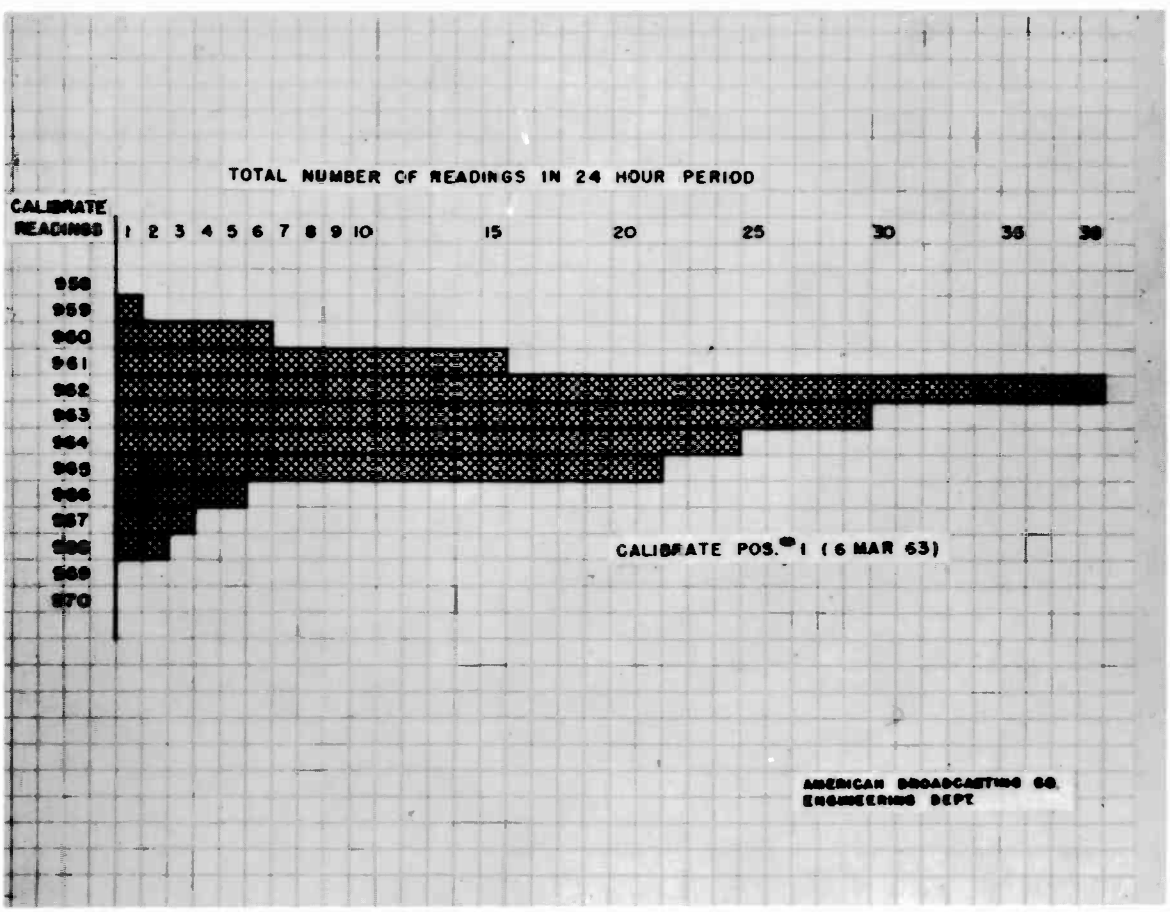
Separate internal compensating circuits are provided in the monitor to provide correct response with shift of pattern between day and night operation. This function is interlocked with and controlled by the automatic day/night pattern change.

It is believed the accuracy and reliability of this new remotely controlled monitor in conjunction with the system of telemetry and control herein described, may be such as to eventually cause favorable consideration to be given to some reduction of the present requirements for attended checking of the array at times of sine on or pattern change.

It is believed possible that with increased availability of means of processing data and with better understanding of the significance of deviations from normal parameters in transmitter performance as recorded by devices such as have been described, that preventive maintenance can be made more effective. This is not to suggest that transmitter maintenance can also be automated in this system but it may well be possible by statistical analysis to detect deterioration on a ground system or loss of emission in power tubes and have such facts clearly indicated in advance of the need for corrective action by a program of automatic data processing.

As with any project of this magnitude, many people are involved. Special recognition is given to Mr. William Gilmore, Paul Rickdeschel, and Russel Harbaugh of the ABC Engineering Department, whose work has contributed immensly to the success of this project.


NUMBER OF READINGS DURING 24 HOUR PERIOD (TOTAL NUMBER-144)
CALIBRATE READING
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 20 25 30
CALIBRATE (POS. # 1) FOR 19 NOV.
953
957
960
961
962
963
14 OF 144 READINGS EXCEED RANGE OF 957 TO 963
2 OF 144 READINGS EXCEED RANGE OF 953 TO 966
AMERICAN BROADCASTING CO.
ENGINEERING DEPT.


TOTAL NUMBER OF READINGS IN 24 HOUR PERIOD
CALIBRATE READINGS
1 2 3 4 5 6 7 8 9 10 15 20 25 30
958
959
960
961
962
963
964
965
967
970
CALIBRATE POS. # 1 (6 MAR 63)
AMERICAN BROADCASTING CO.
ENGINEERING DEPT.

GATES
ENGINEERING
REPORT

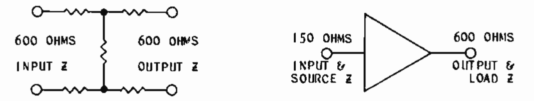
UNITS OF MEASUREMENT IN EQUIPMENT PERFORMANCE

HARRIS
INTERTYPE
CORPORATION

GATES

UNITS OF MEASUREMENT IN EQUIPMENT PERFORMANCE

The Broadcasting Industry employs many technical terms in papers, reports, brochures, text books, conversation and other communications to accurately convey information about components, circuits, equipments and systems. Although the definition of most of these terms may be found in various publications, the exact interpretation and application may differ sufficiently in current usage to cause considerable confusion. Ironically, many of the most commonly used terms or units of measurement are those with the most interpretations. An explanation of some of the units of measurement in equipment performance may be helpful for those engaged in specifying new equipments and/or systems design.



TYPICAL MATCHING ATTENUATOR	TYPICAL MICROPHONE PREAMPLIFIER
VOLTAGE RATIO: 100:1	VOLTAGE RATIO: 1:200
CURRENT RATIO: 100:1	CURRENT RATIO: 1: 50
POWER RATIO: 10000:1	POWER RATIO: 1:10000
ATTENUATOR LOSS: 40 db	AMPLIFIER GAIN: 40 db

THE DECIBEL, ABBREVIATED db, IS A UNIT USED TO EXPRESS THE RATIO BETWEEN TWO AMOUNTS OF POWER (P_2 AND P_1) EXISTING AT TWO POINTS:

NUMBER OF db = $10 \log_{10} P_2/P_1$ FOR POWER RATIOS.

WHEN THE POINTS OF MEASUREMENT ARE OF IDENTICAL IMPEDANCE ONLY:

NUMBER OF db = $20 \log_{10} E_2/E_1$ FOR VOLTAGE RATIOS.

NUMBER OF db = $20 \log_{10} I_2/I_1$ FOR CURRENT RATIOS.

VOLTAGE, CURRENT AND POWER RATIOS

FIGURE 1

GAIN is considered to be the power gain of the equipment or system at 1 KHz, unless otherwise qualified. Two common ratings are the maximum gain, where all attenuators are set for minimum attenuation; and the normal operating gain, where all attenuators are set in their optimum operating position. With two or more attenuators in series in a system, the optimum operating range of each of them must be established and followed for the best results over the dynamic range of the system.

DECIBEL - Gain is normally expressed in db as the ratio of the input power to the output power of the equipment or system. A power ratio of 2 gives 3 db power gain, of 4 gives 6 db power gain, of 10 gives 10 db of power gain, etc. The impedance of the two points compared is relatively unimportant for a measurement of power gain, if the readings are converted to a common base such as RMS power, peak power, etc.

Since many power gain measurements are actually conversions from voltage measurements, considerable chance for error or misinterpretation exists. Voltage gain may be obtained from passive components such as step-up transformers - where the power gain would be less than unity, due to circuit losses. Conversely, power gain may be obtained from active circuits such as emitter-followers - where, due to inherent characteristics, the voltage gain would be less than unity. Thus, the power gain is directly related to voltage gain only when the impedances of the points of comparison are equal. Then, a voltage ratio of 2 will give a power gain of 6 db, of 4 will give a power gain of 12 db, of 10 will give a power gain of 20 db, etc.

The term "db voltage gain" is sometimes used to specify the voltage ratio of two points of unequal impedance. It would be more correct to use "the voltage equivalent of (blank) db gain" instead. Thus, "the voltage equivalent of 20 db (power) gain" would specify that there was a voltage ratio of 10 times between two points of presumably unequal impedance.

DBM - A basic tool of the Broadcast Industry is the term dbm, which has a specific base of reference of 0 dbm for one milliwatt across 600 ohms impedance. It can be applied only to recurrent or periodic waves of a sinusoidal nature, to make it a truly universal reference level. It can be measured on any accurate RMS voltmeter and/or a properly calibrated volume indicator (meter plus attenuator). Impedance transformations or conversions allow the use of dbm on impedances other than 600 ohms, as long as there is a direct power ratio between the points of measurement.

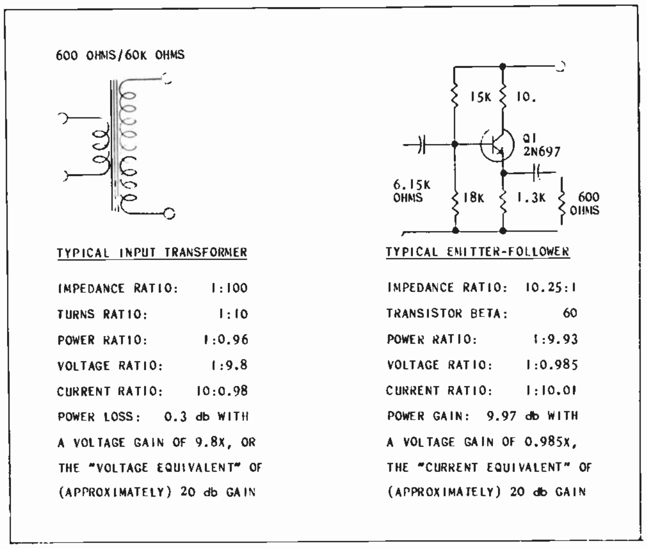


FIGURE 2

The term dbm is particularly useful in specifying the absolute level or capability of any point in a system - such as the threshold of noise, threshold of limiting, maximum input or output level, etc. Properly interpreted, it will give the experienced engineer an excellent indication of the potential behavior of a system or equipment under complex wave conditions over the extreme dynamic range of programming.

VU - Although the volume unit has the same specific base of reference as dbm - 0 vu for one milliwatt across 600 ohms impedance - this is the end of the relationship. While the term dbm can be applied only to recurrent or periodic sinusoidal waves, the term vu can be applied only to nonrecurrent or nonperiodic waves of a complex nature, such as found in speech and music. ASA C16.5-1954, paragraph 3.9 defines: "The reading is determined by the greatest deflections occurring in a period of about a minute for program waves, or a shorter period (e.g., 5 to 10 seconds) for message telephone speech waves, excluding not more than one or two occasional deflections of unusual amplitude."

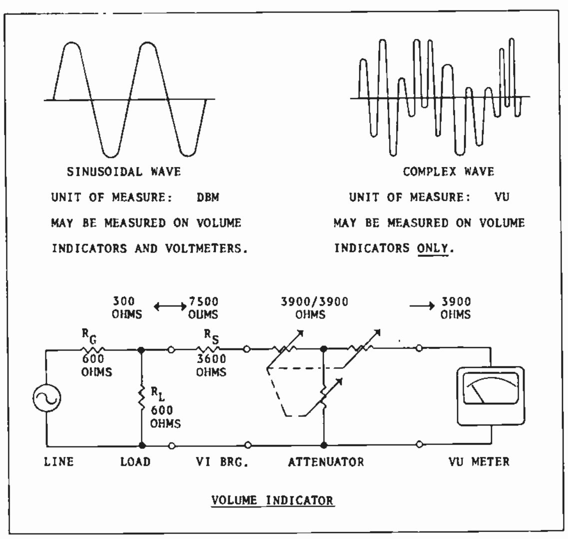


FIGURE 3

The ballistic characteristic or dynamic behavior of a volume indicator under prescribed conditions is clearly defined by the referenced ASA Standard. A volume indicator meeting these standards will give uniform readings for many types of programming. It can, however, give greatly different readings for two dissimilar complex waves with the same peak amplitudes. Thus, the level in vu may be determined more by the volume indicator characteristics than the peak amplitude of the signal being measured. This can be readily observed by comparing the volume indicator readings with an oscilloscope display with different types of programming.

HEAD ROOM - All amplifiers and components in audio systems should have a peak power rating considerably greater than the normal operating power level, in order to prevent serious distortion on complex programming peaks. The ratio of these complex wave peaks to the volume indicator reading is much more than the peak to RMS power ratio of a sinusoidal wave (which is 2:1 or 3 db). The peak factor of a complex wave is generally considered to range up to 10 db with much of the pre-recorded material - where pre-processing has reduced excessive peaks. This peak factor can range up to 20 db or more with certain microphone techniques on some "live" material.

Preamplifiers employed before the first fader in a system must be able to handle this excessive head room, plus exceedingly high levels in dynamic range. Thus, microphone preamplifiers with a maximum input level capability of −17 dbm and output capability of +25 dbm can be fully utilized in today's broadcasting and recording.

There is some preference among systems engineers to label systems block diagrams with the normal complex wave levels in vu - expecting the equipment manufacturer to know the anticipated peak factor, and to provide sufficient head room. It may be better to specify the normal levels and maximum levels in dbm (since most testing is performed with sinusoidal waves), to specify the amount of head room desired.

The standard telephone line feed of +8 vu is generally considered to require a line amplifier with an output capability of +24 dbm; which is reduced to +18 dbm by the 6 db line isolation pad. Although there is no actual relation between +8 vu and +18 dbm (since vu applies to complex and dbm to sinusoidal waves only), the head room is considered to be 10 db. For systems anticipating an appreciable amount of "live" programming, it would be better to consider line amplifiers with a higher output capability.

Some systems are using line amplifiers with +32 dbm output capability. This is reduced to +26 dbm by the 6 db isolation pad, for a program peak factor or head room of 18 db. Program peaks of greater amplitude are nearly always narrow "spikes" that can be clipped off in the amplifiers without any discernible degradation - since they will cause no base line shift, etc., in a properly designed amplifier.

INPUT IMPEDANCE is a term that is frequently confused with source impedance, but the two are distinctly different. Input impedance refers to the loading that the input of an amplifier, or a passive circuit such as a filter, will place across a signal source. Many amplifiers, such as microphone preamplifiers, have an input impedance of 10 times or more than their rated source impedance.

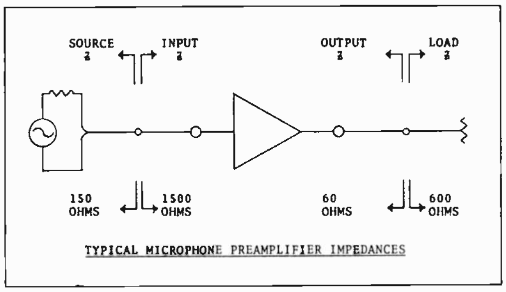


FIGURE 4

SOURCE IMPEDANCE refers to the impedance of the signal source at the point under consideration. When feeding an amplifier a test signal from an oscillator/attenuator panel - the output of the oscillator/attenuator unit would present a certain source impedance to the input of the amplifier. The output of a console mixing bus will present a constant source impedance to the input of the booster or line amplifier.

OUTPUT IMPEDANCE is often confused with the load impedance of a device, especially with an amplifier. A more descriptive term is "reflected output impedance" - the output impedance is determined by the internal impedance of the output section of the device being described. Amplifiers with negative voltage feedback from the output stages normally have an output impedance that is a fraction of the rated load impedance - generally one tenth or less.

The output impedance of a device is an important consideration in systems design. Attenuators and most passive networks have an output impedance that approximates their load impedance. They generally exhibit a difference of twice voltage or "the voltage equivalent of 6 db" on the output between the unloaded and loaded conditions. They are sensitive to bridging loads. For example, when the 7500 ohm bridging impedance of a standard volume indicator is switched across a circuit with 600 ohms output impedance, terminated with a 600 ohm load, the loading effect is approximately 0.4 db. However, if the volume indicator is switched across the output of an amplifier with an output impedance that is 1/10th the rated load impedance of 600 ohms, the loading effect is almost imperceptible.

LOAD IMPEDANCE is the proper term to use to specify the terminating impedance of an equipment whether it is an active or passive device. The load impedance of an amplifier is the impedance that should be placed across the output terminals to obtain its rated characteristics. In systems employing the input of amplifiers, or other devices with an input impedance that is higher than the source impedance (as loads for preceding circuitry), it is common practice to parallel the amplifier input with a resistor that will give a parallel combination that equals the desired impedance. Some components do not require termination or should not be terminated with their rated impedance. Thus, the input of most microphone preamplifiers present a bridging impedance to the output of the microphone - taking advantage of the double voltage output of the unloaded microphone, for approximately 6 db better signal-to-noise ratio.

OUTPUT TO INPUT ISOLATION is an important consideration where the output of an amplifier feeds a combining pad or network where different signals are mixed. In order to keep the signal pure on the input of the amplifier, it is necessary to have a high ratio of output to input isolation. Transistor amplifiers generally have lower isolation than tube amplifiers, especially those with negative feedback to the base of the first stage.

CONSTANT INPUT VERSUS CONSTANT OUTPUT LEVEL - This has been the subject of many an argument between customer inspectors and suppliers, etc., and an area that is seldom defined. Should the input level be held constant at the various frequencies under test, or should the output level be held constant? Of course, on many "hi-fi amplifiers" this is no problem, as they are rated "flat" from 3 Hz to 150 KHz or higher.

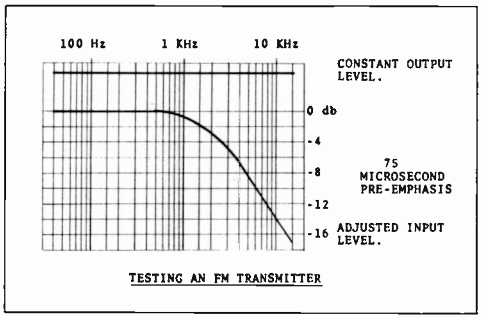


FIGURE 5

Unless otherwise qualified, it is good engineering practice to test harmonic distortion with a constant output level - in order to determine if the maximum output can be obtained at all signal frequencies. This is especially true with units, such as FM Transmitters, that have appreciable preemphasis networks incorporated in them.

If the unit under test is kept below the overload point, there is little difference between using constant input or constant output level in testing frequency response. The decision is generally subject to the flexibility of the source and load measuring equipment. With some it is easier to read input level adjustments. With others it is the opposite. A rather common practice with audio equipment is to test the frequency response with a constant input at the normal operating level; and to test the harmonic distortion with a constant output level at the maximum capability.

HARMONIC DISTORTION is too often shortened to "distortion" although this is certainly not the only kind of distortion encountered in broadcasting. When the reference does not qualify the type of distortion, it is generally considered to be harmonic distortion. It occurs because of circuit non-linearities that create harmonically related signals in the output which were not present in the input of the equipment or system. Single tone testing with the fundamental tone nulled out allows direct reading of the sum of the harmonics on distortion tests.

IM DISTORTION is an accepted abbreviation for intermodulation distortion, created by mixing of two or more signals due to circuit non-linearities. The most pronounced products of IM distortion are the sum and difference frequencies of the fundamental frequencies. Two tone testing with a 4:1 ratio of tone amplitudes yields a commonly accepted measurement.

FREQUENCY DISTORTION is a term sometimes used to signify that the frequency response is other than "flat", or that it fails to faithfully follow some prescribed pre-emphasis or de-emphasis. Where it is used in lieu of the term frequency response; the upper and lower frequency limits, as well as the maximum deviation, should be specified.

SIGNAL PLUS NOISE TO NOISE RATIO, abbreviated S+N/N, is the noise measurement most frequently taken on an equipment or system, although it is often converted to one of the other noise measurement terms. In broadcast equipment, where the ratio of S+N/N is generally higher than 40 db, just the term signal-to-noise ratio is commonly used and is abbreviated S/N. It is normally measured down from a referenced dbm output level.

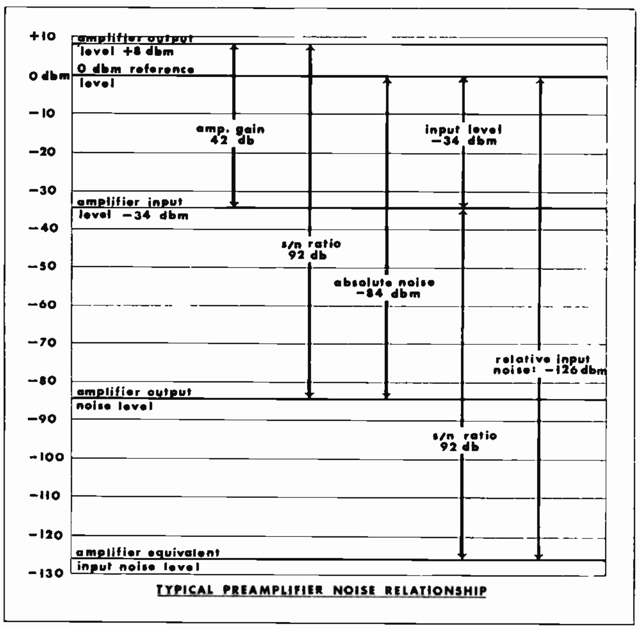


FIGURE 6

ABSOLUTE NOISE is the noise level in an equipment that is referred to 0 dbm. With an amplifier having 42 db gain (measured with an input level of -34 dbm and an output level of +8 dbm) the noise is found to be 92 db below the +8 dbm output reference. The same amplifier would yield a noise measurement of 84 db below a -42 dbm input and 0 dbm output level- which is the absolute noise level. Or, the absolute noise can be derived by subtracting the output above 0 dbm (8 db) from the 92 db measured below the +8 dbm output reference for a figure of -84 dbm.

RELATIVE INPUT NOISE, also referred to as equivalent input noise, is conveniently found by adding the input level of the equipment under test to the S/N measured on the output. Thus, the amplifier with -34 dbm input level and a signal-to-noise of 92 db can be converted by adding the two figures to obtain a relative input noise figure of -126 dbm. This term is particularly useful in a complex system to calculate the S/N at each critical point (generally at the amplifier input terminals). As long as the rated relative input noise of the amplifier allows a S/N of 8 to 10 db better than the S/N of the incoming signal, no noise degradation results in most systems.

WIDE BAND NOISE VERSUS WEIGHTED NOISE - Wide band noise, usually given as "noise", is normally considered to be that band between approximately 5 Hz and 50 KHz which is essentially flat in a modern noise analyzer unit. Both frequency limits greatly exceed the accepted limits of human hearing – which many rate from 30 Hz to 15 KHz maximum. Studies of the sensitivity of the human ear over the past several decades agree that the upper and lower regions of the audible spectrum are considerably attenuated, compared to the 2500 Hz region.. Thus, many noise measurements are more meaningful with a weighting curve that will partially compensate for the non-linearity of sensitivity versus frequency of the human ear. In some instances this curve may be derived from a high-pass and low-pass filter to restrict the limits to a more narrow band. Or, it may be obtained by partially attenuating certain sections of the frequency band compared to those considered more sensitive.

CROSSTALK is the result of signal (s) being fed into adjacent channels by capacitive, inductive and/or resistive coupling. Just as any plant in the wrong spot is considered to be a weed- crosstalk may be considered a form of noise. Since crosstalk is generally a very low level signal - and the human ear is very much more sensitive to mid-range frequencies than those in the upper or lower portion of the audio spectrum - mid-range crosstalk is the critical area. An acceptable level is 15 db below noise (as measured with an oscilloscope or narrow band-pass filter) in the mid-range; with no more than 10 db above the noise level in the upper and lower parts of the audio spectrum.

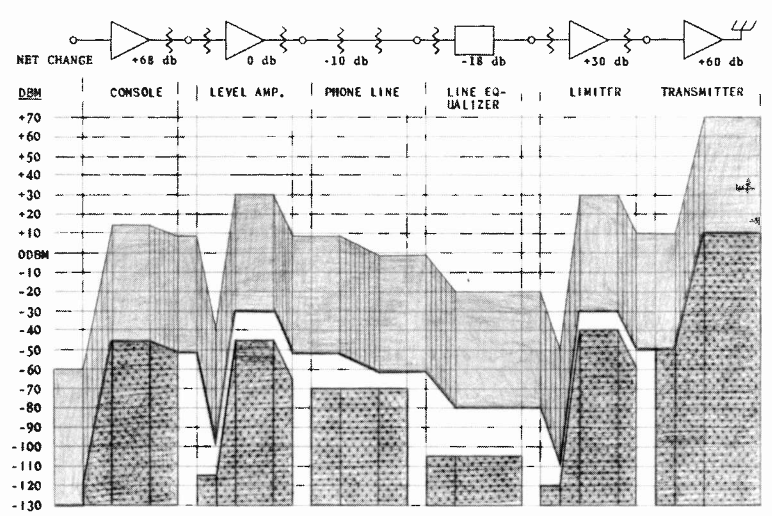
RF NOISE is defined as the noise due to regeneration in a system employing some RF components, where some of the output signal is induced into some section of the system (generally the input section). Considerable regeneration is possible before the point of instability (where oscillation occurs) is reached. In most cases, RF noise resembles shot or tube noise as it does not exhibit any particular tone. In a station proof-of-performance the difference in RF noise level can be quite large when feeding the antenna system, compared to that obtained when feeding a dummy load.

TRANSIENT NOISE is that noise generally fed into the equipment from the power lines or the grounding system. It is often the result of power systems with high impedance or with insufficient regulation. The tower flasher will frequently show strongly in the noise measurements of the transmitter, where the switching transient will be emphasized in all of the equipment in the circuit- including the test equipment.

FM AND AM NOISE in FM Broadcast Transmitters are specified by the FCC. FM noise is a measurement resulting from a shift in carrier frequency, due to any cause. It is normally measured from a reference of 100% FM modulation with 400 Hz - which is considered to be ±75 KHz carrier swing. AM noise on an FM Transmitter is calculated below an equivalent level of 100% AM modulation of the FM carrier: The carrier level is rectified and measured as a D.C. level at the test point - multiplied by 1.414 to give the equivalent RMS level if the carrier were 100% AM modulated - and the AM noise measured and compared to this simulated level.

TYPICAL SYSTEM - Figure 7 shows a typical system in a broadcasting station with the associated signal levels and the corresponding noise levels. The system is all inclusive from the microphone input to antenna output. The upper shaded area represents the signal range, the lower textured area shows the noise level above −130 dbm, and the plain area in between shows the margin of noise between the relative input level of each equipment and the signal-to-noise established by the first unit in the system.

In a properly designed and operating system, the signal-to-noise is established in the first unit – generally the preamplifier, for a microphone input. Assume that the signal from the microphone is equivalent to −60 dbm, and that the signal generator is delivering this level into the microphone input of the console. The relative input noise of the console and its associated system is considered to be −120 dbm. Thus, the signal-to-noise ratio between the −60 dbm signal level and the equivalent input noise is 60 db. Even though the signal-to-noise of the booster and/or line amplifier is at least 10 db better than the pre-



TYPICAL BROADCASTING SYSTEM WITH ASSOCIATED SIGNAL AND NOISE LEVELS

FIGURE 7

amplifier, the original S/N cannot be materially improved in a linear system.

The -60 dbm signal is amplified to +14 dbm by the console, ahead of the 6 db line isolation pad - which reduces it to +8 dbm to feed the "average" level amplifier. The input of the level amplifier is reduced to -40 dbm to prevent distortion in the variable gain stage – then amplified to +30 dbm, the output threshold of compression - and attenuated to +8 dbm to feed into the studio/transmitter telephone line. The line is assigned a residual noise level of -70 dbm; thus, it will not degrade the S/N ratio of the original signal. This typical telephone line has a 10 db loss, delivering a signal level of -2 dbm into the line equalizer at the transmitter site. The equalizer has 18 db insertion loss, giving -20 dbm signal level on its output terminals. It has a residual noise level of -105 dbm, however, and does not degrade the S/N of the original signal either.

The input of a typical limiting amplifier has an attenuator to adjust the incoming signal to the threshold of limiting, generally around -50 dbm. The relative input noise of this point in the limiting amplifier is -120 dbm, which gives a S/N of 70 db to prevent degradation of the original signal. The output level of a typical limiter is +30 dbm, which is attenuated to the transmitter input level of +10 dbm. The S/N ratio of a typical AM transmitter is from 60 to 65 db. Assuming a S/N of 60 db, the transmitter noise will degrade the original signal-to-noise (of 60 db) by as much as 6 db if there is a significant number of coincident noise peaks. A transmitter with a S/N of 65 db would generally degrade the original 60 db S/N by approximately 1 db. A margin of 8 db between the S/N of the original signal or input equipment compared to the following equipments - is considered to be the minimum to prevent any degradation of the original S/N.

SUMMARY - This is essentially a summary of parts of many publications to start with and any further efforts would be redundant. Comments and criticism are invited, especially those with references to standard textbooks normally found in engineering libraries to permit further study. Also, if there is sufficient interest, the NAB may consider some committee action to set up standard ways and means to measure equipment and/or express terms that now have an appreciable degree of ambiguity. Please contact the proper NAB representative and/or the author to show interest in this area.

W. J. Kabrick
Advance Development Engineer
Gates Radio Company
Quincy, Illinois

HARRIS
INTERTYPE
CORPORATION

GATES

GATES RADIO COMPANY
A Subsidiary of
Harris-Intertype Corporation
QUINCY, ILLINOIS 62302

Offices: New York, Houston, Los Angeles, Washington, D. C.
Export: Rocke International Corporation, New York City
In Canada: Canadian Marconi Company, Montreal

DESIGN PHILOSOPHY OF OPERATIONAL AND SETUP FACILITIES IN TV CAMERAS

by

Norman L. Hobson

Manager - TV Camera Engineering
Broadcast & Communications Division
Radio Corporation of America
Camden, New Jersey

Presented at the 20th Annual Broadcast Engineering Conference
National Association of Broadcasters

Conrad Hilton Hotel
Chicago, Illinois
March 29, 1966

DESIGN PHILOSOPHY OF OPERATIONAL AND SETUP FACILITIES IN TV CAMERAS

The camera equipment of today must, of necessity, be more sophisticated in design than that of a decade ago in order to provide the television broadcaster with the high performance he desires. To achieve and maintain this improved performance level requires a greater degree of circuit complexity than previously existed in camera equipment. It is important that a high degree of stability be built into the equipment, and that a means be provided to readily determine whether the equipment is performing as previously adjusted.

With the television broadcasting industry presently expanding at a high rate, there is a shortage of experienced personnel to handle equipment setup and operation. New techniques were required which would enable less-skilled personnel to operate the new equipment effectively.

The foremost objective during the design is the technical performance of the equipment. Second, by a narrow margin, is the ease with which this performance can be established and maintained. This paper deals specifically with operational and setup facilities.

Operational Considerations:

1. Economy as well as greater consistency of picture performance will be attained if a camera video operator can control several cameras. Therefore, the operating control panels should be capable of being physically placed so that an operator can readily control several cameras.
2. The similarity of operating panels for monochrome or color, live or film, should be as great as possible to minimize operator confusion.

3. The operator should have immediately available only those controls which are required to adjust for normal scene variations or minor equipment discrepancies.
4. Adjustments for equipment variations should be kept to a minimum by incorporating stabilized circuitry wherever practical.
5. Where feasible, circuitry should be incorporated to permit the equipment to operate in an automatic mode under as wide a set of conditions as can reasonably be incorporated in the design.
6. Circuitry at the control position should be of the DC type to allow ready movement or delegation to other operating positions that might be at varied distances from the rack equipment, thus eliminating any timing adjustment for pulses or video.
7. A minimum of electronic equipment should be at the control position to ease the servicing problem if an emergency arises.
8. Where possible, rapid checks on the operation of portions, or all, of the video channel should be available on a pushbutton basis.

To illustrate the consolidation and simplification of the operating control position, the control panels will be briefly described. Figure 1 shows the primary control panel which is common to all new RCA cameras, monochrome or color, live or film. Only three adjustable controls are needed. Black Level and Sensitivity control knobs, which are the most frequently adjusted, are located at the bottom for greatest convenience in operation. The Black Level knob position establishes the level at which video is clipped and clamped to reference black. In live cameras the sensitivity knob controls the iris opening of the taking lens; for film cameras it controls the target voltage.

The White Level control provides a means of establishing the reference white level in a "gated Pulse" controlled a.g.c. amplifier that will maintain the output white level constant and independent of adjustment of the Black Level control. This control is intended to be supplemental and subordinate to the Sensitivity control.

The three switches located at the top left of the panel are alternate action, illuminated pushbutton types that select, where applicable, either manual or automatic modes of operation for black level, white level and sensitivity. The switch at the top right selects the video signal polarity. The negative polarity mode is used for negative monochrome film or for "special effects".

The switch in the second row labeled Cap, functions to put the camera in a standby or operate condition. The adjacent switch labeled Test causes test pulses to be inserted into the camera head at strategic points for test or setup purposes. The remaining switch, which is labeled Monitor, is available to use with an external video switcher which would select this camera output signal from among several to be displayed on an external monitor. This facilitates sharing a monitor among several camera chains.

For color cameras (either live or film), a supplementary control panel is added which is shown in Figure 2. The twelve knobs on the lower half of the panel are vernier adjustments in each of the chrominance channels for Horizontal Centering, Vertical Centering, White Balance and Black Balance. The ranges of control are purposely limited to avoid inadvertently introducing gross errors, but still permit a modest degree of "trimming" adjustment.

The Chroma control, a new facility for color cameras is located on the

right side beneath the Chroma pushbutton and permits the chrominance amplitude to be adjusted to the color saturation desired. In the color film camera, the Balance controls and the Chroma control may be adjusted to compensate for film deficiencies. The Chroma pushbutton switch selects either the normal full color mode of operation or a mode in which the subcarrier is absent during active picture time but the subcarrier burst remains.

In the upper left corner is a pushbutton switch labeled Bars. This switch selects either the normal operating mode or a mode where the signals from the pickup tubes are replaced by electrically generated color bar signals within the equipment. The color bar signals are very useful in setting up and subsequently checking the performance of the encoding circuits.

Immediately below the Bars switch is a switch labeled Mono that allows selecting the separate monochrome on the normal operating color output which would be of value in continuing a program in monochrome if a malfunction occurs in the color circuits.

The Monitor switch in the upper left area switches the picture monitor video between Mono (separate monochrome line output), NAM (non-additive mix black and white monitoring signals), BRGM (blue, red, green, and/or monochrome outputs as selected by the BRGM switches) and Color (color line output).

The CRO switch in the upper right area switches the waveform monitor video output between Mono, NAM, BRGM, and Color as described for the Monitor switch.

The B, R, G, and M Switches in the upper center area of the panel select the channel or combination of channels displayed when the Monitor and/or CRO switches are in the BRGM positions.

The basic control panel and the supplementary color panel can be attached to a frame which is 7 inches high and mounts in a standard 19-inch panel mounting space. This combination is shown in Figure 3.

Setup Considerations:

1. Effort should be applied to maximizing the interval of time between

setups utilizing all known techniques for obtaining stability. Practices well recognized by most engineers to achieve stability are:

(a) Use of precision low-temperature-drift components.

(b) Arrangement of circuitry to be self-compensating where possible.

(c) Use of negative temperature coefficient components where needed.

(d) Use of feedback where necessary to achieve adequate circuit stability.

2. Where practical, test circuitry should be built into the equipment to minimize test time.

3. Null or balancing techniques which do not require precision measuring devices should be utilized.

Examples of the new techniques used to ease the setup will be described.

One requirement for proper setup is to establish that the I and Q signals are in quadrature. This involves adjustment of the relative phase of the two signals to set the difference at exactly 90°. Phase measuring devices such as a vectorscope can be utilized but a simple, rapid, and highly accurate alternate method has been chosen for RCA color cameras. It involves only the matching of amplitudes of two signals that can be displayed simultaneously on a conventional waveform monitor. Figure 4 shows the modulated subcarrier waves of color bars for two conditions that are commutated into the one display. When the phase adjustment is proper, the two signals merge into one as shown in Figure 5.

To understand how the adjustment can so simply be made, refer to Figure 6. Assume that two sine waves A and B, which are shown vectorally in diagram (a), are approximately equal in amplitude and that their phase difference is approximately 90°. When added they will produce a new sine wave with amplitude R and phase ϕ.

If the polarity of signal B is reversed ($\theta' = \theta + 180°$) the resultant (R') assumes a new phase position and will change in direction as shown in diagram (b) unless $\theta = 90°$, in which case R = R'. Thus, if the phase between signals A and

B is adjusted to make R = R', the phase between them is 90°. When R and R' are within 1% of the same amplitude, the deviation of θ from 90° is less than 0.5°. Since only the matching of the signals is required, it is relatively simple to adjust the difference in the two amplitudes to less than 1%. A similar technique is used to adjust for proper phase of subcarrier burst relative to the chrominance information.

Monitoring the composite color signal to insure that color receivers and the color transmission channel will not be overloaded due to excessive level has been handled, in the past, generally by monitoring the blue, red, and green signals prior to encoding.

It is important to monitor these three signals since they represent the signals that the receiver grids would see after decoding. The presence of four components in the composite signal representing blue, red, and green chrominance information, plus the luminance information increases the problem of monitoring for optimum control. It is possible under certain signal conditions to have overload of the receiver even when the four channel signals do not show overload. Therefore, it is desirable that the simulated receiver signals are the ones used for monitoring. Further, in RCA color cameras, these signals are combined into the familiar single line or field display used for monochrome cameras by a non-additive mix technique called NAM that displays the highest instantaneous white going signal and the lowest instantaneous black going signal.

The composite signal level can then be adjusted to keep the upper and lower limits of this display within the proper reference levels. To better understand the NAM color waveform display, consider first the formation of the composite color bar signal waveform for 100% saturated color bars. Figure 7 illustrates the composition of the color bar signal by the presence of 100% amplitude signals in the green, red, and blue chrominance channels in all combinations of the three signals. The presence of all three signals at 100%

level results in an output that is white and at 100% level. As you can see, other combinations result in yellow, cyan, green, magenta, red, blue, and a black signal, which occurs in the absence of input to all three channels. While it may not be difficult to ascertain that this color bar signal is at the right level by observing the composite waveform, it becomes difficult to do so when the composition of the televised scene is a variable combination of color components.

Figure 8 shows also the three channel inputs that result in the conventional color bar pattern. If the composite signal which results from encoding were demodulated, the green, red, and blue waveforms shown would be recovered. If these waveforms are now applied to the NAM white level and black level detectors, the waveform at the bottom of the illustration will result. The instantaneous white level is unity from at least one of the channels all of the time except during the black bar. Also, the instantaneous black level from one or more of the signals is at zero level all of the time except during the white bar. Since these signals represent 100% saturation, the waveform displayed at the output of the non-additive mixer should never exceed the white level or black level limits as shown here. Thus a simple display is available to insure that the level of the composite color signal is optimum.

Still another technique has been developed to provide rapid setup and checking of the four video channels for gain, white balance and black balance. This technique employes precisely generated test pulses that can be inserted in the amplifier circuitry at appropriate points. Figure 9 shows the waveform of the two test pulses that are inserted at different points in the video channel. The pulse on the left is a signal generated with 0.7 volts amplitude. It is inserted at the output of each of the video channels in the camera. The second pulse, shown on the right is a calibrated pulse that is inserted at the input of the channel video amplifier to simulate a standard output level from

a pickup tube. This signal is used to make a photometric type of match of the two pulses as seen on a picture monitor display, such as the viewfinder pattern that is shown in Figure 10. The proper output level and video channel gain is correct when the two vertical bars match in brightness. The gain adjustment, which controls the amplitude of the pulse on the right, can be made with higher accuracy by turning down the brightness control so that only the tips of the pulses product light output. The pulse levels are the same when the two bars extinguish together as the brightness control is turned down further. The signal displayed in this figure is the one that is applied to the green channel.

A similar signal, which is shown in Figure 11, is applied to the monochrome channel. It, however, has an additional pulse which is set at .59 amplitude with respect to the other two. This pulse represents the luminance value for a green saturated signal. The adjustment for gain and level utilizes the two full amplitude pulses in the same manner as described for the green channel signal. The picture monitor display is shown in Figure 12. As before, the monitor display can be used for making the adjustment by making a photometric brightness match between the two vertical bars.

After having accomplished the foregoing two steps, black balance and white balance among the color channels can be established. Earlier in the discussion, the technique of non-additive mix display was discussed. By feeding the signals representing the R, G, B receiver signals into the non-additive mixer, a display, which appears in Figure 13, is visible on the picture monitor. As can be noted, both the white bar on the left and the white bar on the right appear to be segmented. This is because the non-additive mix circuit switches rapidly between the NAM white and the NAM black signals. Without going into a detailed description of the circuit action involved, which is beyond the scope of this paper, it is sufficient to say that the black level controls can be adjusted until the vertical bar at the left appears uniformly

white. When this is accomplished, there is a balance of black level in all channels. This condition is shown in Figure 14. It can be observed here that the bar on the right still contains segments of different brightness. By adjusting the white level controls so that this bar becomes uniformly bright, a balance is reached for white levels for all channels, as shown in Figure 15.

When the system is properly set up with test pulses being present in all channels, the color output waveform of the camera chain is shown in Figure 16. The pulses on the left and the right are present in all channels, therefore, they represent a white signal and thus no subcarrier is present on them. The center pulse represents a full amplitude signal in the green channel, thus the subcarrier is present as shown. When this signal is monitored at the output of the non-additive mix circuit, the waveform in Figure 17 is observed. In this case, the green pulse now appears as essentially a 100% level pulse, since the signal as shown in the Figure 16 has been demodulated.

Other advancements that have been made to simplify the setup of the equipment are:

The requirement for horizontal and vertical drive pulses has been eliminated thereby reducing the auxiliary equipment and associated setup time.

An automatic pulse advance system is used which eliminates the need for any adjustment as camera cable length is changed. In addition, this system encloses the delay associated with the encoding function in color cameras. By so doing, the timing of color and monochrome signals is the same, which eliminates the need for delaying pulses to monochrome cameras as is presently done.

Refinements have been made in power supply design, which eliminate any need for adjustment to compensate for line voltage or cable length, thus eliminating any missetting of controls.

A few of the many techniques which are representative of the new philsophy of design of RCA television cameras have been described. Field acceptance of these advances designed to ease the operation and setup of television cameras has been most encouraging.

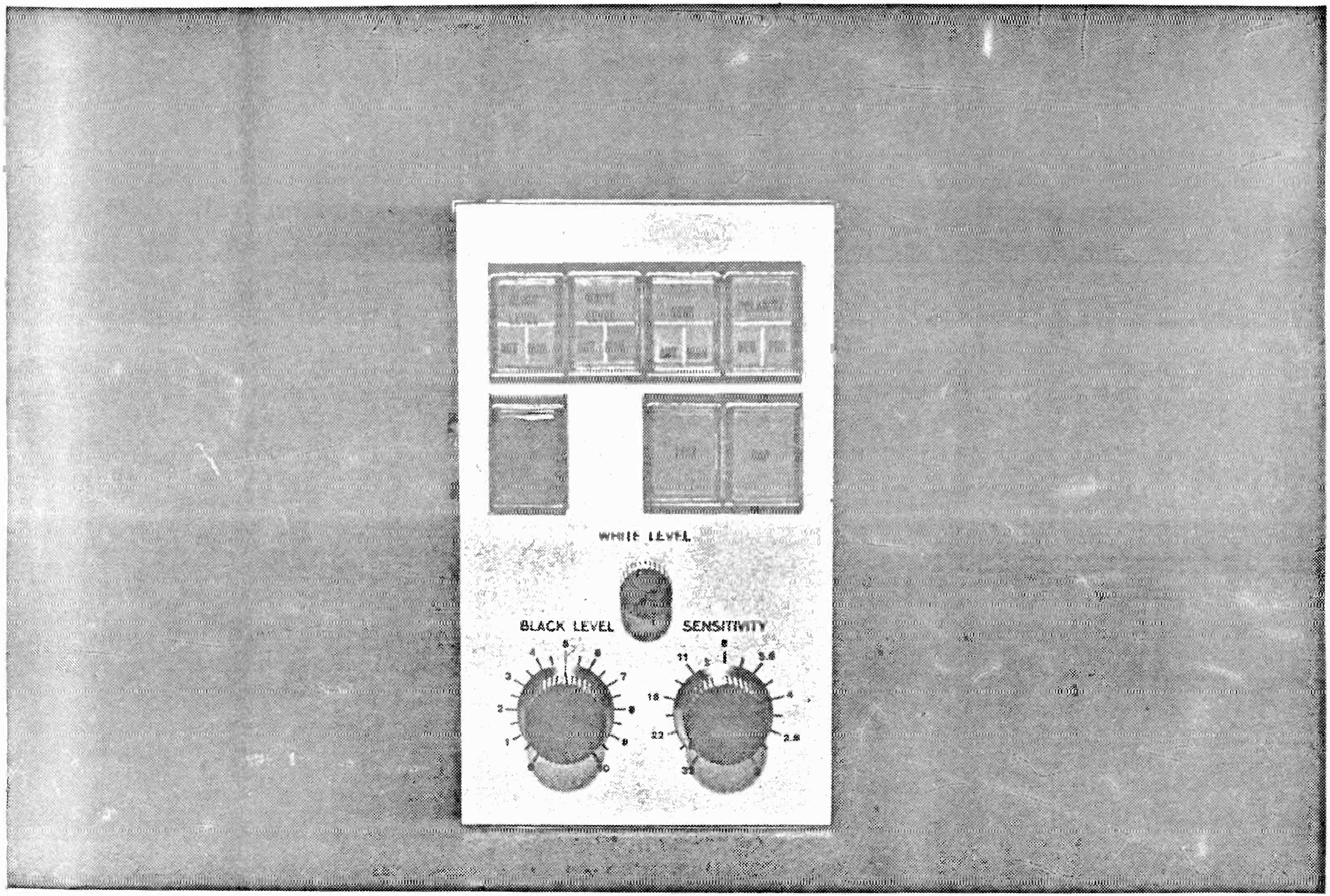


Figure 1.

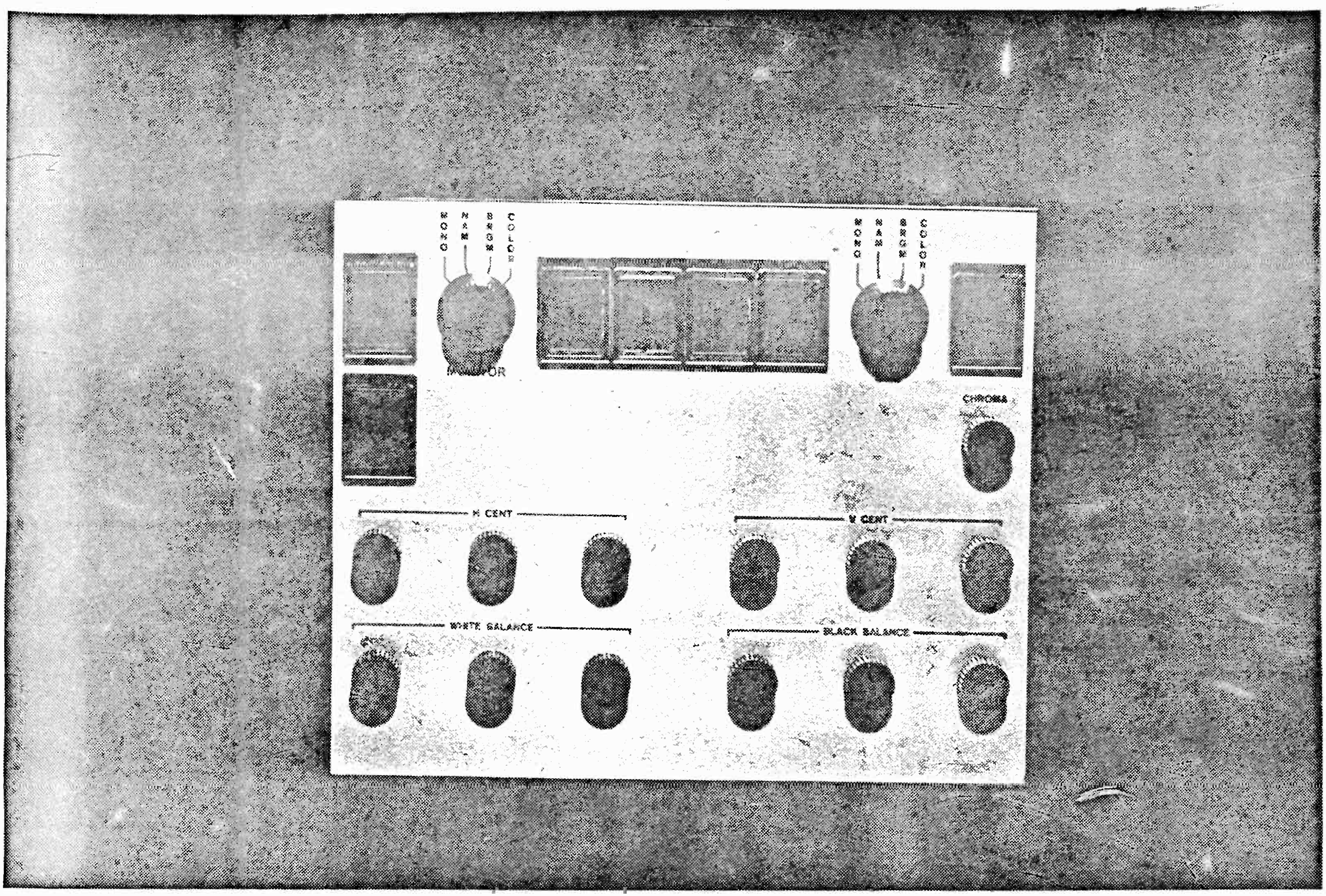

MONO
NAM
BRGM
COLOR
MONO
NAM
BRGM
COLOR
CHROMA
H CENT
V CENT
WHITE BALANCE
BLACK BALANCE

Figure 2.

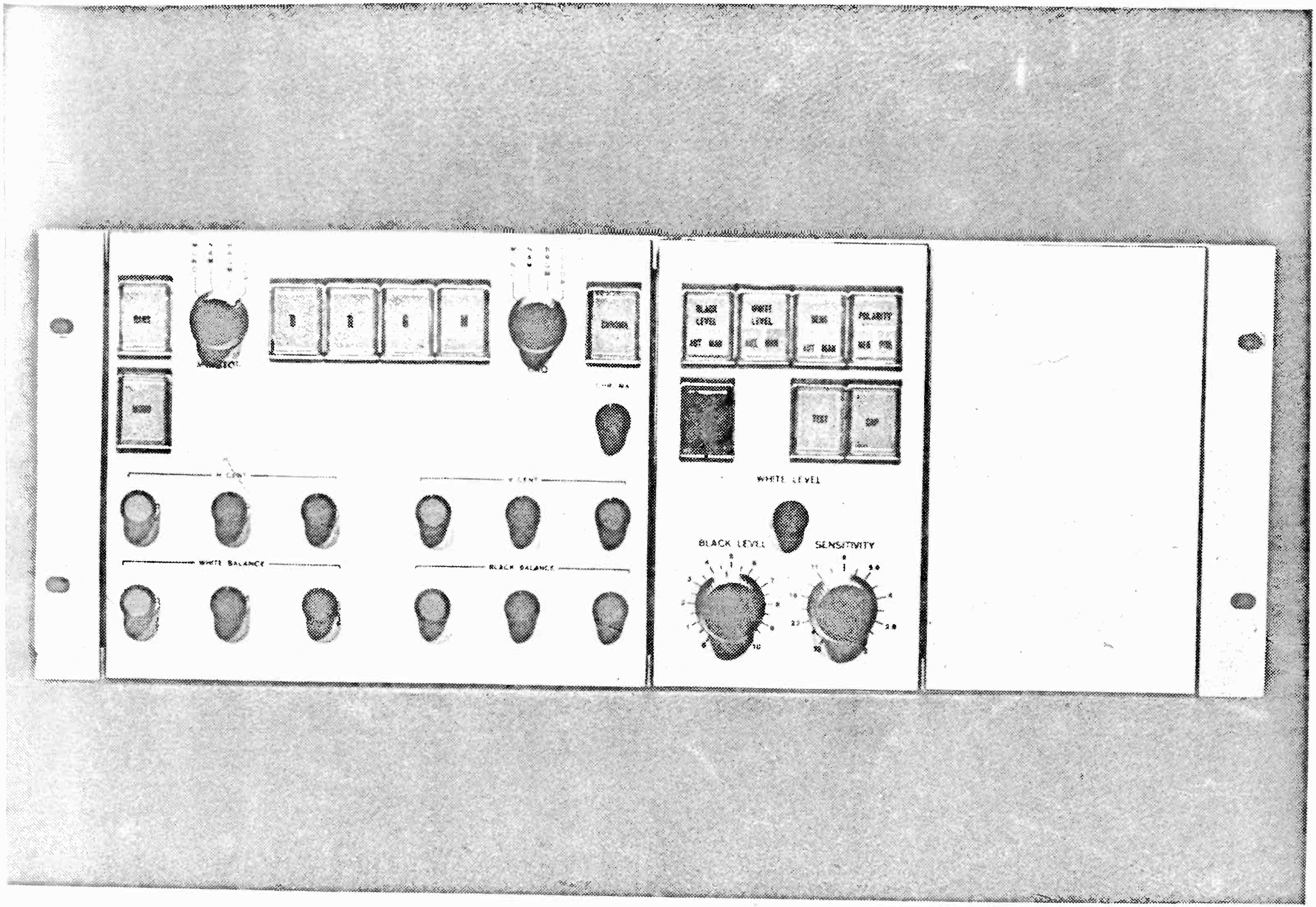

BLACK LEVEL
WHITE LEVEL
POLARITY
TEST
WHITE LEVEL
BLACK LEVEL
SENSITIVITY
WHITE BALANCE
BLACK BALANCE

Figure 3.

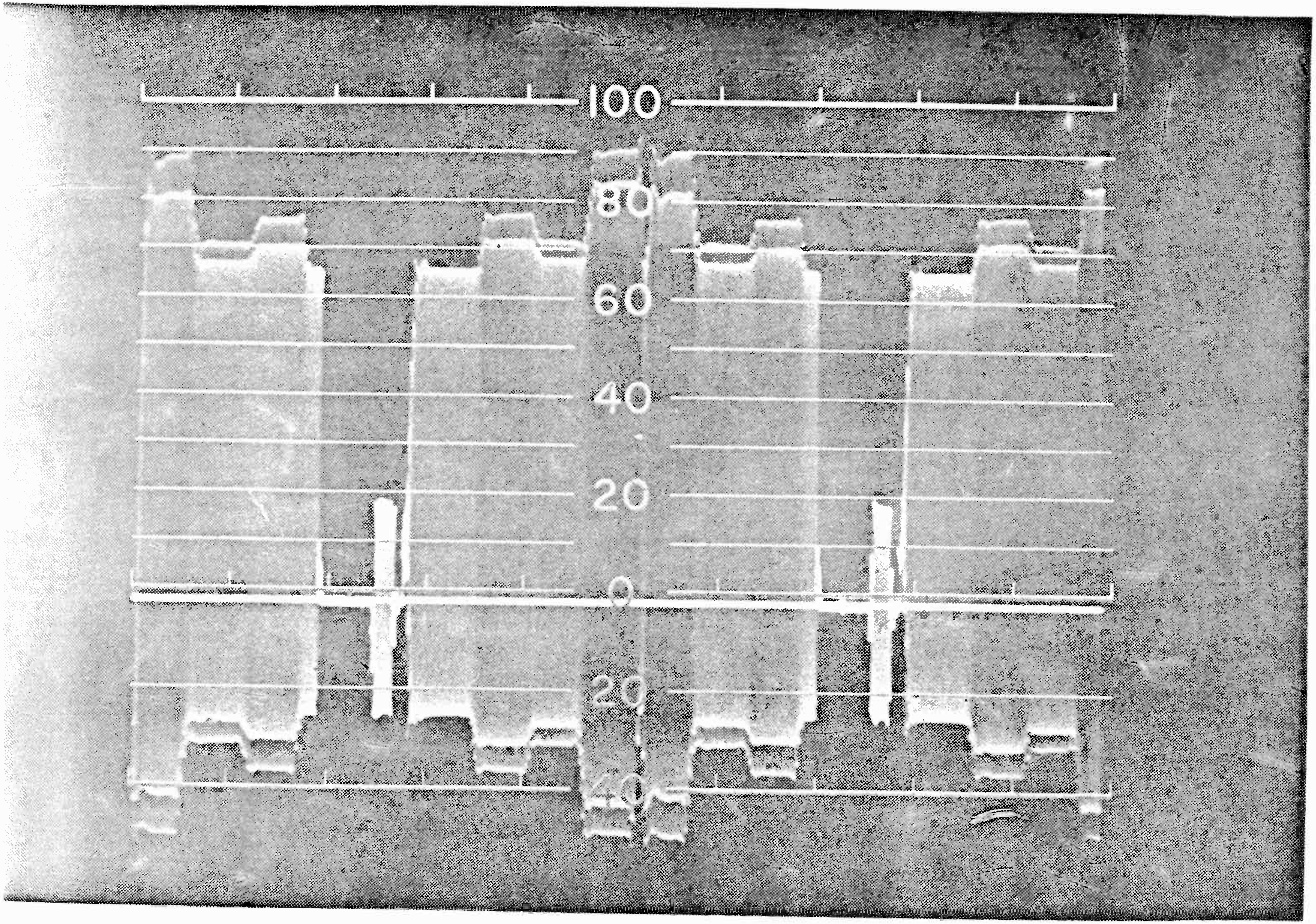


Figure 4

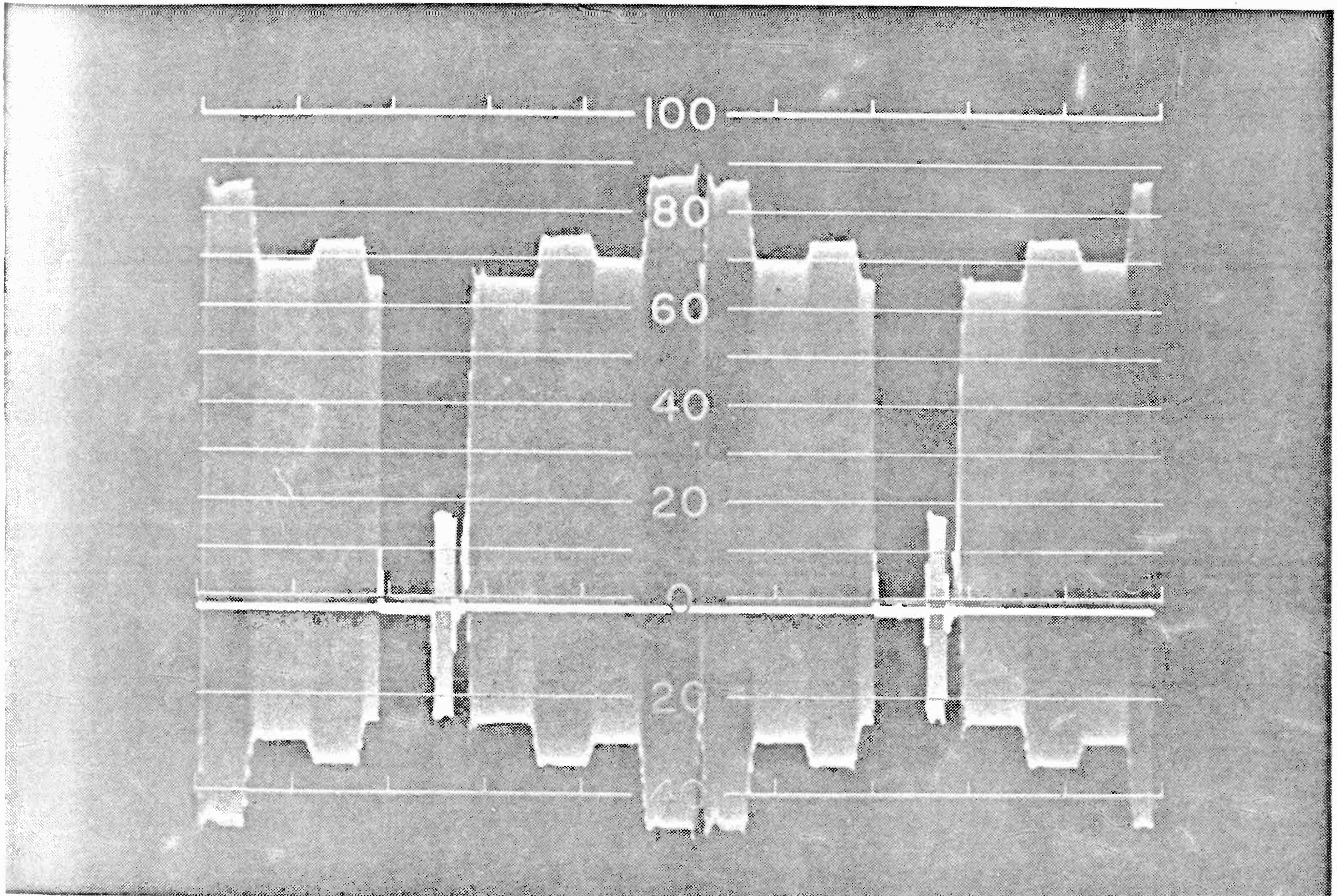
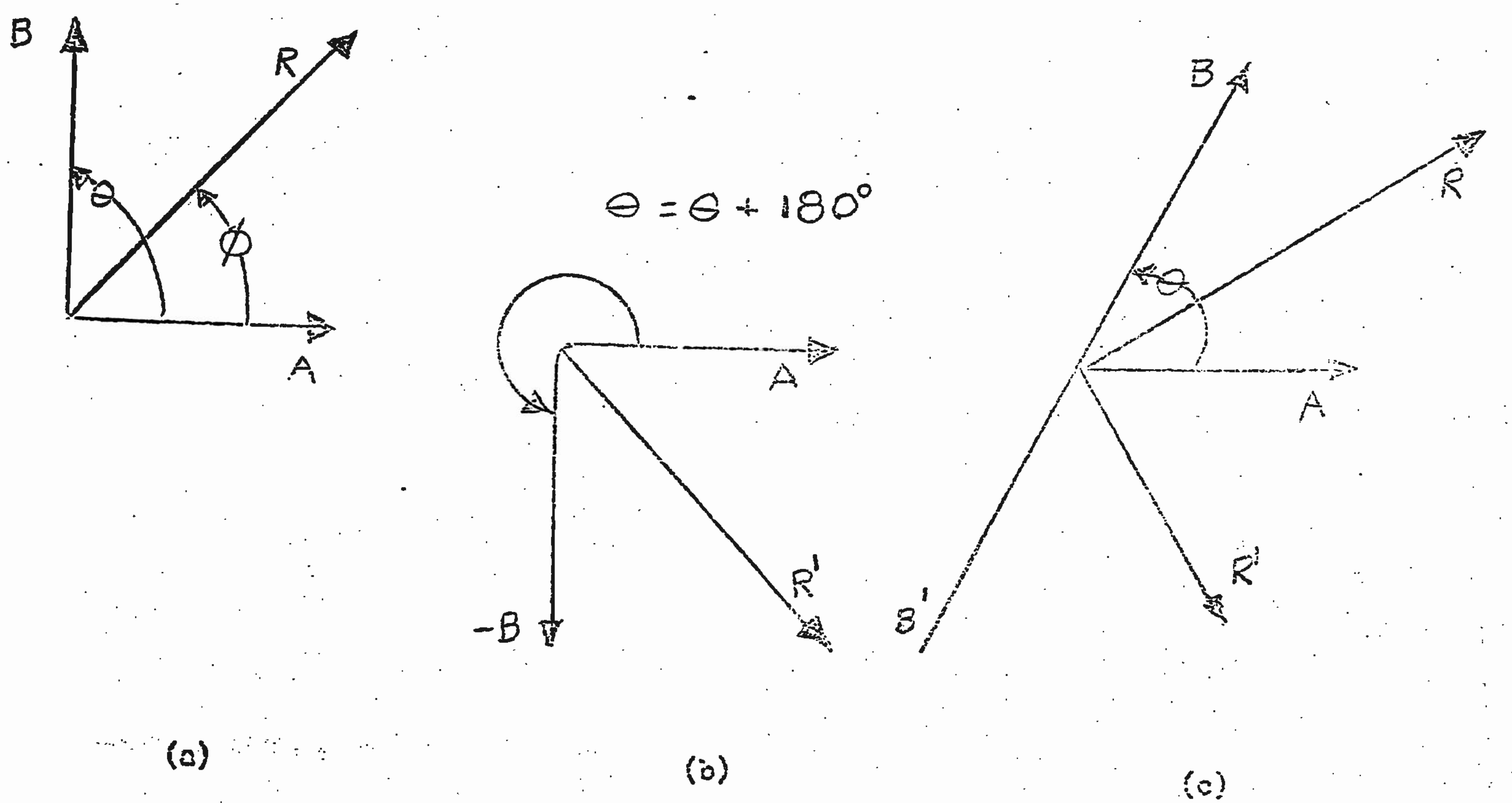
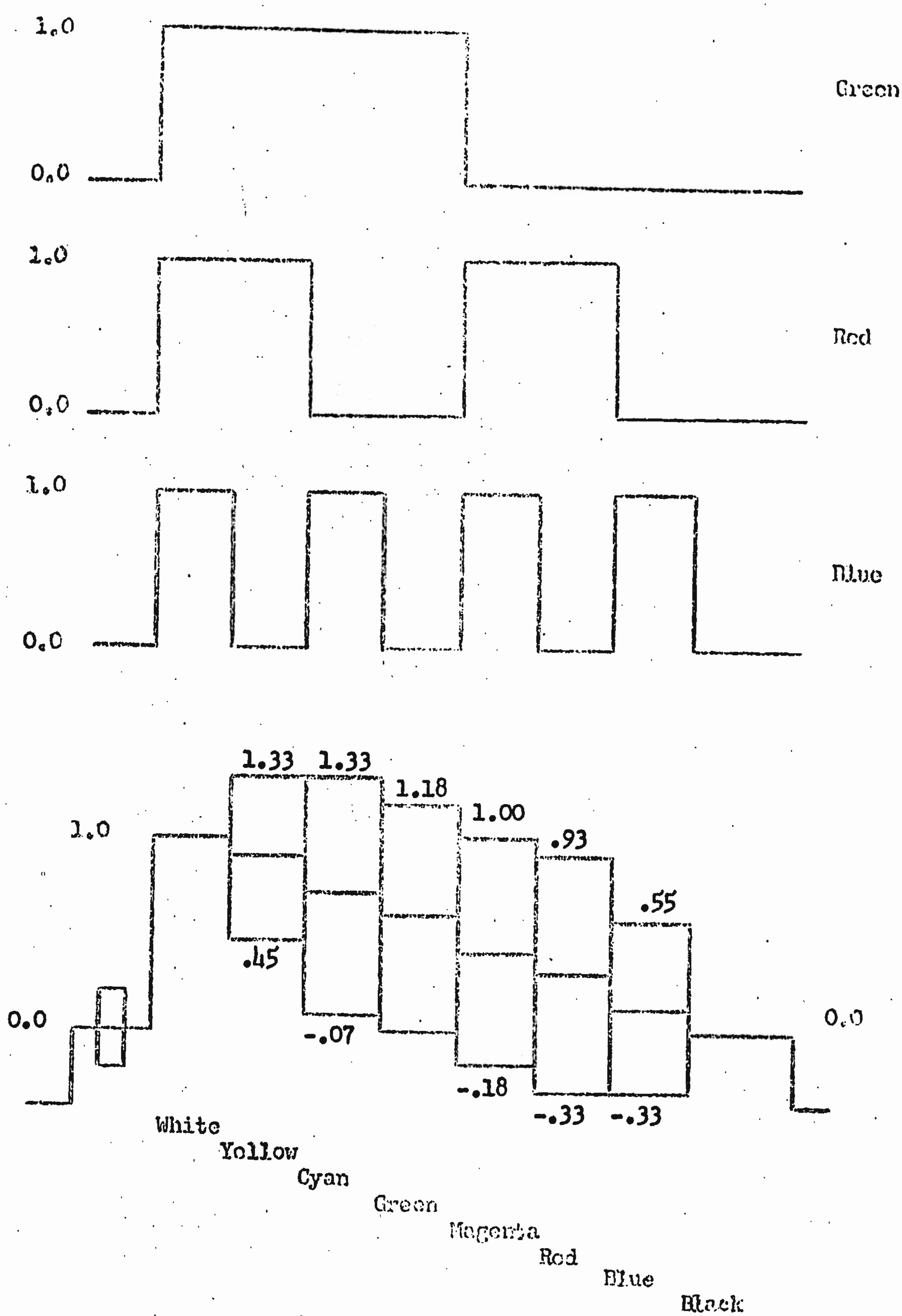


Figure 5



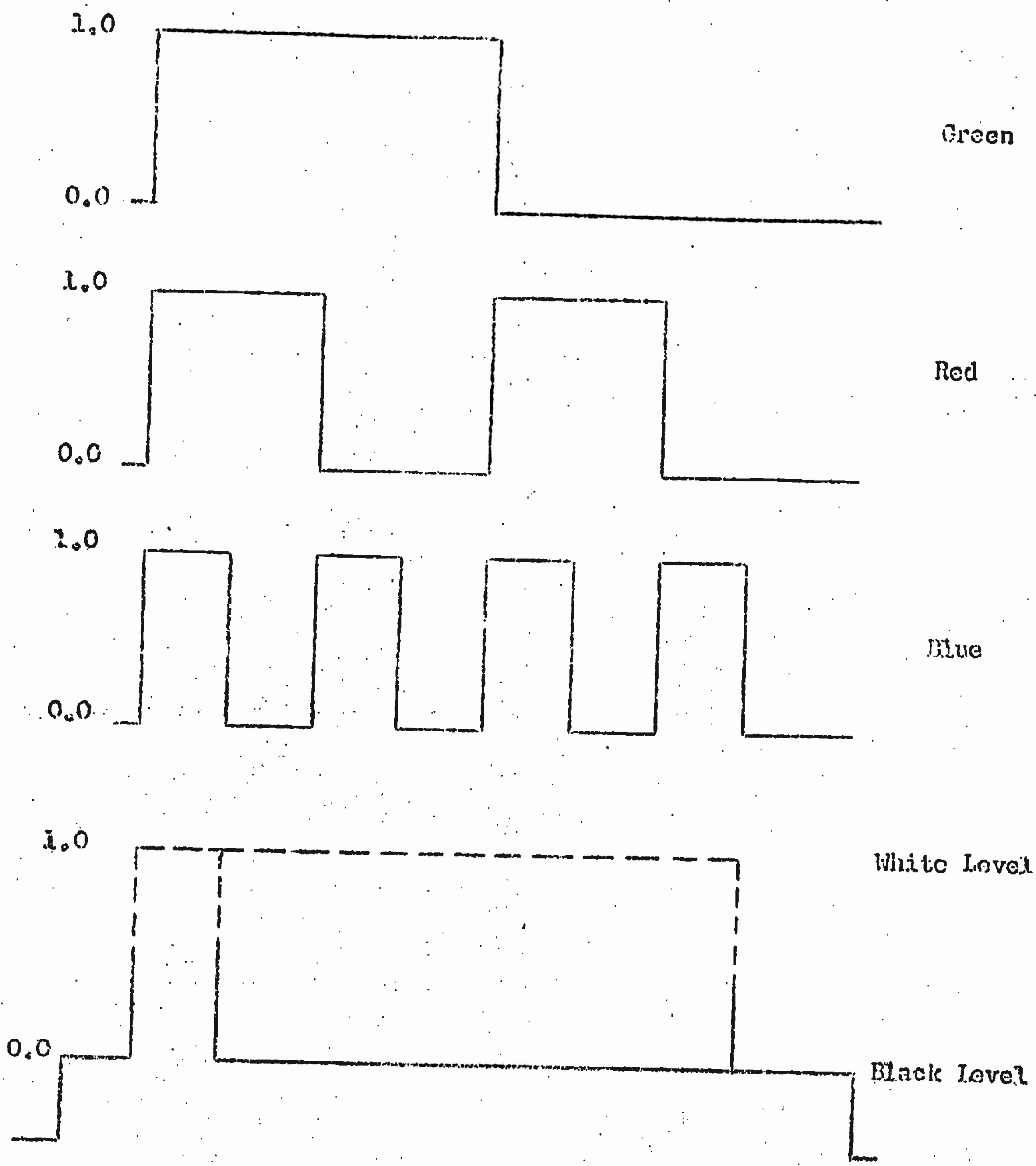
VECTOR REPRESENTATION OF QUADRATURE ADJUSTMENT

Figure 6



COMPOSITION OF 100% SATURATED COLOR BARS

Figure 7.



NAM DISPLAY OF DEMODULATED
100% SATURATED COLOR BARS

Figure 8.

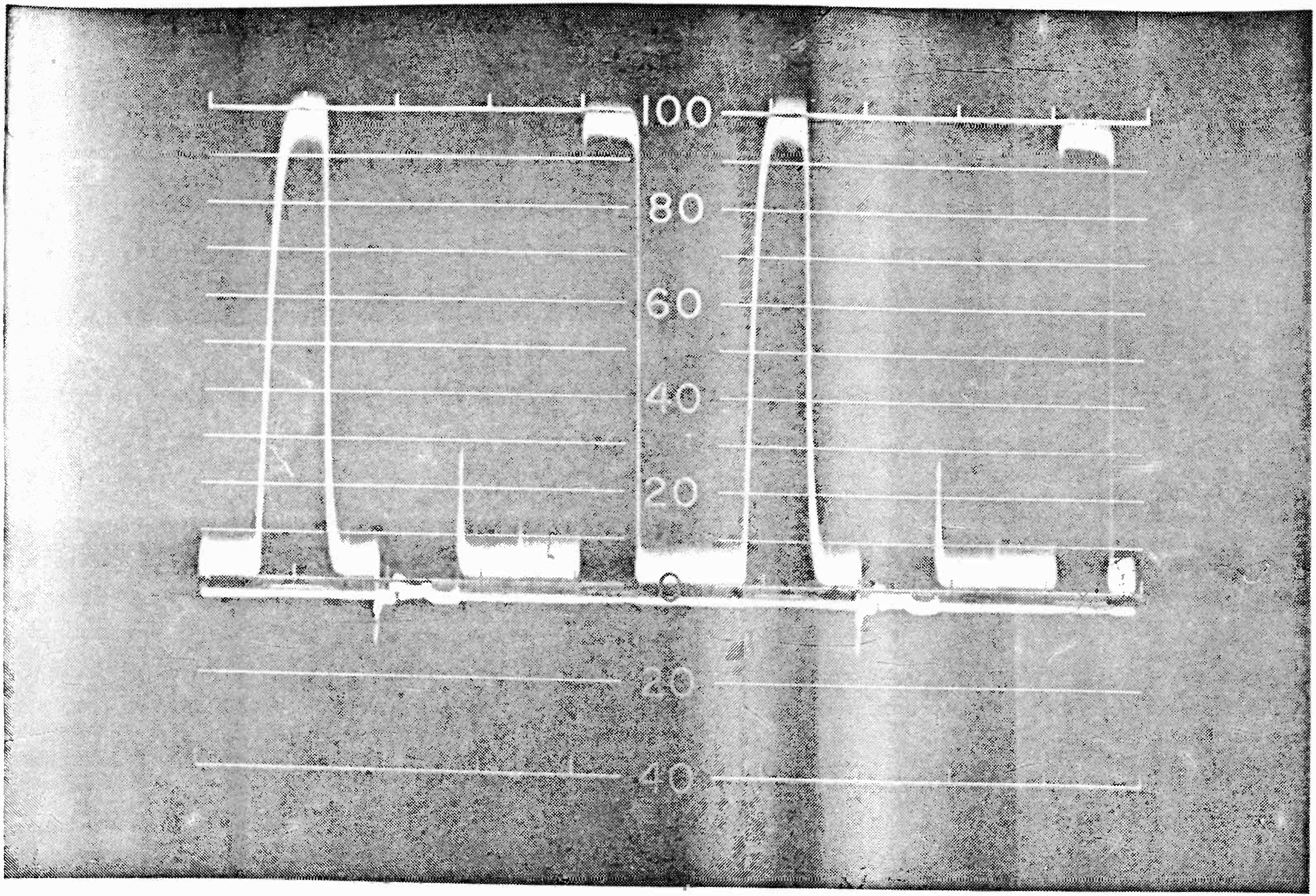


Figure 9

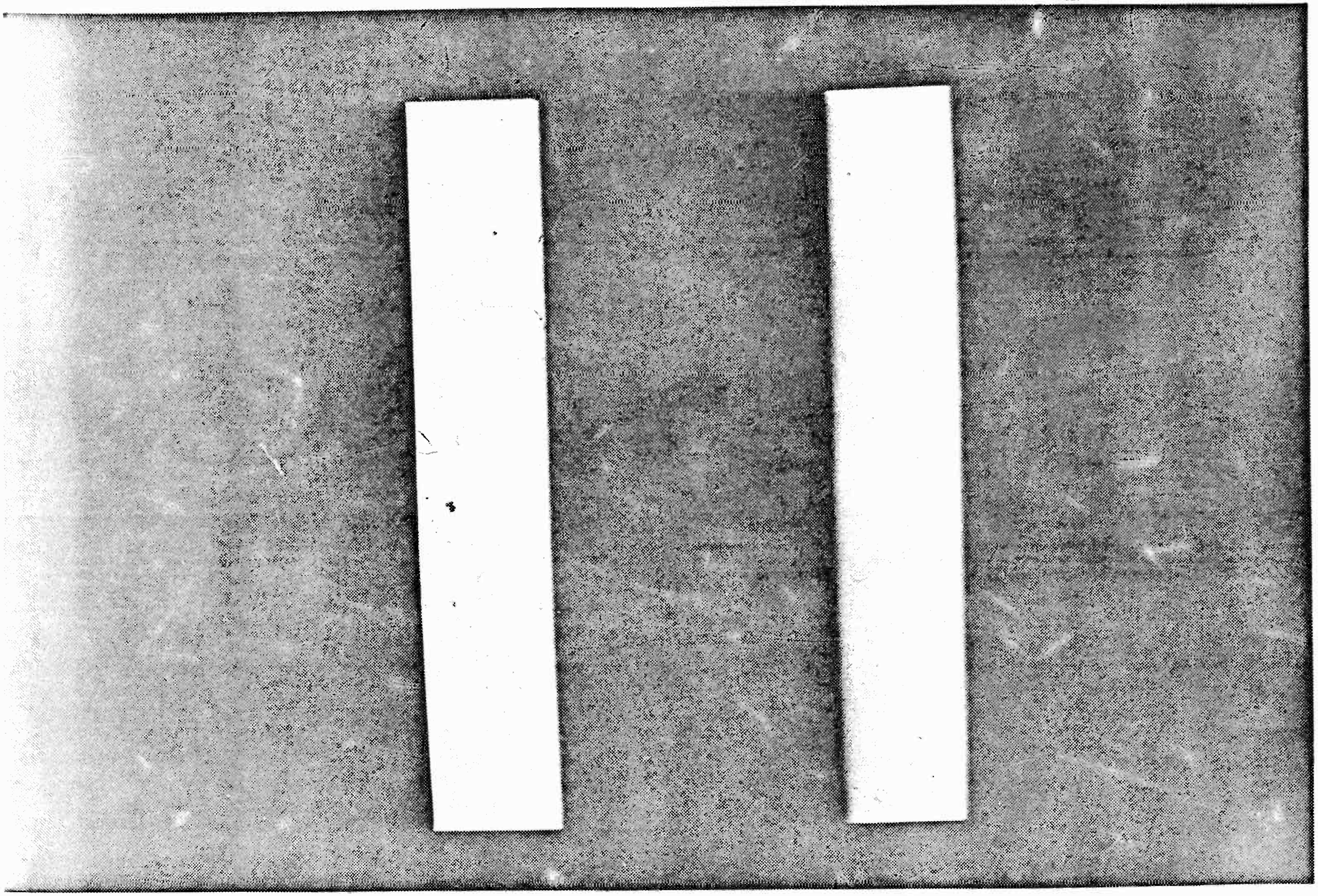


Figure 10

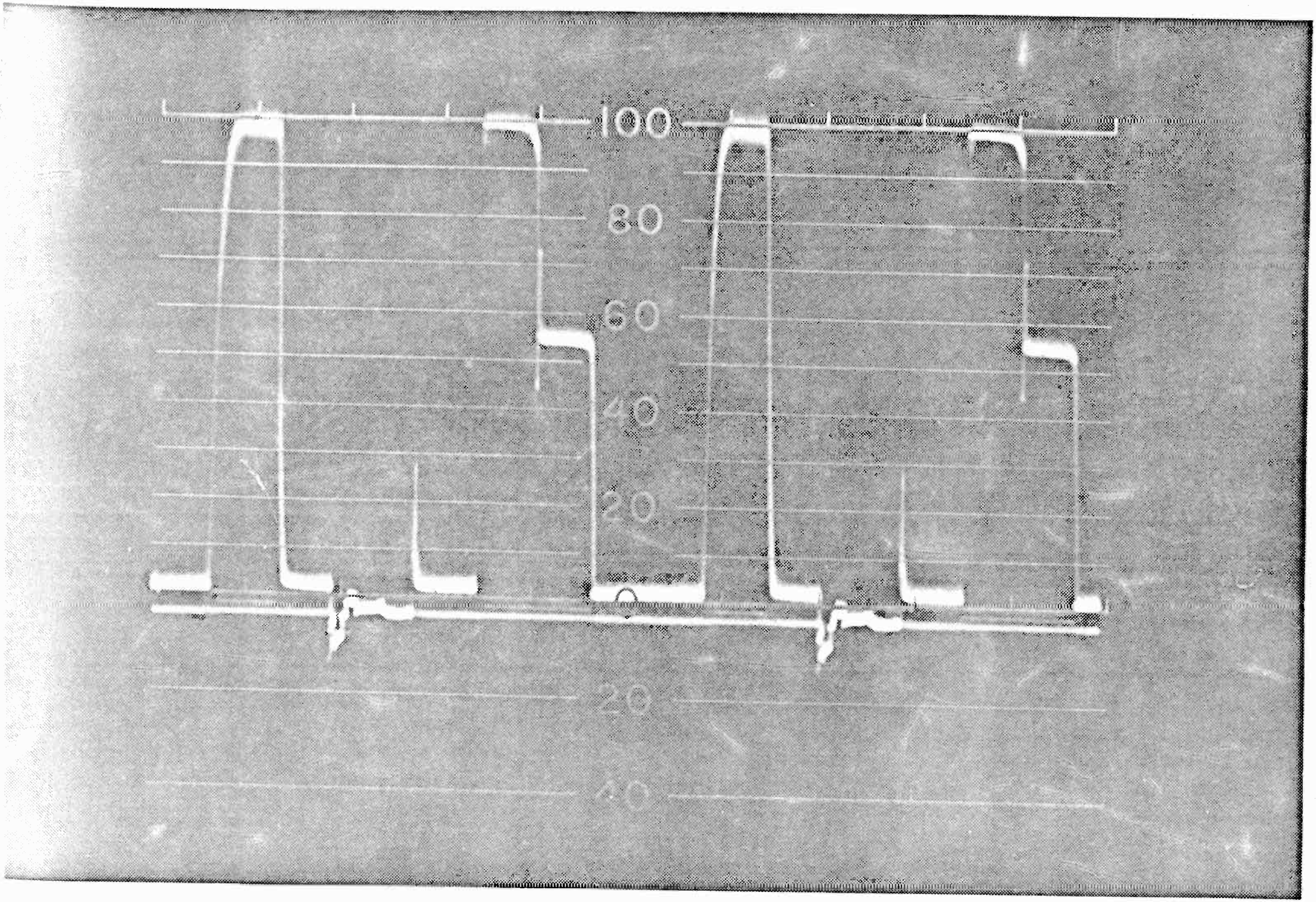


Figure 11

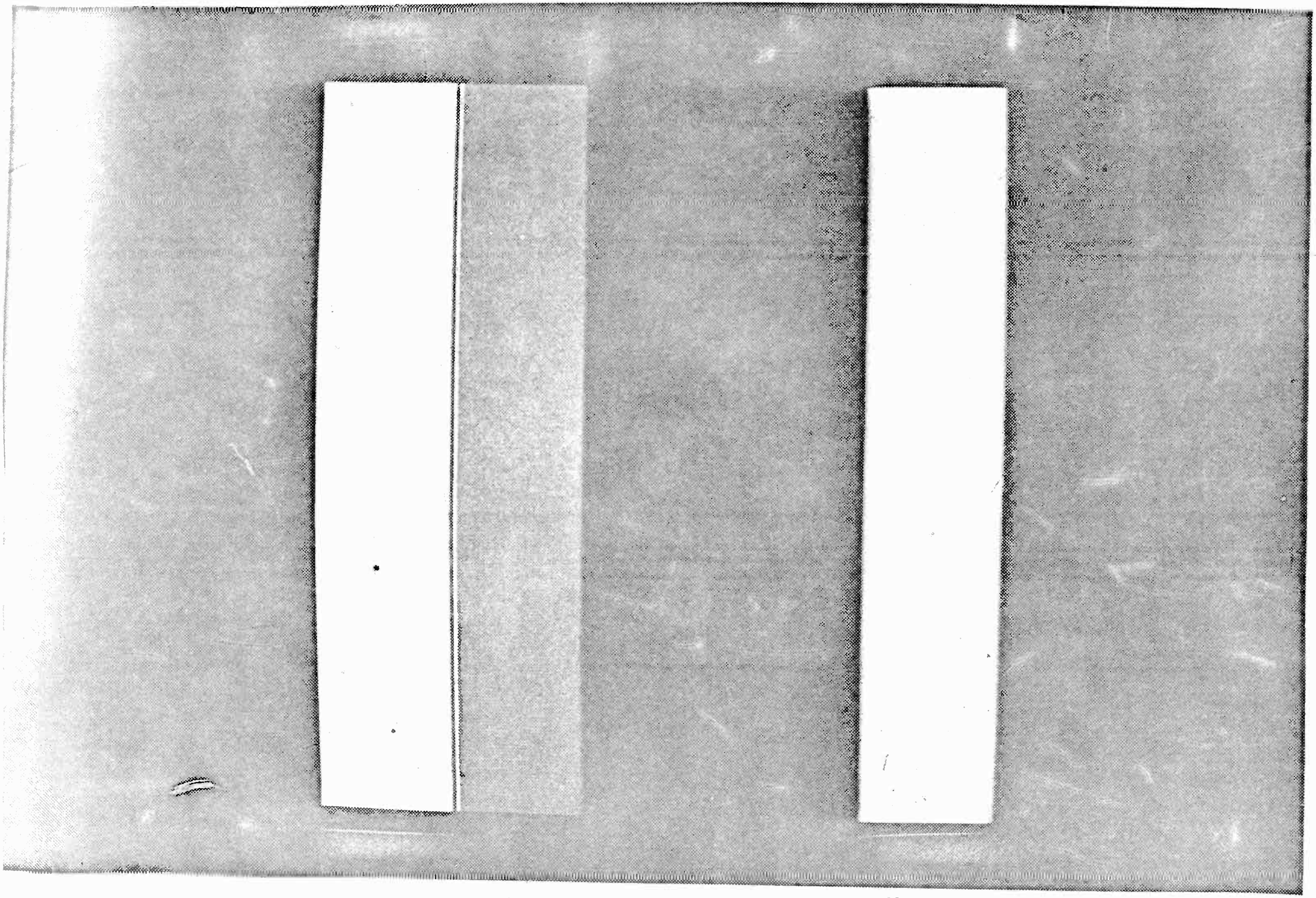


Figure 12

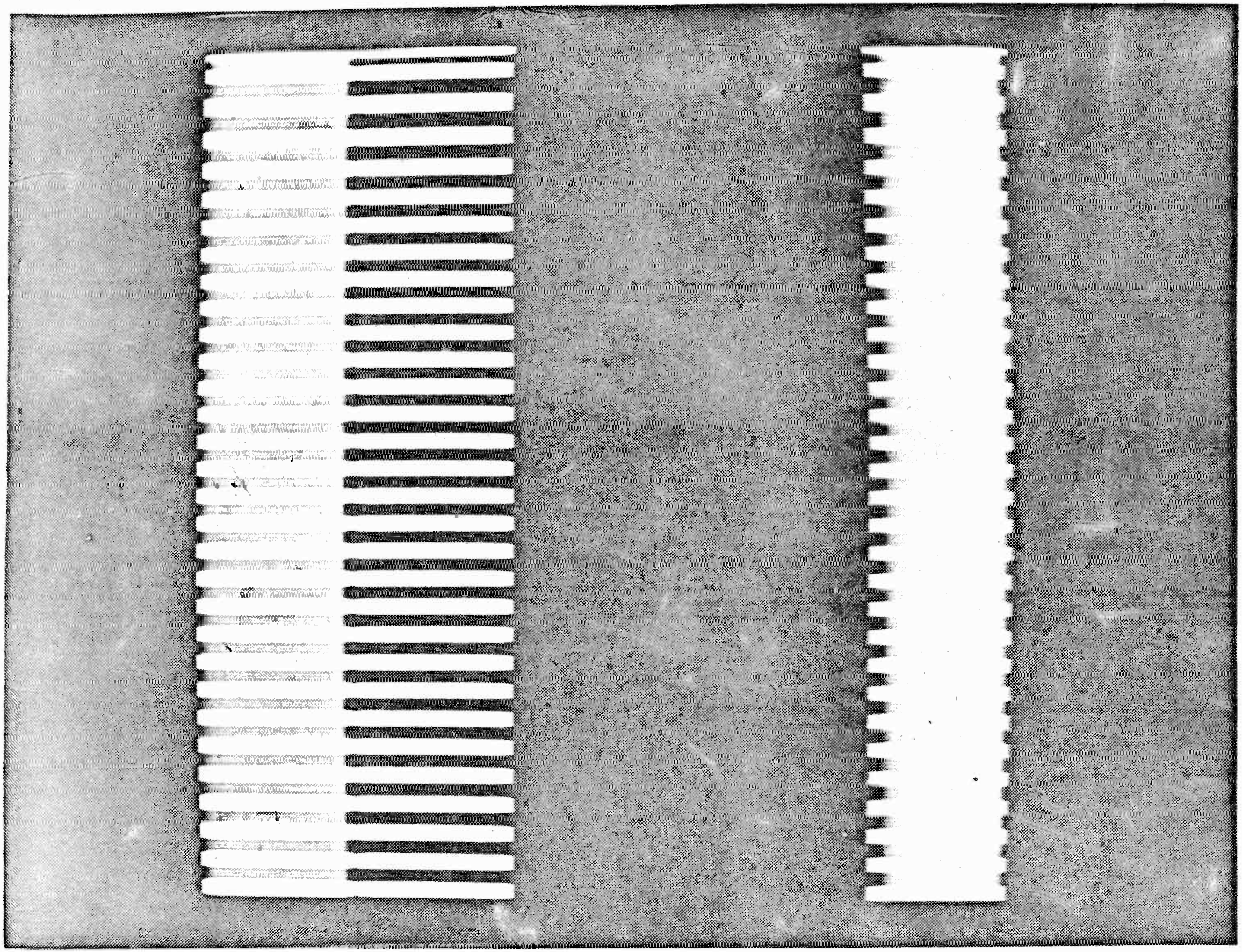


Figure 13

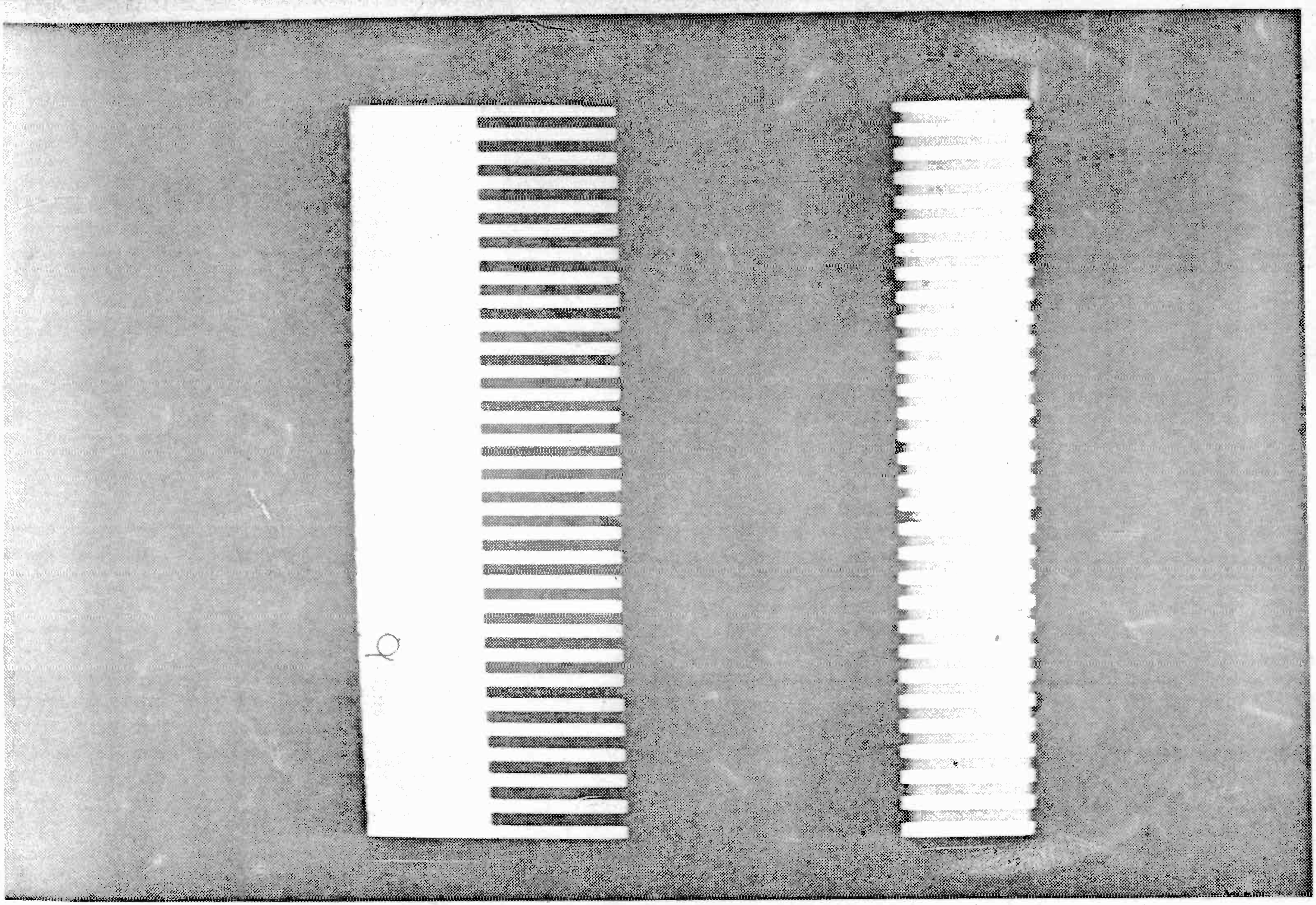


Figure 14

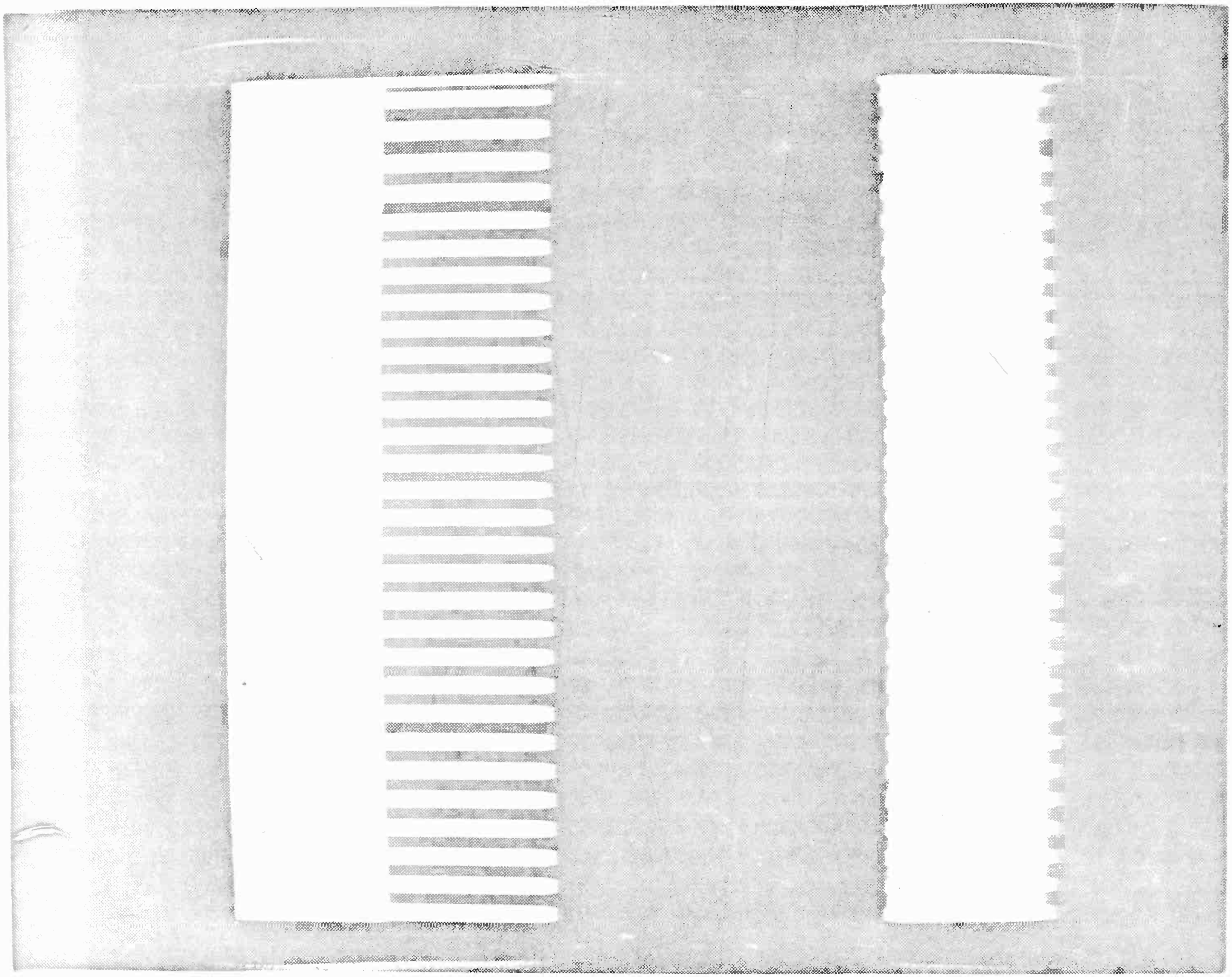


Figure 15

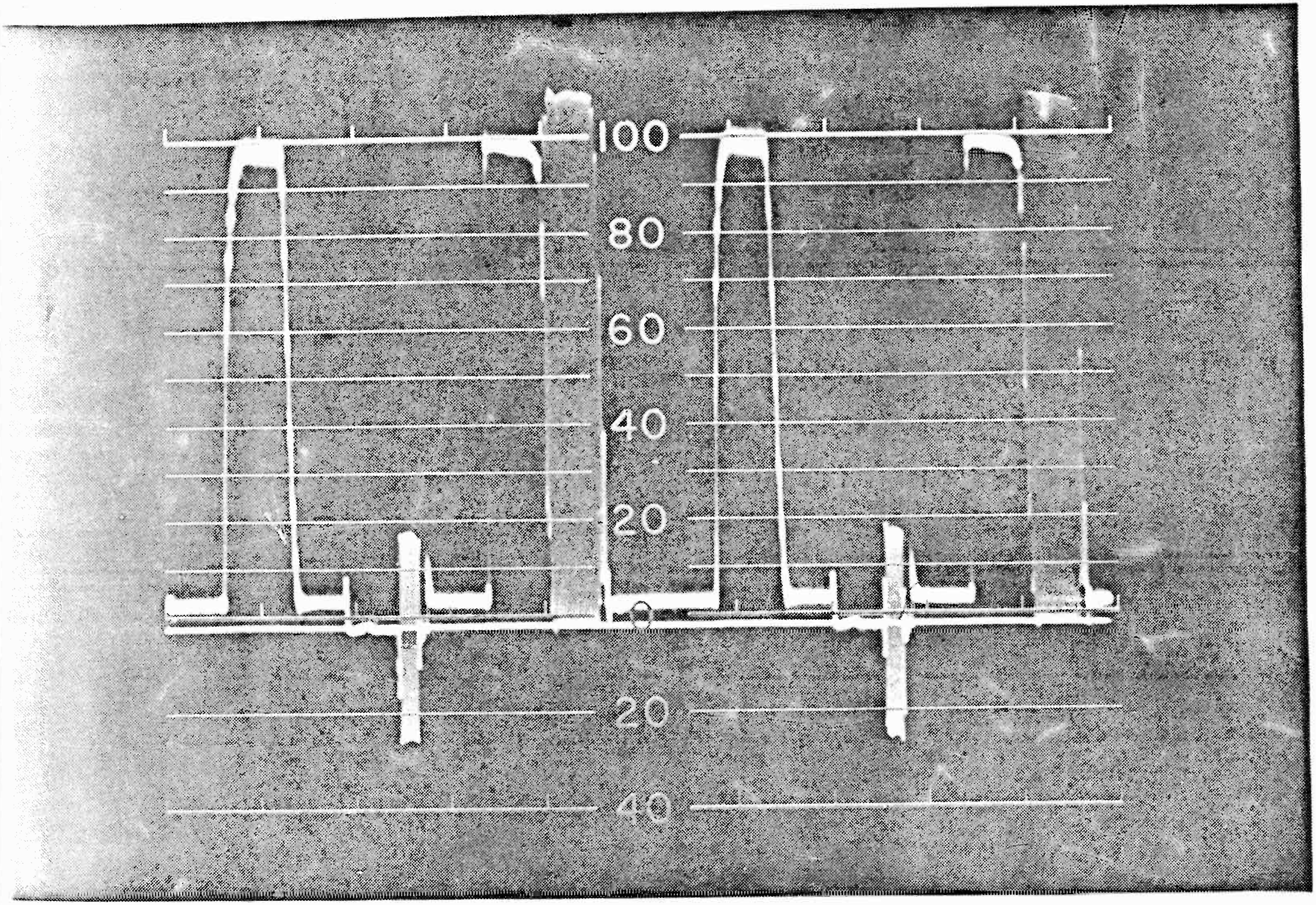


Figure 16

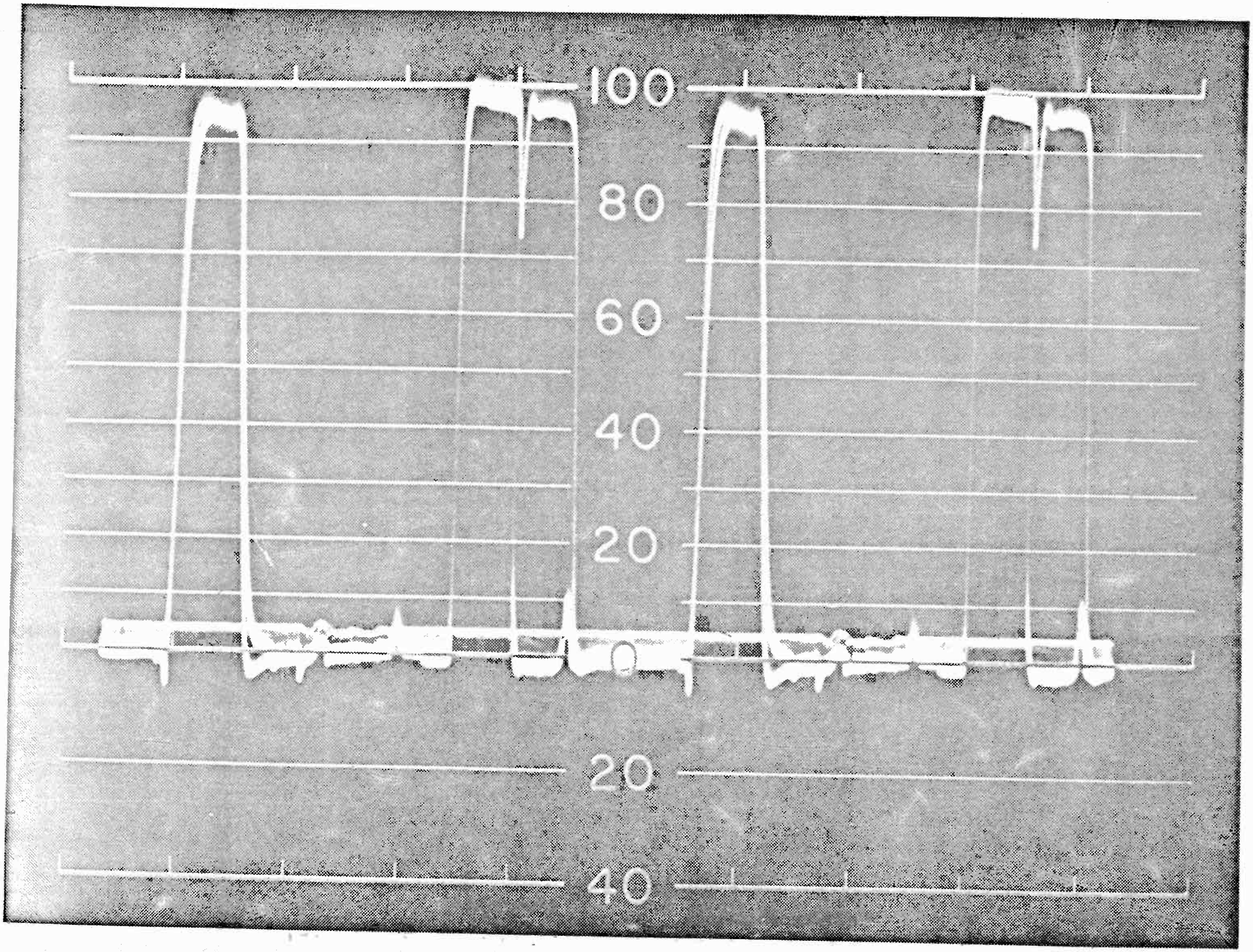


Figure 17

AUTOMATICALLY CONTROLLING THE PERFORMANCE

OF A COLOR FILM CAMERA

by

H. H. Martin, Consultant-Video Engineering
Visual Communications Products Business Section
General Electric Company, Electronics Park, Syracuse, New York

For presentation at the 20th Annual Broadcast
Engineering Conference - National Association
of Broadcasters

Conrad Hilton Hotel
Chicago, Illinois
March 29, 1966

AUTOMATICALLY CONTROLLING THE PERFORMANCE OF A COLOR FILM CAMERA

Since there is closer control of the production of newer films for color television transmission, much current program material requires relatively little corrective action by the video operator. This is not always true, however, of many films originally made for theater projection and of some poorly controlled slides. Such material may suffer from varying highlight and lowlight densities, which result in contrast variations. Obtaining consistent color balance is also at times a problem, particularly when interpersed commercials differ in quality from that of the main program film because they have been printed in a different laboratory or on a different type of film.

This paper does not propose to offer a solution to the problem of rapidly changing color balance, but is concerned with automatic compensation for density and contrast variations in the film chain. In the General Electric PE-240-A Four-Vidicon Color Film Camera Channel, the highlight standardizing function is called Automatic Exposure, and the combination of this and Auto Black Level is called Automatic Contrast.

The following are considerations that influence the choice of a particular method of automatically obtaining compensation for density and contrast variations in a color telecine chain:

1. Control Range

   Highlight density variations of as much as 100 to 1 have been reported with black-and-white film. While it is unlikely that color film representing these extremes will be encountered, or would be useable if it were, a density variation of at least 30 to 1 should be provided for.

2. Color Tracking

Perfect color tracking or balance is achieved when identical signals are obtained from all color video inputs to the encoder when using a neutral slide or film as the program material. Once achieved, the balance should not be disturbed by the level or contrast controlling process.

3. Control Characteristics

Ideally, when using automatic controls, picture quality should duplicate or excel that achieved by a competent video operator when televising the same material. Automatic controls can be made to react faster than a human operator using manual controls. In fact, the reaction can be so fast that unpleasant transients result, since automatic circuits are not able, as the operator is, to anticipate scene changes or exercise judgment.

AUTOMATIC CONTROLLING MEDIUMS

Automatic features that have been available for some time in monochrome film chains include some form of white level control and, in some cases, black level control. It is not too surprising that automatic features were incorporated in monochrome equipments before their use in color chains when one considers the added technical requirements dictated by color.

Contrivances that have been used in monochrome vidicon film chains for both manual and automatic control of peak white level include the following:

1. Target Voltage Control
2. Video Amplifier Gain Control
3. Projector Lamp Voltage Control
4. Optical Attenuation in the Projector Light Path
5. Combinations of the above.

Correction signals for these level controlling mediums are usually voltages which in the automatic mode are derived from the video signal at a point in the chain beyond the controlled point, thus forming a closed loop.

Black level in a monochrome chain is adjusted by varying the black clipping level. During automatic operation, a black level correction voltage is formed by measuring the difference between the darkest part of a scene and reference black. The automatic black level control point is usually inside the automatic white level loop.

The controlling mediums that have been used in monochrome manual and automatic level controls will be discussed particularly with respect to their suitability for use in a color telecine chain.

Target Voltage Control. Varying the vidicon target-to-cathode potential changes the sensitivity of the tube and therefore the video signal output. Some undesirable effects are also produced by target voltage variations: first, a change in dark current and shading and, second, a variation in "gamma," or slope of the light transfer characteristic. These effects are usually insignificant in a monochrome system. In a color system, however, if the effects are not exactly identical for all of the vidicons in the chain, imperfect tracking results. Larger tracking errors may be caused by differences in the intrinsic target voltage characteristic between vidicons. Tube specifications indicate that for a given signal current, the target voltage can vary as much as two to one between vidicons. It is obvious that no single variable target control voltage, simultaneously applied to all vidicons, can give satisfactory gray scale matching between color channels with a tolerable amount of tube selection.

Video Amplifier Gain Control.

In early monochrome vidicon film chains, video level control within the signal processing system was sometimes used as the sole operating level control, since the target voltage of the original vidicon tubes was fixed for optimum shading characteristics.

Since the adjustable level control is located at an intermediate point in the video path, film with low highlight densities may cause overloading of the vidicon signal current or of the video amplifier circuits ahead of the control. At the other extreme, dense film will cause degradation in the signal-to-noise ratio as the gain is increased to maintain a standard output. When used for level trimming, video gain controls are indispensable, but their value as wide-range operating controls, either manual or automatic, is limited. In a color vidicon chain, it is difficult to achieve satisfactory performance with even a limited range of proportional gain control in all channels. By using feedback or AGC techniques, a close level match can be achieved between channels of a color telecine, provided the gammas of the vidicon tubes are identical in all channels. Since this is never precisely the case, it is possible for some gray scale unbalance to result from simultaneous gain changes.

Projector Lamp Voltage Control. Film density variations can be rather effectively compensated for in a monochrome film chain by controlling the projector lamp filament voltage. Rheostats, adjustable transformers, reactance dimmers, and silicon controlled rectifier (SCR) dimmers have all been successfully used for this purpose.

While a considerable variation in lamp color temperature is acceptable for monochrome use, it is obvious that much less spectral variation can be tolerated in a color chain. As the visible light is reduced by means of the lamp voltage, the color temperature of the emitted light shifts to give a relative increase in the intensity of the red wavelengths and a decrease in

the blue. The range of level control that can be achieved with acceptable color shift is not nearly enough for use as an operating control.

This does not mean that the projector lamp must be run at exactly the voltage marked on the bulb. Lamp life is greatly extended by reduction in voltage, and the camera chain can be set up to give gray scale balance under such conditions.

Optical Attenuation. Adjustable irises have been used as exposure controls since the beginning of photography. Many television color and monochrome live studio cameras now use the taking lens iris as a remotely operated level control. The iris is also used with these cameras to adjust the depth of focus, which is a function of the aperture. While a useful feature in a live camera, the change of depth-of-focus limits the use of the iris as an operating level control for television projectors or film cameras, since the projector lamp filaments and other optics tend to be brought into focus as the lens is stopped down.

A device utilizing colloidal graphite suspended in oil has been used as an optical attenuating medium in monochrome film chains. The solution is sealed and confined between two parallel glass plates. Changing the plate spacing varies the light transmission over a large range with little or no change in color temperature. In a color system, this device imposes a limitation, since it has a rather high minimum insertion loss.

Another optical method of controlling the film chain video level is that of positioning a gradated neutral density filter in the projector light path. The attenuation of the filter is linearly tapered to produce a maximum light transmission of nearly 100% and a minimum of about 1%. Although other configurations have had limited use, the most common form consists of an optically flat disk with a metallic filter material deposited in a nearly closed arc in an area extending radially from the rim to almost the center.

The attenuation can be rapidly changed by varying the angular position of the disk, using a syncro or servo-controlled motor.

The neutral density disk is positioned either immediately in front of the projector lens or in the projector condenser lens system. Separate neutral density disk attenuators are required with each projector in an optically multiplexed color film system. Because of the large cross-sectional area of the light bundle, a single disk in the output side of the multiplexer would be impractically large. Since the disk coating remains neutral, varying only in density, perfect color balance is maintained with level adjustment.

Combinations of Mediums. Various combinations of the previously described controlling mediums have been used. For example, either target voltage control or optical attenuation can be combined with video amplifier gain control.

Some interesting color film chain level control possibilities involve the color signal encoder. One scheme is to use a single video attenuator in the encoder after the chrominance and luminance are combined but before burst, setup, and sync are added. Another method is to combine the chroma level feature now provided on the latest encoders with separate control of luminance.

Incorporating the operating level control in the encoder is perhaps a simpler way to achieve gain tracking than to simultaneously gain-adjust each separate channel, but unless it is combined with another medium, the same limitations of possible overload, inadequate signal-to-noise ratio, and vidicon selection apply.

SENSING SIGNALS

The NTSC color system as originally constituted generated the luminance signal in the color encoder by combining proper proportions of the three gamma-corrected color video signals.

In the General Electric Four-Vidicon Channel, the gamma-corrected monochrome luminance signal is obtained entirely from the added channel. Among other advantages, this technique gives sharper color and monochrome pictures than can be obtained from a three-tube camera. As explained by I. C. Abrahams in his 1963 NAB Convention Paper, A New Approach to a Color Film Channel, use of the separate luminance signal introduces some error in the luminance of the receiver decoded video. This error is greatest for saturated colors and diminishes to zero as the chromaticity approaches white. Fortunately, practical pictures do not contain high luminosity saturated colors. By using a properly shaped optical trimming filter on the luminance channel, an excellent brightness match with three-vidicon operation can be achieved.

When compensating for film variations, the objective is to standardize, as nearly as possible, the positive and negative voltages corresponding to the picture highlights and lowlights. It is obvious that if the picture contains some white and some black information, the positive and negative peaks will be identical at the output of all channels if the chain is properly adjusted.

With a three-tube color chain, the practice has been to adjust the highest peaks of the three camera signals to 100% and to set the most negative at reference black. Considering the close match that can be achieved between the three-vidicon and four-vidicon output levels, it is not surprising that similar level setting is satisfactory in a four-vidicon chain.

A single signal that is at any given instant comprised of the highest levels of all of the encoder video inputs is generated for use as the control video in the Automatic Exposure Control. Similarly, a signal that includes the lowest, or most negative, levels of the encoder inputs is produced for the Automatic Black Control. Fig. 1 illustrates how these two signals are produced. For simplicity, only two inputs are shown, but the principles

apply to any number. The input signals, A and B, are both clamped to ground potential during the horizontal blanking interval. Let us first consider the formation at output Y. At time t_0, current from input A passes through D_1 and R_y, producing a duplicate signal, except for the diode drop, at output Y. Input B initially does not appear at Y, because the level of B is such that the cathode of D_2 is more positive than its anode, causing the diode to be reverse-biased. Output Y continues to duplicate input A until input B exceeds the amplitude of A, forcing D_1 to cut off and D_2 to conduct. The waveform shown at Y will be formed by the assumed inputs.

It may be recognized that this circuit is actually a logic OR gate with the characteristic that conforms to the rule that output Y represents either A OR B, whichever is the greater. In like manner, output Z is produced by a negative OR gate, which follows the rule that output Z represents A OR B, whichever is the smaller. The two signals corresponding to Y and Z are called logic video-white and -black, respectively.

AUTOMATIC EXPOSURE

After analyzing the several alternative level controlling mediums, the servo-driven neutral density light-control disk was selected as the method for automatically adjusting video peak level in the General Electric PE-240-A Four-Vidicon Color Film Camera Channel. This method of compensation is called Automatic Exposure Control. The advantages of this type of control, including to those previously mentioned, can be summarized as follows:

1. The device contributes no spectral errors with setting and cannot cause drift of the color balance.

2. It has more than sufficient control range.

3. It assures constant signal-to-noise ratio and other operating characteristics in the camera chain.

4. It does not appreciably degrade resolution.

5. The operating speed is satisfactory.

6. It has had a successful history when used as a manually operated level control.

7. Existing light-control servos are easily adapted to automatic control.

A simplified diagram of the automatic exposure control used in the General Electric PE-240-A Four-Vidicon Channel is shown in Fig. 2. The circuit is completely transistorized.

The manual settings of three neutral density disks are simultaneously controlled by a three-ganged potentiometer. Turning this control temporarily unbalances each disk servo amplifier, causing the disks to be driven in the proper direction to restore balance. In the automatic mode, voltages from the driver amplifiers in the automatic exposure control unit replace the manual control potentiometers.

Referring to the upper row of blocks in Fig. 2, the input video is amplified to increase the accuracy of the peak detector, which is, in essence, a peak-reading voltmeter with its d-c reference set by the automatic exposure level control. The detector output is direct coupled to the paralleled inputs of three d-c driver amplifiers, one for each servo disk. Adjustments on each driver amplifier permit separate settings of the maximum and minimum attenuation limits for each of the three disks when operated in the automatic mode.

Fade-to-black scenes in the film cause the neutral density disk to rapidly assume its minimum attenuation position when operated in the automatic mode. If the scene then fades back in, the disk attenuation decreases to hold the peak video at 100%. The automatic control action does not seriously alter the effect of this transition. However, if the all-black

scene abruptly reverts to a scene of normal density, a momentary overload will result regardless of the speed of the corrective device, since the attenuation was initially minimum. If the film does not have too wide a density gamut, this effect can be lessened by restricting the minimum attenuation limit of the disk.

The circuit represented by the lower row of blocks in Fig. 2 was developed to prevent these momentary overloads by sensing the presence of an all-black picture and causing the projector disk to change to a preset attenuation position, an action called Repositioning. A peak detector similar to the one in the main automatic exposure circuit, but with a fixed d-c reference, is also fed from the amplified video signal. The detected voltage is compared with the threshold voltage in the d-c differential amplifier. Proper adjustment of the Reposition Threshold control produces an output from the differential amplifier only when the detected voltage indicates an all-black picture. The output from the differential amplifier is coupled through the delay network, RC, to the base of the transistor, TR. The relay in the collector of this transistor operates to transfer control of the disk servo to the Reposition adjustment on the corresponding driver amplifier. The neutral density disk remains at this preset density until the scene again contains video information at which time control immediately reverts to the automatic condition. If desired, the initiation of the repositioning action can be delayed as much as a second by increasing the value of Reposition Delay resistance in the transistor base circuit. The diode D, across the delay adjustment, provides fast return to auto control when the signal returns.

AUTOMATIC BLACK LEVEL

Manual adjustment of the black-level control in a color film chain varies the blanking pedestal to hold the negative peaks of the video signal at reference

black. When setup is added in the color encoder, reference black is the same as blanking level at the video processors. With Auto Black Level control, it is necessary to measure the difference between blanking level and the negative peaks and to develop a corrective voltage proportional to this difference.

Fig. 3 illustrates how the input signal to the Auto Black Level control is modified so that the required correction voltage can be detected. A pulse resembling system blanking, but with an off interval slightly longer than that of the input signal and bracketing it in time, is added to the inverted input signal as shown in Figure 3(c). The dotted reference black level always differs from blanking level by the amplitude of the added blanking. Measuring the voltage difference between the new blanking level and the black peaks, which are now positive, is thus equivalent to measuring the difference between reference black and the video black peaks.

The Automatic Black Level control is shown in simplified block form in Fig. 4. The video inversion and blanking addition described above are performed in the differential amplifier. The output video from this stage is clamped at the input of the video amplifier and the peak is detected at its output. DC amplification completes the formation of the Auto Black Level control voltage.

It is essential that adjustments of the master black level not disturb the critical black level balance which must be maintained between color channels. Since the single control voltage is introduced into the processors at a point where the tracking characteristic is almost completely determined by passive components, an excellent match of black level is achieved at the encoded output.

AUTOMATIC CONTRAST CONTROL

The Automatic Contrast Control system used in the General Electric PE-240-A is comprised of automatic exposure control and automatic black level control.

As shown in the photograph of the Selector Panel, Fig. 5, illuminated push buttons permit the video operator to select either manual or automatic operating modes. The video polarity reversing switch is electrically interlocked to assure that <u>only</u> the luminance signal is sensed when monochrome negative film is televised. With positive film, the selection of the sensing signal is optional. Controls are also provided for setting the black-level and white-level references.

When manually riding levels, the operator does not always adjust the extreme positive peaks to reference white or negative peaks to reference black but correctly allows small area peaks to extend beyond these limits. The frequency response of the peak detectors in both automatic controls have been shaped to closely duplicate this characteristic.

Occasionally certain photographic effects tend to confuse a manual operator as well as an automatic control. Some shots, such as night, underwater, shady and foggy day, and similar scenes with small density extremes, may be adjusted to raise the contrast over what the film maker intended. Other effects, typified by lightning storms, flashing signs, or flickering firelight, make it advisable to limit the attack time of the automatic controls. If the corrective action is too fast, excessive "nervousness" or bounce is produced in the video signal. The inclusion of reference white and reference black in all scenes would greatly reduce the chances of getting incorrect level adjustments.

SUMMARY

A simplified diagram of the Automatic Contrast Control used in the General Electric PE-240-A Four-Vidicon Channel is shown in Fig. 6. The separate functions of Automatic Exposure Control and Automatic Black Level Control provide an effective answer to the problem of film density and con-

trast variations. While the reaction time of the automatic controls is somewhat faster than that of a human operator, photographic effects limit the maximum speed of operation.

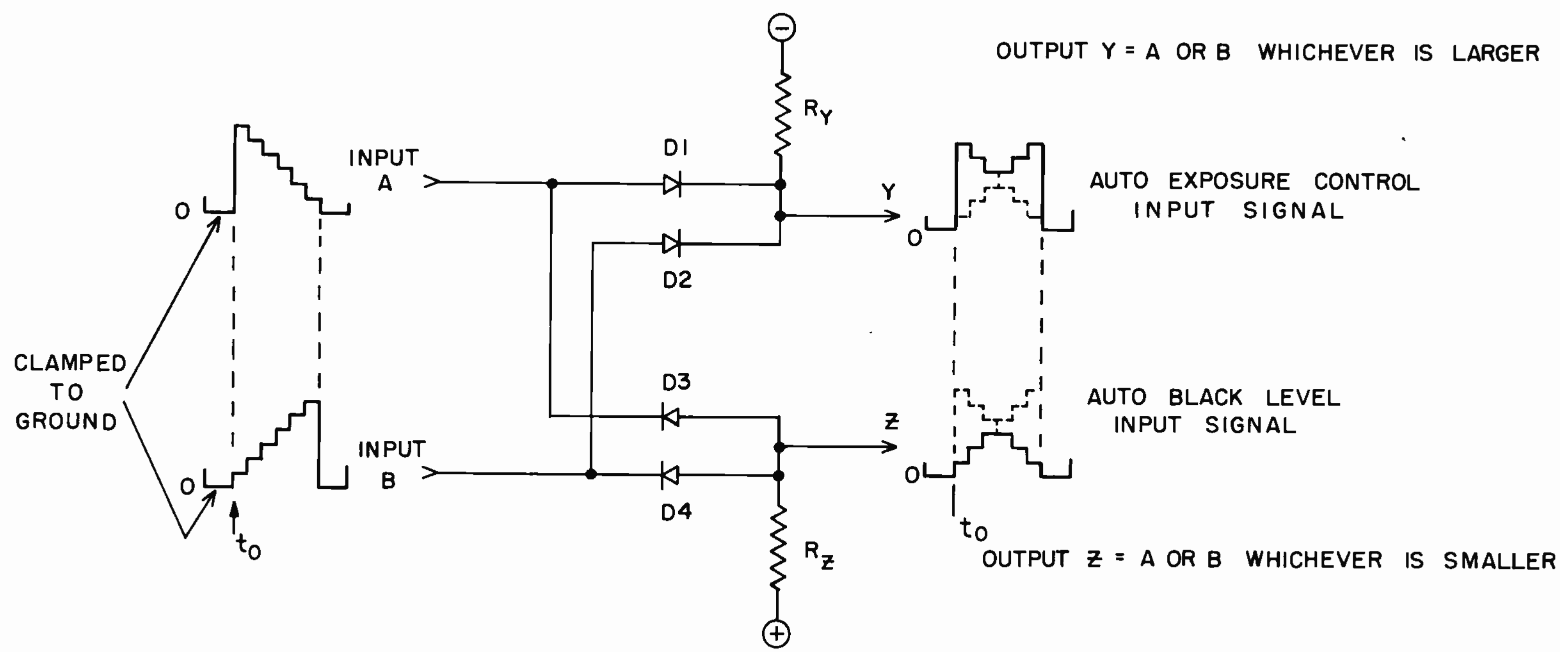


Fig. 1 Generation of Automatic Contrast Signals

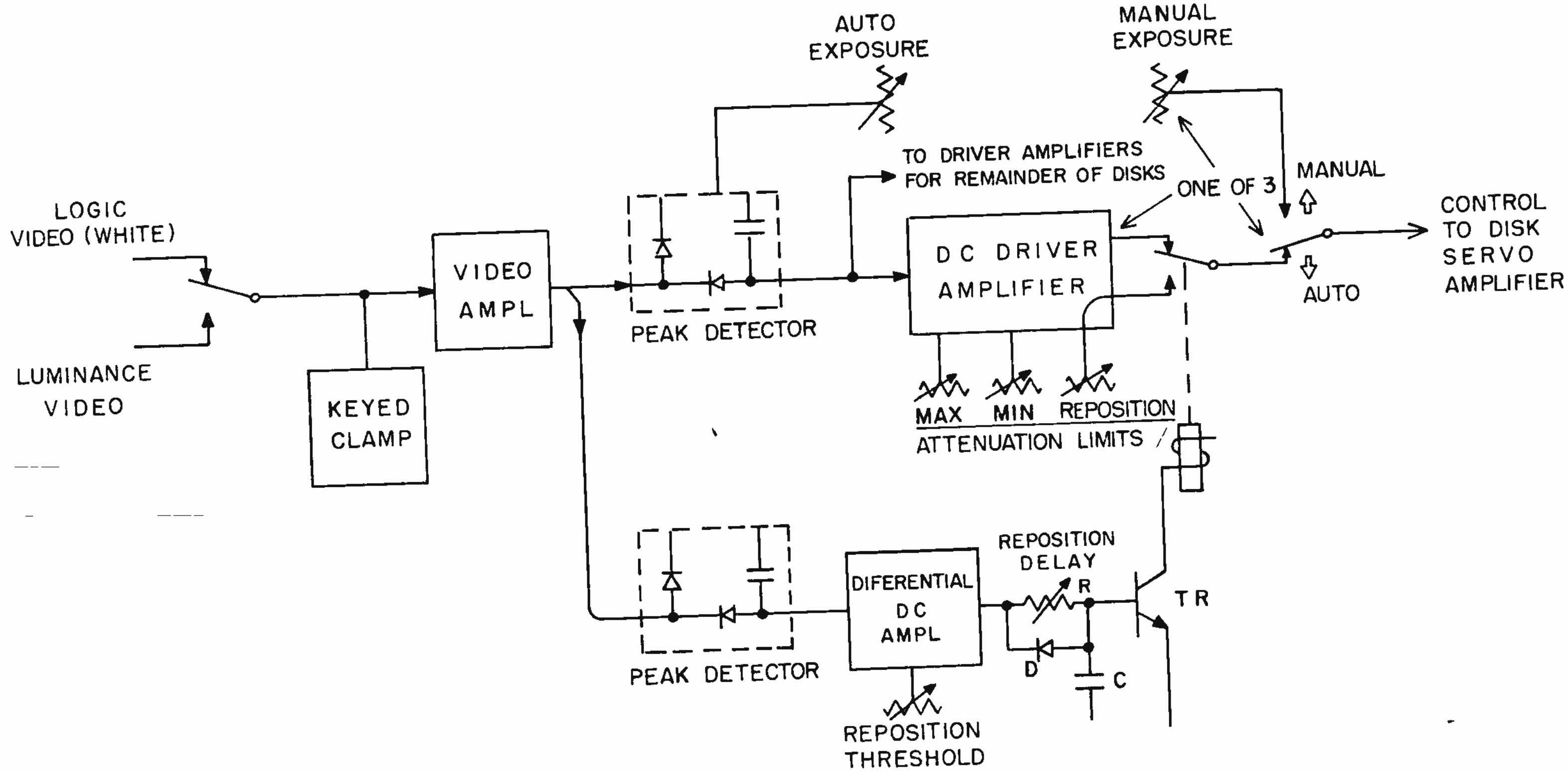


Fig. 2 Simplified Block Diagram of PE-240-A Automatic Exposure System

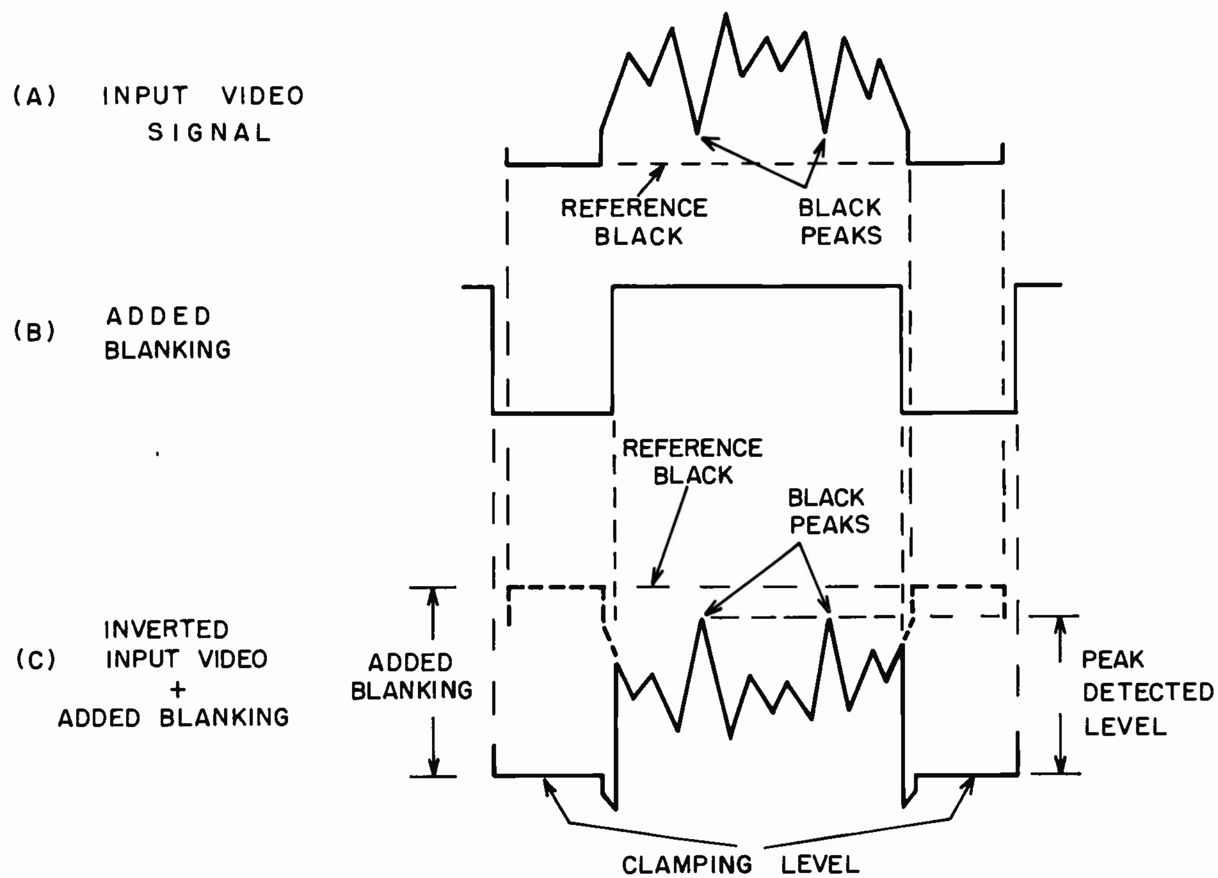


Fig. 3 Video Signal for Automatic Black Level Detector

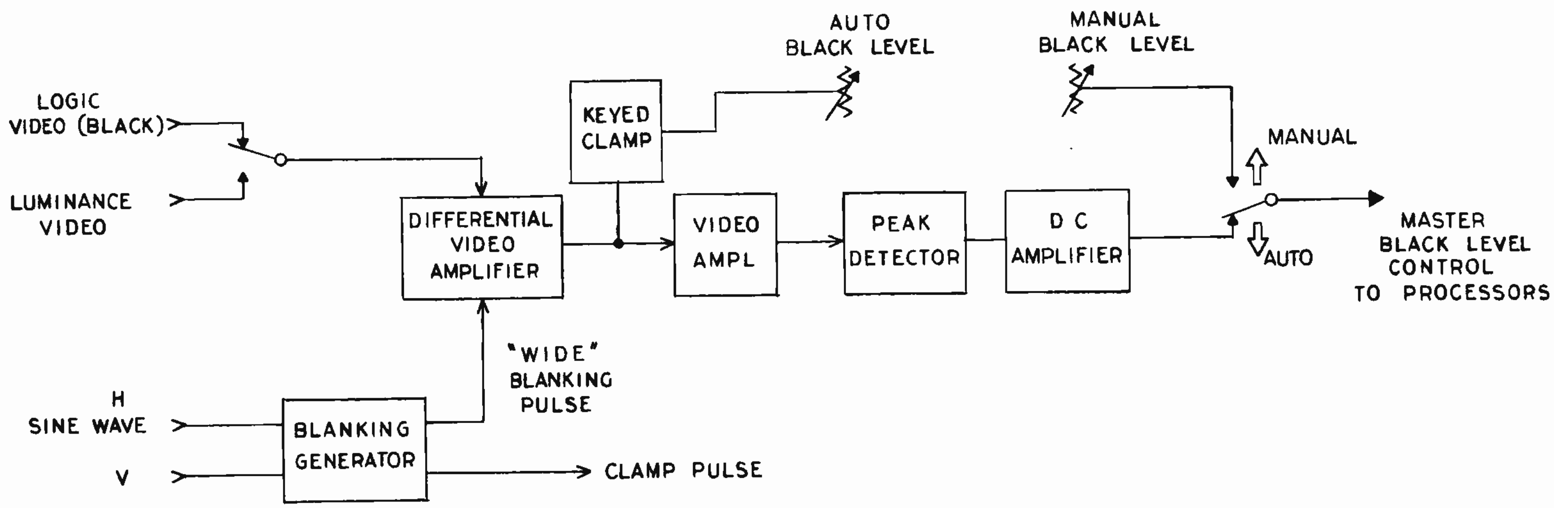


Fig. 4 Simplified Block Diagram of PE-240-A
Automatic Black Level Control

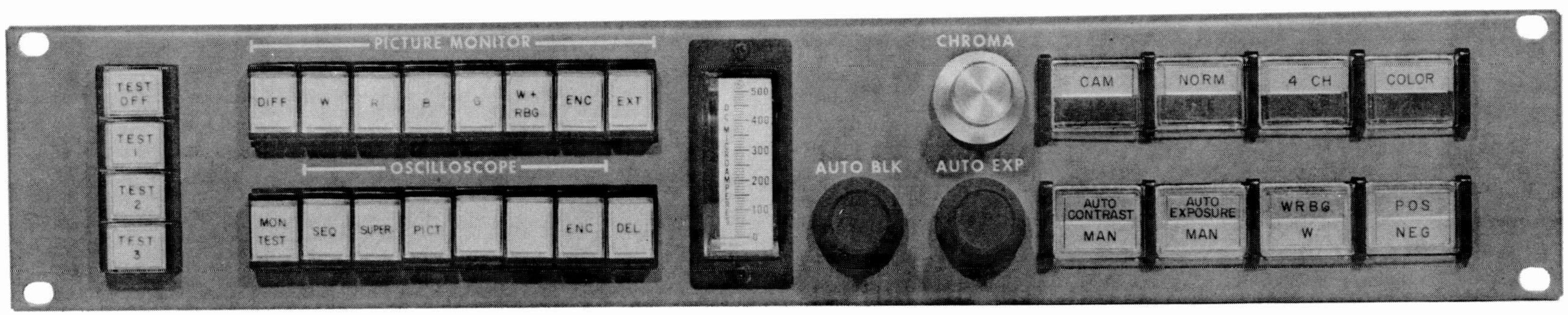


Fig. 5 PE-240-A Selector Panel (22266-18)

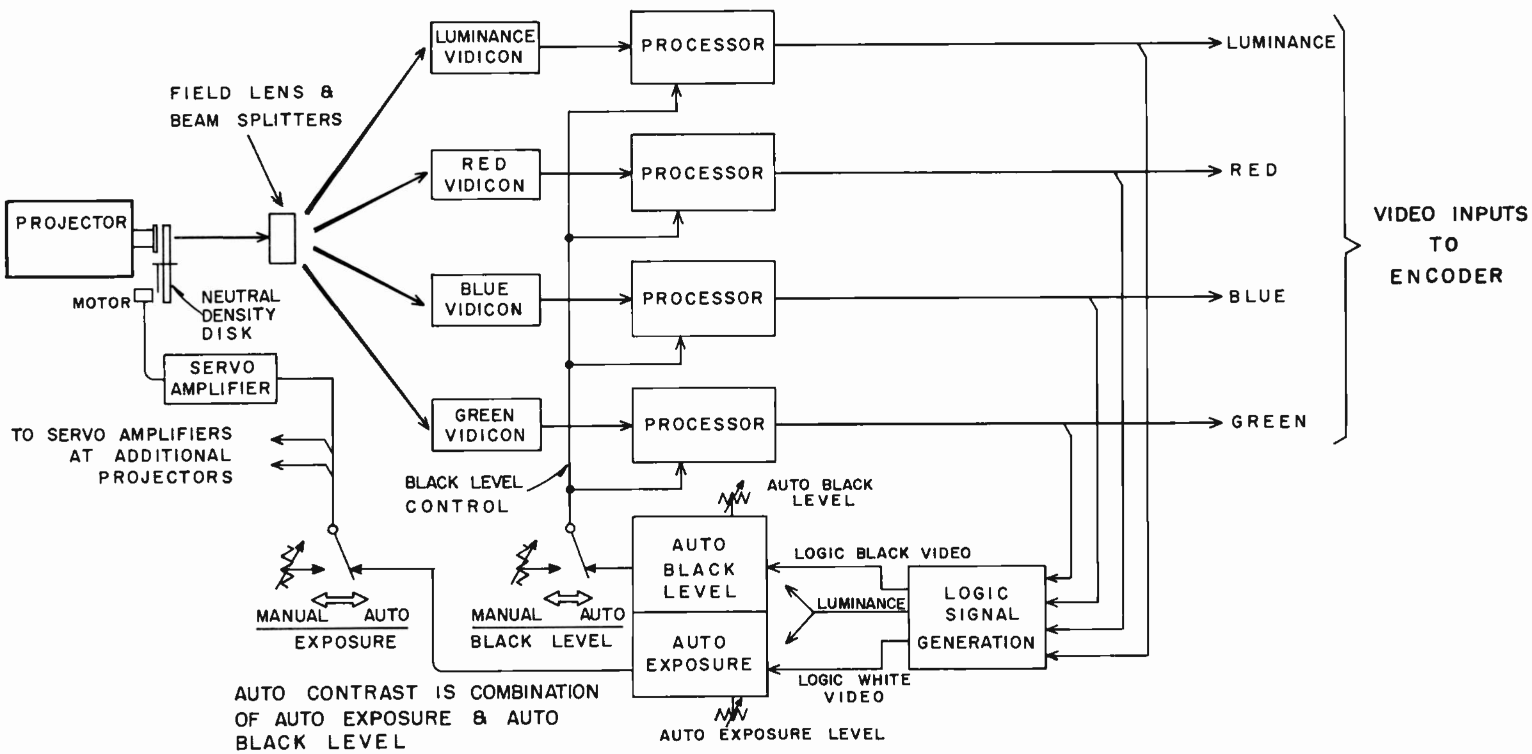


Fig. 6 Simplified Block Diagram of PE-240-A
Automatic Contrast Control

OPERATION OF THE 4-V FILM CAMERA TO REDUCE LUMINANCE ERRORS

Frank J. Haney
American Broadcasting Company

Operation of the 4-V Film Camera to Reduce Luminance Errors

Introduction: In 1953, the FCC authorized the present color television signal specifications which were based upon the studies, recommendations and conclusions of the NTSC. These specifications included the use of a three primary color separation system. Each color primary has a specified center wavelength and spectral bandwidth. Also specified are proportions of each color primary which constitute a neutral (luminance), the spectral response of which is illuminant "C".

With the installation of four 4-V film cameras at the Union City, New Jersey network playback center, noticeable color differences were experienced when running the same film (or slide) through a properly adjusted 3-V camera. These differences were subsequently traced to a substantial error in the luminance signal.

Special Response: In the 3-V type of film camera it is well established that a neutral test slide or film yields equal video levels in each of the R-B-G channels. Furthermore, the encoding of these three channels (into NTSC) will produce a neutral (luminance) signal (by means of a matrix) which is composed of the proper proportions of each channel. As a matter of routine adjustment, the electronic gain control of each channel is changed in order to compensate for spectral response variations which may occur with different vidicons and/or different lamps in the projector light source.

In the 4-V type of film camera, the neutral (luminance) signal is derived from the added (fourth) channel instead of a matrix in the encoder. In this case, the luminance signal is determined by the summation of the spectral responses of (1) the projector light source (2) luminance channel spectral response filter (if any) and (3) the vidicon. Thus you can see the neutral (luminance) signal is determined optically and is independent of the settings of the electronic gain controls of the three color channels. The equation for the luminance portion of a properly encoded NTSC signal is given in Figure 1.

It is essential for correct and "believable" color response in the 4-V system that any necessary adjustments to the luminance spectral response be made in the optical section of the luminance channel to match the NTSC specifications (Fig.1). A suggested procedure for this adjustment is as follows:

It is assumed the film chain is otherwise correctly aligned particularly with respect to uniformity of illumination at the gate of the projector both in intensity and color temperature (variation of intensity and variation of difference in intensity between red and blue portions of the spectrum should not exceed plus or minus 1 db across the gate). Gamma correction adjustments should be normal (0.7). Using a neutral stairstep test slide of normal density range, the signals from the four camera systems should be

adjusted to equal values of 100 IRE units. No setup should be used for this test so that black or zero signal is at zero units on the oscilloscope scale. White reference would be at 100 units.

A green filter (Wratten 58) is then placed in the light path from the projector (all four vidicons). The main gain control (optical not electronic) should now be adjusted until the signal in the green channel is again 100 IRE units. The value of the luminance signal under these conditions should be read and noted. The same procedure should be followed using a red (Wratten 23A) and then a blue (Wratten 47B) filter. These particular filters closely approximate the respective spectral response specifications of the NTSC for the three color primaries. Readings obtained in this manner on a correctly aligned 3-V film camera would be 59 IRE units for green, 30 IRE units for red and 11 IRE units for blue which is in conformity with Figure 1.

In the case of the 4-V film camera, the luminance channel matrixing is done optically and prior to gamma correction. Consequently, the readings obtained in the aforementioned test will usually be higher in value than those obtained on a 3-V film camera. Figure 2 shows a comparison of 3-V and 4-V luminance channel readings. The calculated 4-V values are based on the luminance (fourth) channel having a spectral response in conformity with NTSC (illuminant "C"). The measured values indicate that on this particular camera the spectral response of the luminance channel is excessive in the red primary.

The effect of higher than NTSC specified luminance readings is to produce a de-saturated color for those primaries out of specification. If correct values of primary color signals are not obtained, color correction filters of appropriate characteristic should be applied to the light input to the luminance camera and the test above repeated. Recommended color correction filters are given in Figure 3. Figure 4 shows measured results obtained by operating the luminance channel at values less than 100 IRE units for peak white. As a result of subjective evaluation of these tests, present ABC operational practice is to set luminance at 90 IRE units maximum corresponding to simultaneous maximum readings of 100 IRE units on each of the three color channels. The oversaturated blue obtained at the 80 IRE point was more objectionable than the slightly de-saturated green and red at the 90 IRE point. Level riding on program material is, of course, made in the usual manner using 100 IRE units as the maximum value of reference white for the luminance component of the signal. Care should be taken to see that adjustment of the luminance vidicon is such that its maximum capability of 100 IRE units is preserved, prior to setting the 90/100 ratio.

Concluding Remarks: Although satisfactory subjective performance has been achieved by the methods outlined, it is hoped that this solution is only temporary, and that a simpler and more direct scheme can be incorporated into the basic design of the 4 tube camera. The author wishes to express his gratitude to R. M. Morris for his guidance and assistance in the preparation of this paper.

Bibliography:

1. Principles of Color Television, McIlwain & Dean, 1956
John Wiley & Sons

2. A New Approach to a Color Film Channel,
Irwin C. Abrahms, NAB 1963

$$Y = 0.59G + 30R + 0.11B$$

Fig. I LUMINANCE PORTION OF NTSC SIGNAL

PRIMARY	NTSC	3-V	4-V	
			CALCULATED	MEASURED
GREEN	59	59	88	84
RED	30	30	45	66
BLUE	11	11	13	11

Fig. 2 LUMINANCE CHANNEL RESPONSES

FOR EXCESSIVE RED	CORRECTION	FOR EXCESSIVE BLUE
CC CYAN 0.05	1 db	CC YELLOW 0.05
CC CYAN 0.1	2 db	CC YELLOW 0.1
CC CYAN 0.2	4 db	CC YELLOW 0.2

Fig. 3 RECOMMENDED COLOR CORRECTION FILTERS

PRIMARY	CALCULATED	MEASURED				
		UNCORRECTED 100 I.R.E. UNITS	CORRECTED 100 I.R.E. UNITS	CORRECTED 90 I.R.E. UNITS	CORRECTED 80 I.R.E. UNITS	CORRECTED 70 I.R.E. UNITS
GREEN (59 BY NTSC)	88	84	80	72	63	54
RED (30 BY NTSC)	45	66	41	37	31	26
BLUE (11 BY NTSC)	13	11	14	11	9	7

Fig. 4 4-V LUMINANCE CHANNEL RESPONSE

THE SMPTE COLOR TELEVISION SUBJECTIVE REFERENCE TEST FILMS - ISSUE #2

Report prepared for the Society of Motion Picture
and Television Engineers by the Society's joint
Subcommittee on Color Films for Color Television,
John M. Waner, Chairman

For those of you unfamiliar with the SMPTE -- the Society of Motion Picture and Television Engineers founded in 1916 -- it is a non-profit, scientific and educational organization of over 6,500 members encompassing over sixty countries. Members are engineers, scientists, technicians, and executives in motion pictures, television, instrumentation and high-speed photography, and educators and others in allied fields.

Among its many goals and aims, the Society formally prepares and sponsors industry recommended practices and American Standards as a function of one or more of the various engineering committees with final approval for submission voted by the officers and Board of Governors.

Today I would like to present to you the results of nearly four years of work on the part of a joint Color and Television Engineering Subcommittee as a recommended industry practice for color film for color television.

Briefly, the subcommittee was formed in July 1962 to determine recommendations for the density and contrast range for color film in its use for color television broadcasting and to prepare recommendations and to give assistance in the procurement of a standard set of SMPTE color test slides for use by the industry.

A subsequent assignment for the preparation of motion pictures in both 35mm and 16mm was added.

During the subcommittee's work, it became evident that optimum control of release print contrast and density range could best be achieved by careful control of the original photography. Therefore, it was felt essential to provide an appendix to any future recommended practice which would discuss in some detail the proper approval for photography of color films for color television. An article entitled "Considerations in Color Film Production for Color Television" was presented as a joint subcommittee report and was printed in the May 1964 Journal of the SMPTE, Volume 73, No. 5, pages 411-414.

Also, as a result of the subcommittee work on transmission of various color release print films, Dr. Henry N. Kozanowski, RCA, prepared the article entitled "Infrared Transmission Characteristics of Various Color Release Prints and Their Effects on Color Television," which was printed in the November 1964 Journal of the SMPTE, pages 939-940, as a report to the parent engineering committees.

The test footage consists of seven interior (both day and night) scenes and was photographed on 35mm color negative; contact and direct reduction prints are now available. A set of eight slides printed from an eight-perforation format color negative is also available.

An agreement on the color balances of these materials was reached at the 98th Technical Conference of the SMPTE held in Montreal in November 1965.

These motion picture films are intended to fulfill two separate functions. First, in the color balance of the color scenes, these films are representative of that subjective balance which will give acceptable reproduction on color television and appear satisfactory in a properly set-up review room. In this regard film laboratories can use these films as a guide to a desirable color balance of prints intended for color television transmission. Second, these films can be used for subjective evaluation of color television film transmission systems after the chain has been properly aligned.

Prints made available by the SMPTE are monitored densitometrically and tolerances for acceptance are identical to or less than those published in the paper, "Considerations in Color Film Production for Color Television."

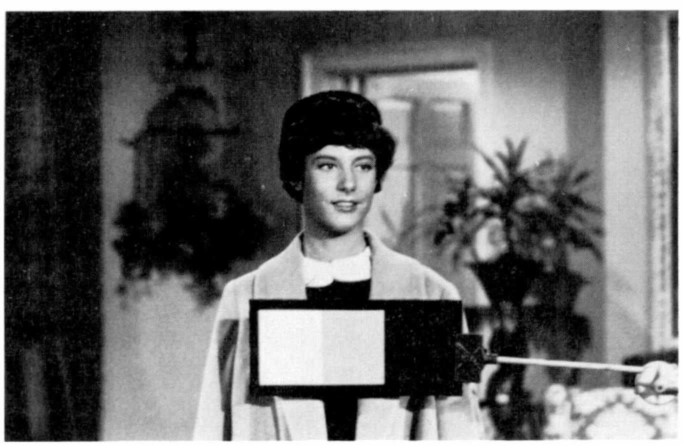
Test slides consist of eight 2 x 2 glass mounted slides using the identical scenes of the motion picture test films. The one additional slide (versus seven scenes in the motion picture reel) is included to give one scene printed on two different types of color release print material to make possible the test of the infrared transmission characteristics of the film-system combination.

It should be emphasized that these films and slides are designed for subjective reference and not as alignment tools to set up a color television film reproduction system. For this latter procedure test films and slides are either in existence or in preparation by the SMPTE.

Acknowledgments for contributions by individuals and companies are too lengthy to mention at this time but appear in an article in the February 1966 SMPTE Journal.

Seven Scenes from the Color Test Film and Slides

Scenes from the Color Test Film and Slides (cont.)



REMOTE OPERATION OF A HIGH POWER TELEVISION TRANSMITTING STATION

L.S. Lappin, Senior Systems Engineer
Radio Corporation of America
Gibbsboro, New Jersey

E.R. Hill, Director of Engineering
Kaiser Broadcasting
Philadelphia, Pennsylvania

D.R. Musson, Leader
UHF Transmitter Engineering
Radio Corporation of America
Meadow Lands, Pennsylvania

REMOTE OPERATION OF A HIGH POWER TELEVISION TRANSMITTING STATION

INTRODUCTION

After many years of successful operation of remote controlled AM and FM broadcast stations, the FCC, on May 6, 1963, put into effect rules permitting remote control of UHF TV stations. While remote operation of VHF TV stations is not presently permitted, it is being given serious consideration by the FCC.

The most obvious reason for remote control is, of course, the improvement of operational efficiency. Remote control is of special importance to a new UHF station starting up in an established VHF market with low UHF receiver penetration, where operating costs must be held to a minimum.

SYSTEM RELIABILITY

Extremely high reliability and stability of the equipment are of utmost importance in the successful remote controlled station because a minor fault resulting in a power shutdown can cause a considerable loss of expensive air time. The highest grade components and conservative design with adequate safety factors must be used throughout. Simplicity of circuits, wherever practical, must be stressed to reduce the possibility of failure and to shorten trouble shooting time, when it becomes necessary.

Of even greater importance, than in the locally controlled station, is regularly scheduled routine preventative maintenance, the main purpose of which is to anticipate a potential failure and take corrective action before losing air time. A carefully planned maintenance schedule, based on the manufacturer's recommendations, will result in a significant reduction in off air time. In many cases, reliability can be improved through the use of duplicate facilities; such as, parallel transmitters which provide, in effect, an operating standby transmitter.

In the event of complete failure of one unit, the remaining unit continues to operate with a radiated power one-quarter of normal. By the addition of automatic or remote controlled switching, the radiated power can be maintained at one-half of normal until repair of the defective unit can be accomplished. Loss of air time, due to power failure, can be minimized by the use of a standby generator with automatic change-over. Redundancy in the remote control system is seldom required for normal system application, due to the reliability of the equipment.

UHF-TV REMOTE CONTROL

The FCC Rules for remote control of UHF-TV transmitters are quite similar to those for AM and FM transmitters, and basically are intended to ensure the complete control of the transmitter by the operator at the remote point, and that the radiated signal meets the technical requirements of the Rules. In fact, the remote control system to be discussed is considerably simpler; and, in some respect, more stable than the typical directional AM station with its critical ground system, multiple towers, common point and base currents, and tower lighting currents.

In December, 1965, Station WKBS in Philadelphia operating on Channel 48, with a transmitter power of 30 KW became one of the first high power UHF television stations to operate by remote control, and since the latter part of January, the transmitter has been operating completely unattended. This system will be discussed as a typical remote controlled TV station. Variation may be found from station to station, due to unique requirements. However, most of the equipment and circuits used at WKBS will be required at all stations to meet the requirements of the FCC.

CONTROL EQUIPMENT

Control of the transmitter is by means of the RCA BTR-20C Remote Control Equipment. Twenty control and metering functions are provided by means of two d-c telephone lines between a studio and transmitter, with a loop resistance up to 5000 ohms. Satisfactory performance can be obtained at distances greater than twenty miles.

Simplified schematic diagram of the remote control equipment is shown in Figure 1. Five basic signals are required to perform the control functions; a high level positive signal used to actuate the studio and transmitter stepping switches controlled by a pulse generator, a high level negative signal used to home or synchronize the two stepping switches, low level positive and negative signals to perform the "ON" and "OFF" operations respectively, after the desired function has been selected, and finally an AC fail-safe signal used to shut down the transmitter in the event of loss of control of the transmitter due to failure of the control telephone line, or loss of remote control power.

The studio is located near the business center of the city, and all programming and operating controls are centered in the master control room. In addition to the usual control room equipment, there is a single rack containing the remote control equipment. The transmitter is located at a distance of about 11 airline miles from the studio in the highest part of the city with an antenna approximately 1100 feet high. The transmitter is a TTU30A, 30 KW transmitter operated at rated output. The remote control equipment at the transmitter consists of three rack mounted units, and occupies only a small portion of a rack. Programming is transmitted from studio to transmitter by means of an STL microwave link, and remote control functions are carried on two dc land lines.

CONTROL EQUIPMENT OPERATION

Figure 2 is a block diagram of the remote control system. The BTR-20C remote control studio unit is the master unit, and is located in the master control room. All transmitter controls originate at this point and all transmitter metering signals are read on the remote control multimeter or the associated monitor meter panel. At the transmitter, the BTR-20C remote control transmitter unit selects the desired function and, on command, performs one of the eight transmitter control or tower lighting functions. Simultaneously, the selected metering function is displayed on the appropriate studio meter. Ten metering signals are provided, six originating in the transmitter, three in the TV monitor and the tower lighting current.

For maximum accuracy and freedom from extraneous telephone line noise, all metering functions have been standardized at 200 microamperes dc corresponding to a full scale meter reading. In several of the metering functions to be monitored remotely, such as

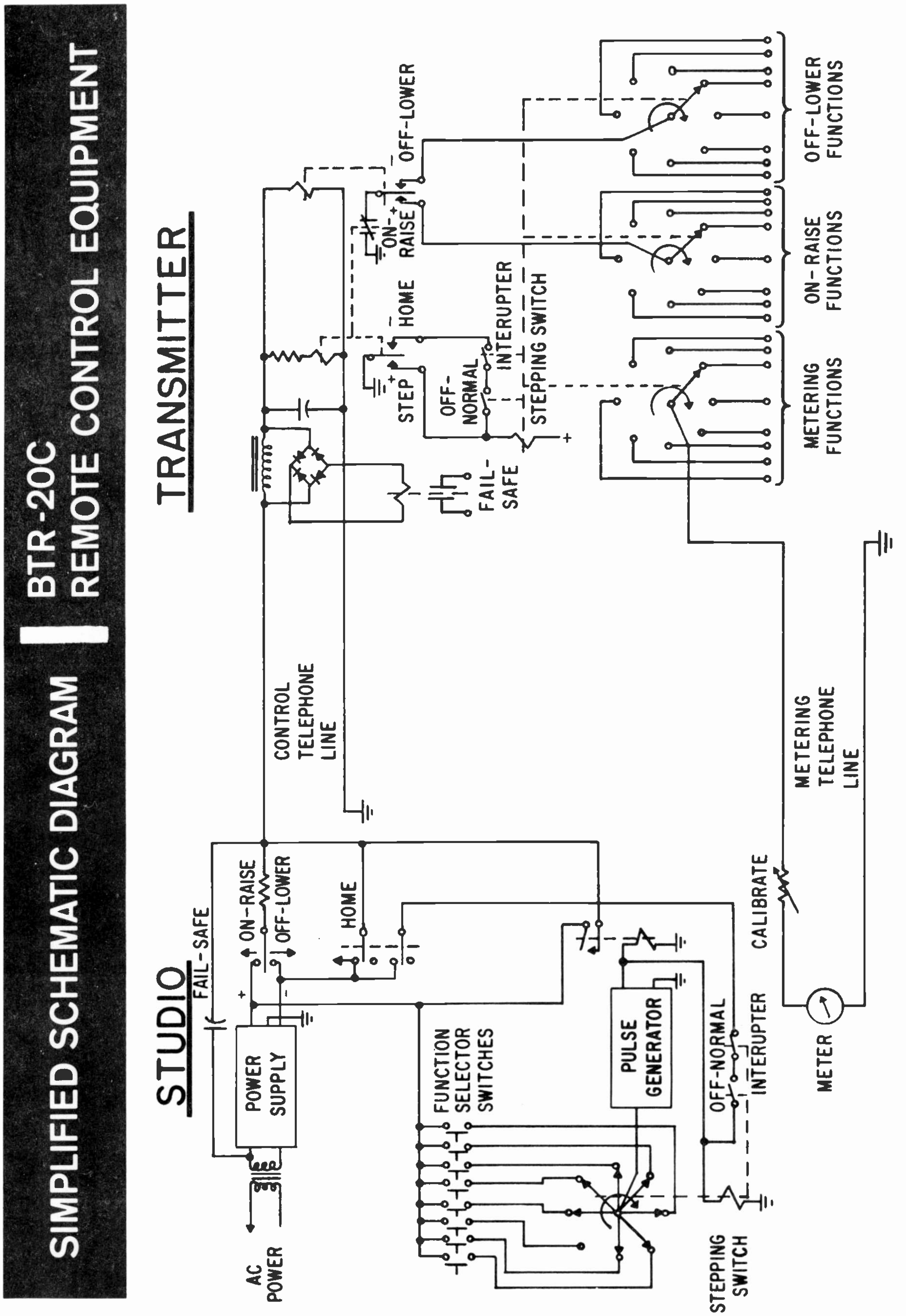


Figure 1—Remote Control Equipment, Simplified Schematic Diagram

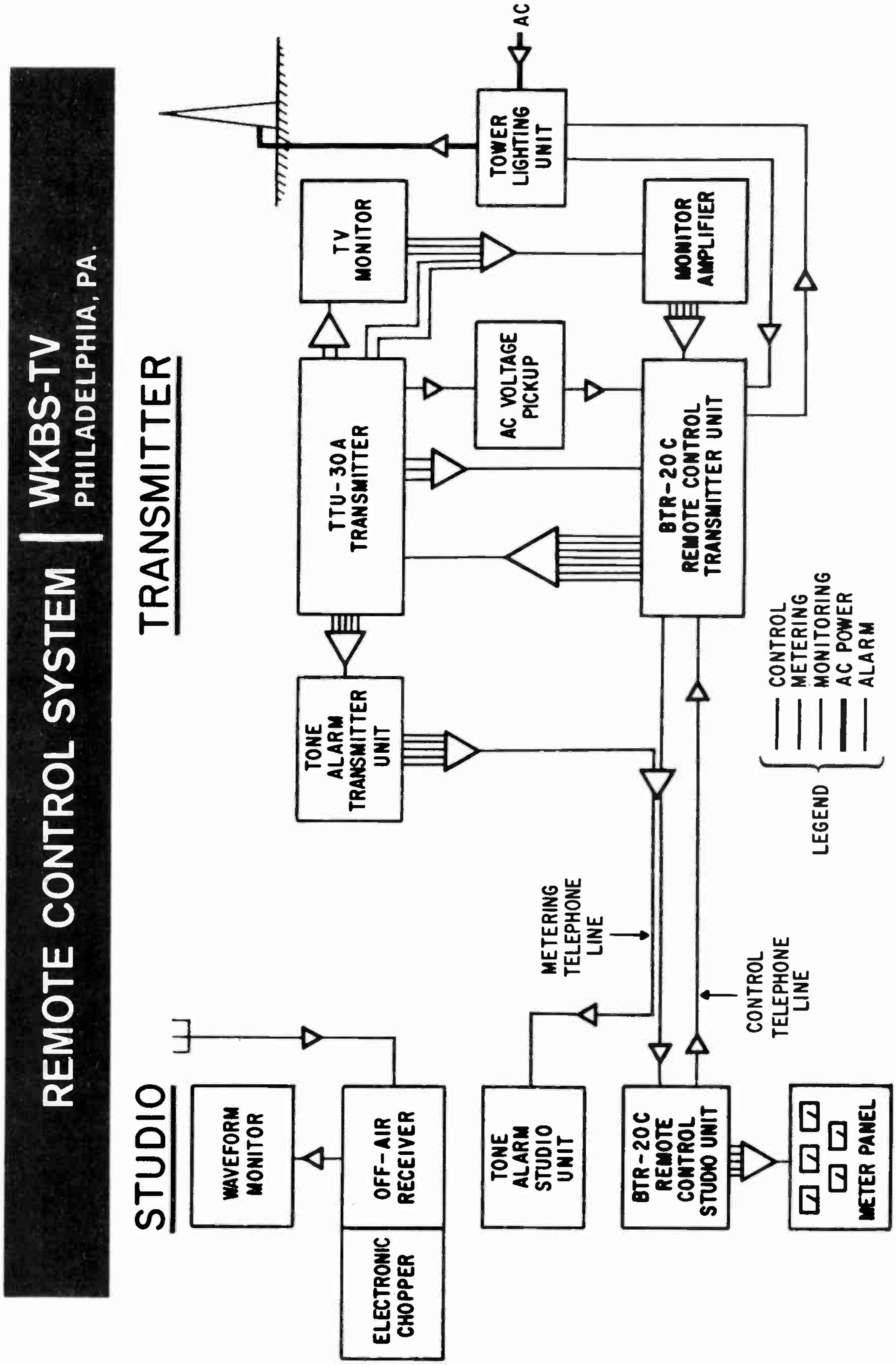


Figure 2—Remote Control System, Block Diagram

frequency deviation, power output and aural modulation, the available current is as low as 20 microamperes. To permit remote metering of such low currents, plug in solid state operational amplifiers connected as current amplifiers are used for these circuits. Very heavy feedback is used which results in extremely stable operation. Five amplifiers are used for the five signals and at the studio, a separate meter, suitably calibrated for the signal to be monitored is provided for each function.

The requirement for observing the waveform of the visual signal is met by an off air receiver at the studio, and a waveform monitor with an electronic chopper which chops only during the vertical blanking interval. Chopping may be continuous since it is synchronized with the video signal and does not affect the display on the picture monitor. Thus, the radiated picture may be viewed on the picture monitor without distortion, while the base-line appears on the waveform monitor. The operator at the studio, therefore, has all of the necessary information with which to adjust the video gain, blanking level and visual excitation by remote operation of the motorized controls in the transmitter.

Control of the tower lights is by means of a remote operated latching contactor in the lighting circuit, and metering is accomplished by rectifying the output of a current transformer connected in series with the lighting line, and adjusted to give an arbitrary reading on the remote meter.

In addition to the control and metering functions, a tone alarm system permits the automatic display of five abnormal alarm conditions by means of lights and a buzzer. The alarm tones are in the low audio frequency range and are superimposed on the metering telephone line, so that a separate line is not required. Additional alarm functions may be obtained by the addition of a second tone alarm system to the control line.

CONTROL AND READ OUT FUNCTIONS

The remote control functions are listed in Figure 3. The normal start up sequence of operations is first to home the system by pressing the HOME switch. This ensures the synchronization of the studio and transmitter stepping switches. Next, the telephone line resistance is calibrated by means of a front panel control and the panel meter. Pressing function 2 switch selects the TRANSMITTER ON/OFF AND FILAMENT VOLTAGE circuits, and operation of the ON-RAISE switch starts the transmitter and the remote control multimeter reads the filament voltage to indicate that the desired switching function has been accomplished. After the necessary time delay, the next function may be selected and the high voltage turned on, and the collector voltage read and recorded. The next two functions are for visual and aural collector currents. In the event of an overload, the circuit may be reset by using function 4. The visual excitation, blanking level and video gain may now be adjusted using functions 6, 9 and 10, while viewing the visual output meter and the chopped waveform. Aural output power is adjusted by function 7 by varying the aural excitation while observing the output meter. Functions 11 and 12 are used to read frequency deviation and function 13 is used to control the tower lights and read the tower light current. Finally, the aural modulation level is read on function 14.

Whenever the remote control equipment is not otherwise used, the aural modulation should be monitored. Whenever practical, control functions are associated with the most meaningful meter reading, so as to be most useful in making adjustments or to indicate that the desired control function has been accomplished.

REMOTE CONTROL FUNCTIONS

FUNCTION	CONTROL	METERING
1	SPARE	CALIBRATE
2	TRANSMITTER ON/OFF	FIL. VOLTAGE
3	H.V. ON/OFF	COLLECTOR VOLTAGE
4	O.L. RESET	COLLECTOR CURRENT (VIS.)
5	SPARE	COLLECTOR CURRENT (AUR.)
6	VIS. EXCITATION RAISE/LOWER	OUTPUT (VIS.)
7	AUR. EXCITATION RAISE/LOWER	OUTPUT (AUR.)
8	————	SPARE
9	BLANKING LEVEL RAISE/LOWER	OUTPUT (VIS.)
10	VIDEO GAIN RAISE/LOWER	OUTPUT (VIS.)
11	————	FREQUENCY DEV. (VIS.)
12	SPARE	FREQUENCY DEV. (AUR.)
13	TOWER LIGHTS ON/OFF	TOWER LIGHT CURRENT
14	SPARE	MODULATION (AUR.)
15-19	SPARES	SPARES
20	HOME	SPARE

Figure 3—Remote Control Functions

The alarm functions shown in Figure 4 are intended to call attention to an emergency condition which demands immediate attention. In addition to the individual lights, a buzzer can be made to operate as desired when any, or all, of the alarms are actuated. The alarmed functions are Klystron Body Overload, VSWR overload, Power Supply Overload, Water Overtemperature and Loss of AC Power. It may be desirable, in some stations, to add fire, forced entry, building overtemperature, and standby generator status alarms by the addition of a second alarm system.

RACK LAYOUT

The studio remote control rack contains the monitor meter panel at the top, then the BTR-20C remote control studio unit, picture and waveform monitor, tone alarm unit, and off air receiver. See Figure 5.

The transmitter remote control rack is shown in Figure 6. At the top is the remote control unit, below it the monitor amplifier assembly and then the tone alarm unit. The monitor amplifier assembly contains the five solid state plug-in amplifiers, and two plug-in power supplies.

INTEGRATION OF CONTROL EQUIPMENT AND TRANSMITTER

This remote station installation has proven that remote control of a UHF television transmitter is not only possible, but also highly practical. Now that the WKBS-TV remote system has been outlined, it is important to analyze the philosophy behind the remote operation of this UHF transmitter. The success of a remote operation stems largely from the proper integration of the control system and the transmitter. Each transmitter type has its own compatible control level, based on the design and operating concept.

Fundamentally, a television transmitter is more complex than an AM and FM transmitter. To avoid a cumbersome control system, maximum use must be made of a minimum number of control functions. Two methods are employed to simplify the control problems. First, the transmitter is called upon by circuit logic to provide self control. As an example, during start up a sub-system must be in complete normal operation before a succeeding system is automatically commanded to start. Secondly, a single function is designed to perform several operations simultaneously; thus eliminating duplicated effort, even though it is necessary to maintain individual control over one function of the group. For example, it is desirable to control aural and visual amplifier on and off functions simultaneously, and have a separate control to mute aural carrier for EBS operation. The start up sequence is simplified in this manner, but the aural carrier can still be controlled independently. Starting of all systems by serially sequencing them automatically on,in preparation for plate voltage application, is another control system simplification. Additional readout can be provided for status indicators in the subsystems; such as the cooling system, for example, but seldom do these provide additional information which would save an emergency trip to the transmitter. A transmitter ready light can be remoted, but is not mandatory.

On the WKBS installation, the basic group of functions; transmitter start, high voltage on and overload reset, provide all the essential operator control. Some might suggest that time delay bypass is desirable. In this installation, the transmitter contains a hold in relay which prevents filament circuit drop out for the time required for power station breakers

ALARM FUNCTIONS

FUNCTION	ALARM
1	BODY OVERLOAD
2	VSWR OVERLOAD
3	POWER SUPPY OVERLOAD
4	WATER OVERTEMPERATURE
5	LOSS OF AC POWER

Figure 4—Alarm Functions

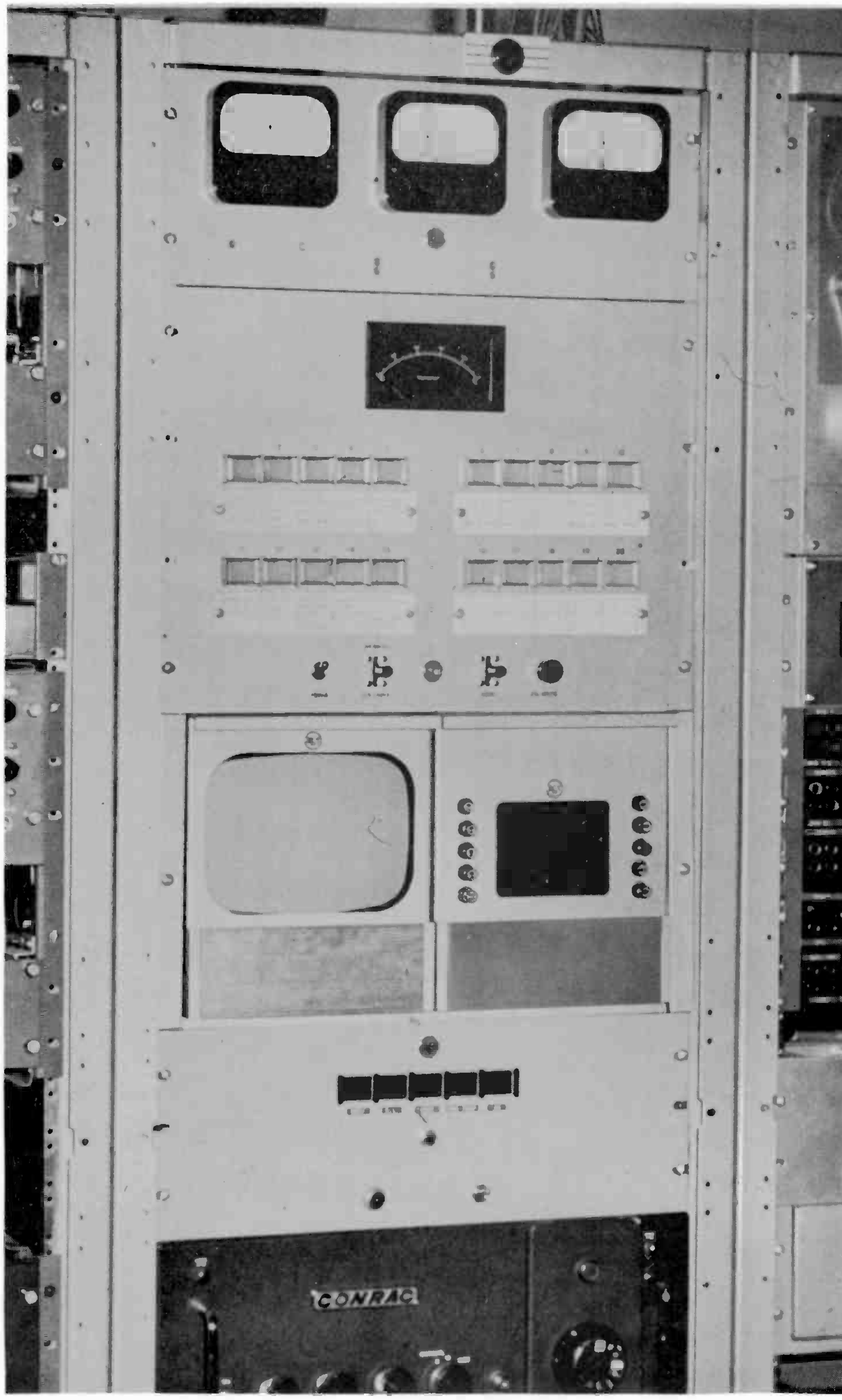


Figure 5—Studio Remote Control Rack

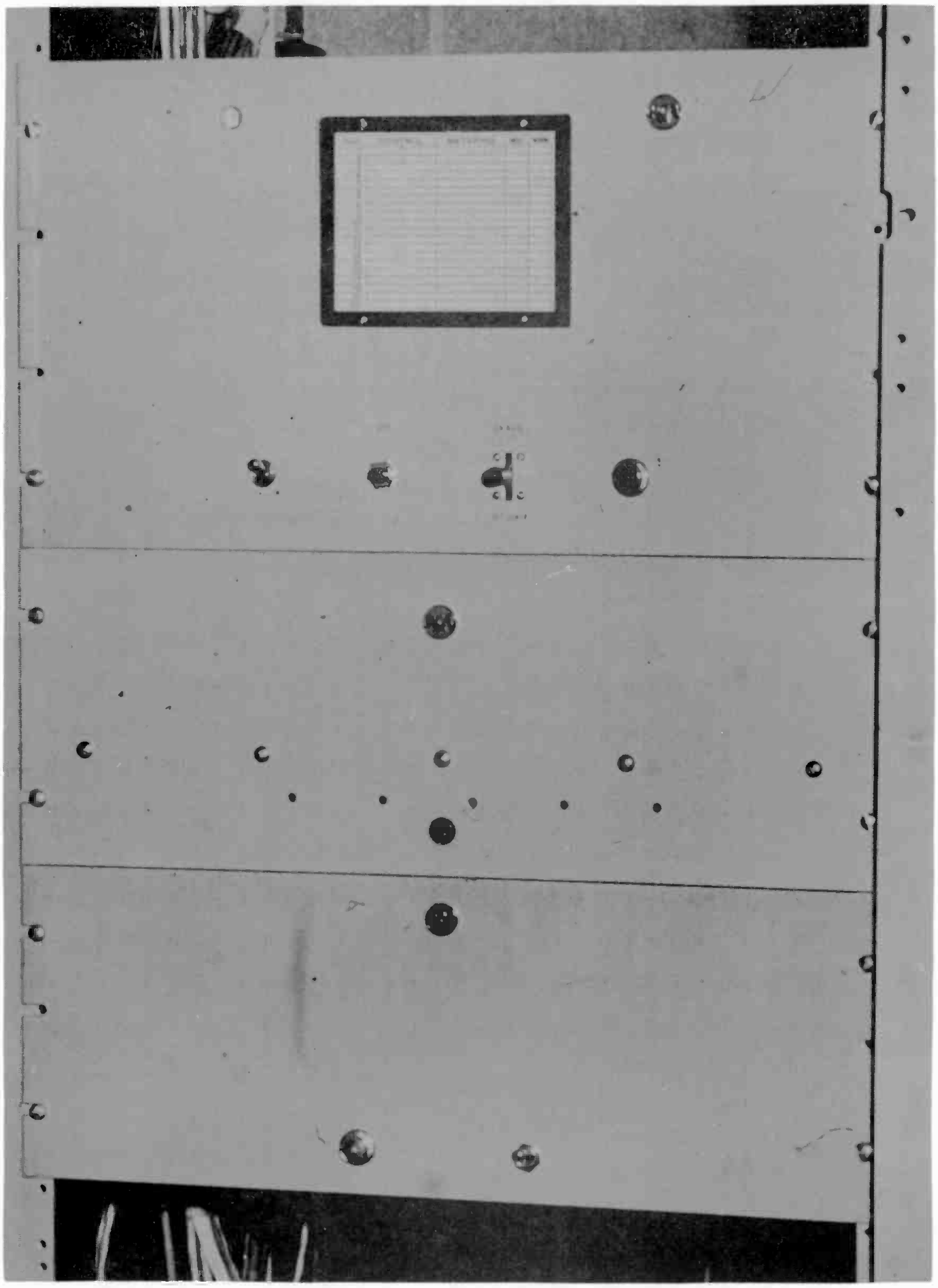


Figure 6—Transmitter Remote Control Rack

to recycle on power outages; this requirement, therefore, is less binding.

SUPERVISORY CONTROL DURING OPERATION

The second set of functions, fulfilling an integrated remote control plan are the necessary supervisories, and monitors for maintenance of an optimum television picture and sound transmission. Less obvious, yet more compelling reasons exist for careful appraisal of these control functions. More constraints are placed on the modulation system in the television transmitter, than those of the AM and FM remote control predecessors. Therefore, care must be taken to integrate the transmitter and its supervisory system to assure simple and effective control.

Two principles are used to simplify the video and r.f. control. Both have already been discussed as a part of the control circuit philosophy. First, place as much as possible of the burden of control on the transmitter itself. Secondly, make each control serve a multitude of functions. Some examples of self control can be taken from the means used to gain output power stability in the UHF klystron transmitter. The klystron amplifier saturates at a steady and predictable power output level as long as input DC power parameters are held constant. Hence, by regulating the overall power supplied to the transmitter, and driving the klystron to approximate saturation, the peak power output is greatly stabilized, requiring little, if any, supervision. A second example is stabilization of gain of the klystron amplifier. Slight changes in structural dimensions on the klystron amplifier results more as a change of gain than a change of response in the amplifier. By stabilizing the cavity and drift tube cooling water temperature using a temperature controlled mixing valve on the inlet, the cavity dimensions are made virtually independent of surrounding ambient temperature, and temperature of the air passing through the heat exchanger. This temperature control also minimizes start up drift.

Absolute stability is not practically attainable in a UHF-TV transmitter, but a great deal of the burden of stabilization can be placed on the transmitter itself. Those controls remaining, must necessarily be planned so as to provide maximum control, and be adjustable from a simple indicator. Since r.f gain stability is one of the more difficult long term characteristics to stabilize in a high power transmitter, particularly at UHF, some supervision is desirable over periods of time. To adjust for variation of gain in the linear amplifier circuits, an excitation control is desirable. This can be used to correct for gain differences in the amplifier chain and should idealy not affect the overall performance of the system. A motorized attenuator following the modulated amplifier is used for r.f. gain or excitation control in the WKBS transmitter. It has virtually no effect on differential phase or gain of the system, and little effect on the frequency response with 10 db of control, hence is used to correct for gain changes from many sources. The video modulation monitor and power output meter provide the necessary indication. Video gain control is provided to maintain proper modulation levels and to compensate for all variations of video levels; although these are usually only experienced ahead of the transmitter. If this control is included in a remote control system, it should be located ahead of gain and phase pre-emphasis. The system linearity is then not a function of the setting of this control.

There are also parameters which must be observed to assure minimum operating costs. Included here is the careful management of heater power in the power amplifier tubes. Operation just above the knee of the emission curve for the UHF klystron cathode can pay great dividends in life expectancy for the tube. Of first importance is regulating the input

power to the heater. Secondly, practical management requires a reading accurate enough at the remote location to indicate when an increase of heater power is dictated on an aging filament, without first suffering loss in emission. With regulated voltage, the desirable remote indication is heater current to establish a given threshold heater power. With this current indication accurately available at the remote location, judicious management is practical.

In addition to the individually metered circuits, several warning devices are typically included in any high power transmitter remote system. They are generally not unique to television transmission, but warrant mention in a typical system. Physical security, fire detection, and building overtemperature are often included. When the transmitter includes a major air system, it is desirable to detect restricted flow. On the WKBS system, a water overtemperature warning alarm circuit in the transmitter performs this function at a temperature low enough to allow travel time to the site to remove the air blockage. This type of system can anticipate a problem due to buildup of foreign matter deposited from the air stream, and prevent lost air time.

In general, any detection warning system should be planned to anticipate a major problem and allow time to act before air time is lost. Double locked doors, with the indicator on the outer door, might allow time for police to investigate a forced entry before transmission is jeopardized.

REVIEW OF WKBS-TV SYSTEM

Several of the principles for remote control of high power television transmitters are applied in the WKBS-TV installation. The station's objective was to provide adequate control and metering which could be expanded as desired. Refer to Figure 3. As seen by control functions 2, 3 and 4, the two step control sequence is used with the third overload reset operation included to augment a three shot reclosure system in the transmitter. Functions 6 and 7 control excitation to the final amplifiers for maintenance of optimum drive levels. The video modulation monitor assists in adjustment of visual drive. Functions 9 and 10 allow control of video modulation. Blanking level adjustment, though seldom required, can be used effectively when vertical interval test signals are available. The remaining metering completes the readings required. Warning functions have been applied to selected transmitter overloads, loss of primary power, and water overtemperature.

The WKBS-TV system represents a practical application of a remote control system to a high power UHF-TV transmitter. Although basic functions were made available in this system, many additional ones could have been included to provide more detailed information at the studio. Each transmitter station will have unique requirements, but those outlined in the WKBS-TV system are typically required.

We would like to thank Kaisėr Broadcasting for the opportunity to describe the remote control system at WKBS-TV Channel 48, Philadelphia, Pennsylvania.

ENGINEERING
DEPARTMENT
PUBLICATIONS
CBS TELEVISION NETWORK

CBS Stop Action Magnetic Video Disc Recorder

ADRIAN B. ETTLINGER
PRICE E. FISH

PRESENTED AT 20th NAB BROADCAST ENGINEERING CONFERENCE
CHICAGO, ILLINOIS MARCH 30, 1966

CBS STOP-ACTION MAGNETIC VIDEO DISC RECORDER

By Adrian B. Ettlinger and Price E. Fish
(For Presentation at the 1966 NAB Convention)

The past few years in television coverage of sports events have been marked by a number of advances in technique to give the home viewer a better understanding and enjoyment of the action. Football coverage, because of its commanding importance in network sports broadcasting, has been a major focal point for technical innovation. One important example is the isolated camera with immediate video tape replay, which was introduced by CBS on its broadcast of the 1963 Army-Navy game.

In early 1965, the CBS Sports Department, planning for the National Football League season of that year, wished to introduce a new element into the recorded replay technique to aid the viewer in comprehending the often complex and fast action of a football play. At this time, there recently had been introduced by MVR Corporation (Machtronics), a video disc recorder whose basic characteristics offered the opportunity of an equipment design which could be tailored almost precisely to the demands of the football replay operation.

A common technique long used in film presentations of football action has been the "freeze frame" by which a film sequence is interrupted to highlight a crucial instant of action by "freezing" the picture for a few seconds, after which the action resumes. The goal was established to accomplish this effect electronically so that it could be used on the immediate recorded replays of football telecasting.

There is a capability for an electronic "freeze-frame" effect in most helical-scan video tape recorders. This capability, although useful for industrial applications, has some serious disadvantages for broadcasting. When the tape is stationary, most helical-scan recorders will produce a readable still frame. However, the signal is characterized by a large horizontal noise bar. The position of this bar can be phased manually into vertical blanking, but in broadcasting operations, if the attempt is made to freeze the action of the replay while on the air, the noise bar can appear unpredictably in any part of the picture. Thus, for a "clean" operation, any freeze frame to be broadcast first must be previewed so that the noise bar can be phased out of the picture. The second disadvantage is that the helical-scan recorder freeze frame signal output is non-standard as to synchronizing signal format. The ratio of horizontal to vertical frequency is altered, such that the signal becomes non-interlaced, and the horizontal frequency is shifted slightly, usually downward, by one-half to one per cent. To standardize the signal requires a standards conversion process, with its attendant quality degradation.

The recording technique employed in the video disc recorder is one that has been used successfully for several years in digital recording applications associated with computer technology. The recording medium is a polished magnetic alloy plating on an aluminum disc. The recording head rides in direct but low-pressure contact with this disc. In the unit under consideration, the disc is twelve inches in diameter and rotates at 1,800 rpm.

Computer applications of this type of disc unit generally employ a number of fixed heads to record multiple continuous tracks. In the first demonstrated video application, recording was also on continuous circular tracks, but with a single movable head. With such a device, it is possible to store a number of fixed video frames, which may be selected by radially positioning the record/playback head.

CONTINUOUS RECORDING

The first key development leading to the final stop-action unit was a mechanism to provide the required head motion to create continuous recording capability. This mechanism takes the form of a lead screw drive to transport the head carriage assembly in the radial direction. The lead screw is driven by a worm drive directly from the disc drive shaft. This arrangement establishes a positive relationship between disc and head position, which insures accurate tracking. There are two control features in this mechanism (1) a pin-type clutch for disengaging the lead screw drive and (2) a method for disengaging the head carriage from the lead screw.

The worm drive ratio is 10:1, so that the lead screw rotates at 3 rps, or 10 television frames per revolution. With a track width of .004" and a guard band of .001", sufficient head travel is provided to permit a continuous recording of 20 seconds duration. This requires a total head travel of 3". These parameters result in writing speeds ranging from a maximum of approximately 1,100 inches per second at the outer periphery of the disc to a minimum of 565 inches per second. The direction of head travel was selected as "outside-in", based on the assumption that few recordings in practice would be of full duration, so that any deterioration in signal quality is preferred to be at the end, rather than the beginning, of the recording interval.

The head carriage disengagement feature is used to allow the recording head to move quickly back to the starting position after a partial or full recording is made. This feature, of itself, is of considerable value in football telecasting, since it is a solution to the operating problem of the time delay normally involved in recueing tape for an immediate replay. Any recording operation can be interrupted and a playback started with a delay only on the order of one second.

The lead screw drive disengagement feature is used to stop the motion of the head carriage assembly while a stop-action frozen frame is being transmitted. Stoppage of the head carriage permits continuous replay to be started again with the appearance of a resumption of the action from the point at which it was frozen by the stop-action effect.

STOP-ACTION CHANNEL

To achieve the stop-action effect, an additional record/playback channel is used with a continuous circular track. This track is on the underside of the disc, located near the outer edge for maximum writing speed.

For a satisfactory stop-action picture, it does not suffice merely to record and then repeatedly replay a single complete frame of the video signal. Particularly on fast-moving sports material, there can easily be sufficient displacement of portions of the image between the two fields of a complete frame to cause an objectionable degree of flicker in areas of motion. It is essential, therefore, that the video signal of one field only be used for the played-back stop-action frame. This can be accomplished by using two playback heads on the circular stop-action track, at opposite sides of the disc, and switching between them at the field rate. The angular displacement between the heads cannot, however, be exactly 180 degrees. Since the number of lines in a frame, or the number of lines on a complete track, is an odd number, if the heads were 180 degrees apart, when one head was reading a sync pulse, the other would be reading the center of a scanning line, so that there would be a half-line time displacement when a switch was made from one head to the other. The displacement between the heads, therefore, is made 180 degrees minus the angle corresponding to one-half of a line interval. When the displacement is set to precisely this value, it is possible to switch playback instantaneously from one head to the other with no time base discontinuity. The switching points are arranged so that both the even and odd vertical synchronizing intervals are played back by one head while the other plays back the video interval only. This switching pattern is essential to recreate the vertical synchronizing signal properly.

The angular displacement of the two heads is quite critical to permit switching without a time base discontinuity (.001" difference in position corresponds to approximately one micro-second in time). One of the stop-action heads, hence, is mounted on a micrometer screw positioning assembly permitting minute adjustments in its position in the angular direction. Both heads can also be positioned in the radial direction to permit some choice in the location on the disc of the stop-action track.

CONTROL SYSTEM

A marriage is required of the two recording channels thus far described into a system permitting the required operational control to alternate between continuous replay and the stop-action still frame. A series of events must take place to achieve the transition from continuous replay to stop frame, and vice versa. In going to stop frame, the actions are as follows and are illustrated in Figure 2:

1. A transfer recording is made on the stop-action track of a frame currently being replayed.
2. A switch is made to play back alternately from the two heads of the stop-action channel.
3. The lead screw drive is disengaged.

At this point, the continuous channel's playback is halted close to the point where it played back the selected stop-action frame. To revert to continuous play, the sequence is as follows:

1. The lead screw drive is engaged.
2. After a short delay to permit mechanical tracking stabilization, playback is switched back to the continuous channel.

   Figure 3 illustrates this sequence.

In this system, the transition to the stop-action frame is ideal, in the sense that the picture motion halts precisely on the frame being transmitted at the instant of the halt. In resuming continuous motion, however, there is a slight gap in the action since the switch back to the continuous head must be made after it has traveled slightly beyond the point where it played back the stop-action frame. The gap, however, is held to less than three video frames.

OPERATING FEATURES

The control panel of the unit includes, as operating controls, push-buttons designated "Record", "Play", "Freeze", and "Reset". In the "Reset" state, the record-playback head is at the starting position and the electronic circuits are in the "E-E" mode (or electronic-to-electronic), providing a check on the operation of the video signal path through the recorder. The "Reset" button can be operated while a recording is in progress. If a full 20-second recording is made, reset occurs automatically at the end. The "Play" button initiates playback of the continuous recording. The "Freeze" button may be operated at any time during a playback, and "Play", can, of course, be resumed while in the "Freeze" mode.

The control logic also permits use of the Stop-Action channel independently of the continuous recording channel. If the "Freeze" button is operated while in the "Reset" state, the Stop-Action channel will capture a frozen frame directly from the incoming signal. One useful aspect of this feature is that it permits the best possible quality of a played-back Stop-Action video signal, since the Stop-Action channel is in this mode making a first-generation recording, as against the usual second-generation resulting from "Freezing" the output of the continuous channel.

A block diagram of the major elements in the signal system is given in Figure 4. Signal routing is accomplished by relays for those functions, such as Record vs. Play, where precision timing is not required. For switching functions related to the "Play-to-Freeze" and "Freeze-to-Play" transitions, plus the head switching in the Stop-Action mode, electronic switching must, of course, be applied.

Electronic circuitry is completely solid state. The unit weighs approximately 40 pounds and measures 17" x 19" x 11". Power consumption is approximately 100 watts. Provisions are made for remote control operation.

APPLICATIONS

The stop-action recorder was initially used by CBS on the first pre-season NFL exhibition game broadcast of the 1965 season, a Baltimore Colts intra-squad game on August 6. Units were used subsequently on two or three games each weekend throughout the remainder of the NFL season. Other sports applications have been for basketball, skiing, and track meet coverage. The Stop-Action unit has also been used by the CBS News Division in its coverage of both Gemini and Saturn rocket launches from Cape Kennedy. Despite the difficult circumstances of the early period of application, involving constant shipment of the units to various locations around the country, the equipment has proven to be quite serviceable and adequately reliable in its operation, and its use has become a common feature of CBS sports broadcasting.

FIGURE 1 VIDEO DISC RECORDER

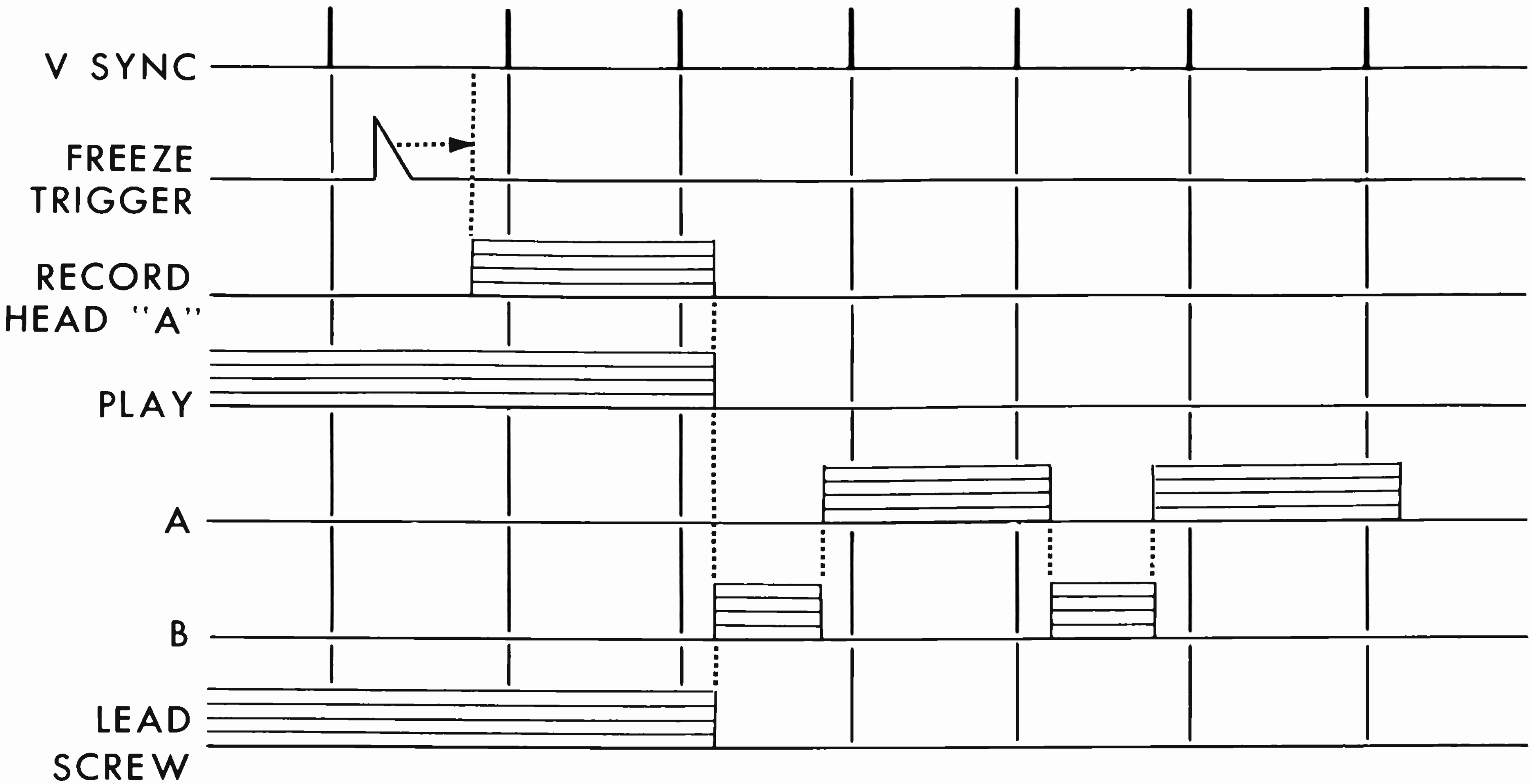


FIGURE 2

TRANSITION "PLAY" TO "FREEZE"

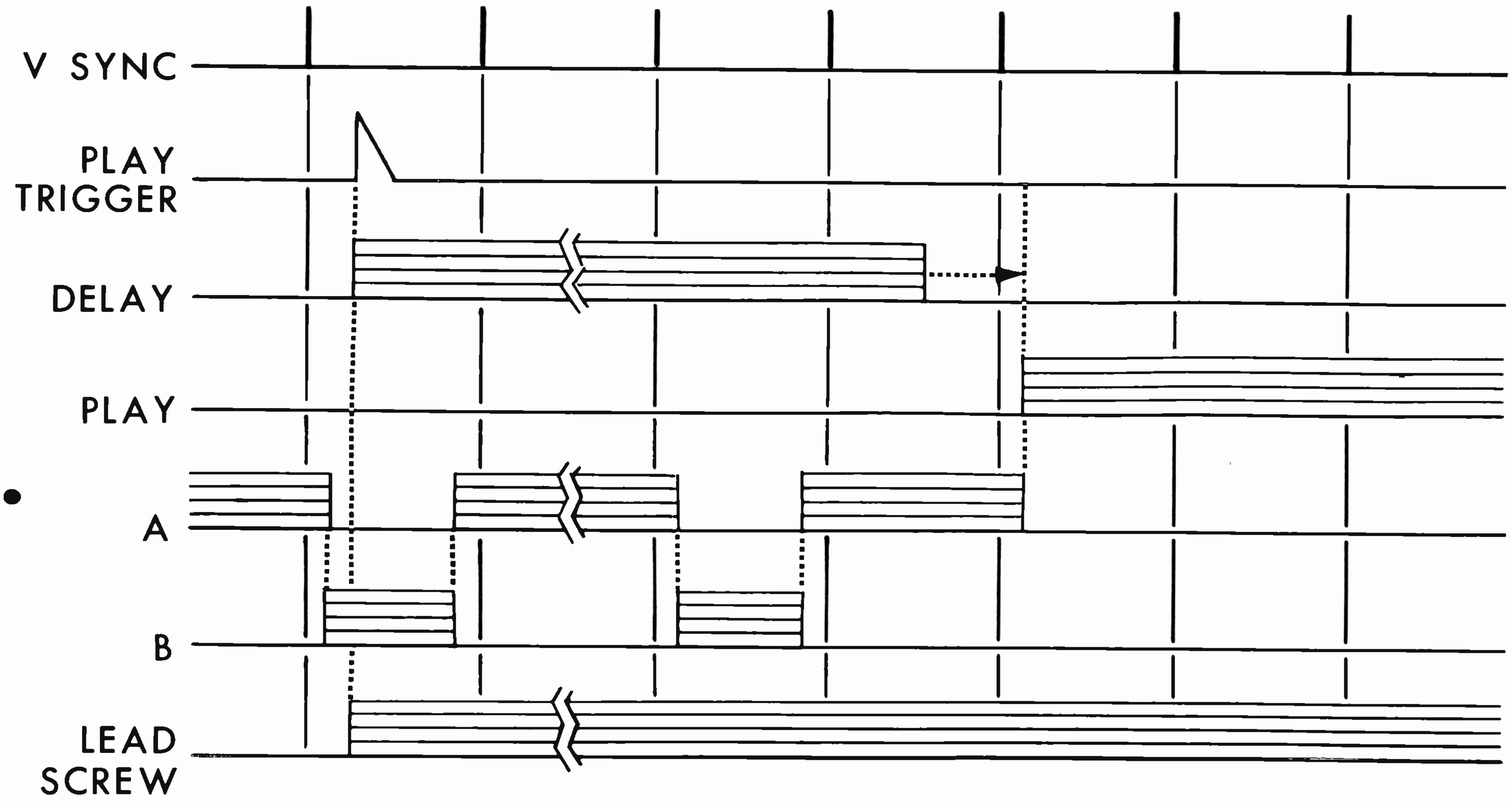


FIGURE 3

TRANSITION "FREEZE" TO "PLAY"

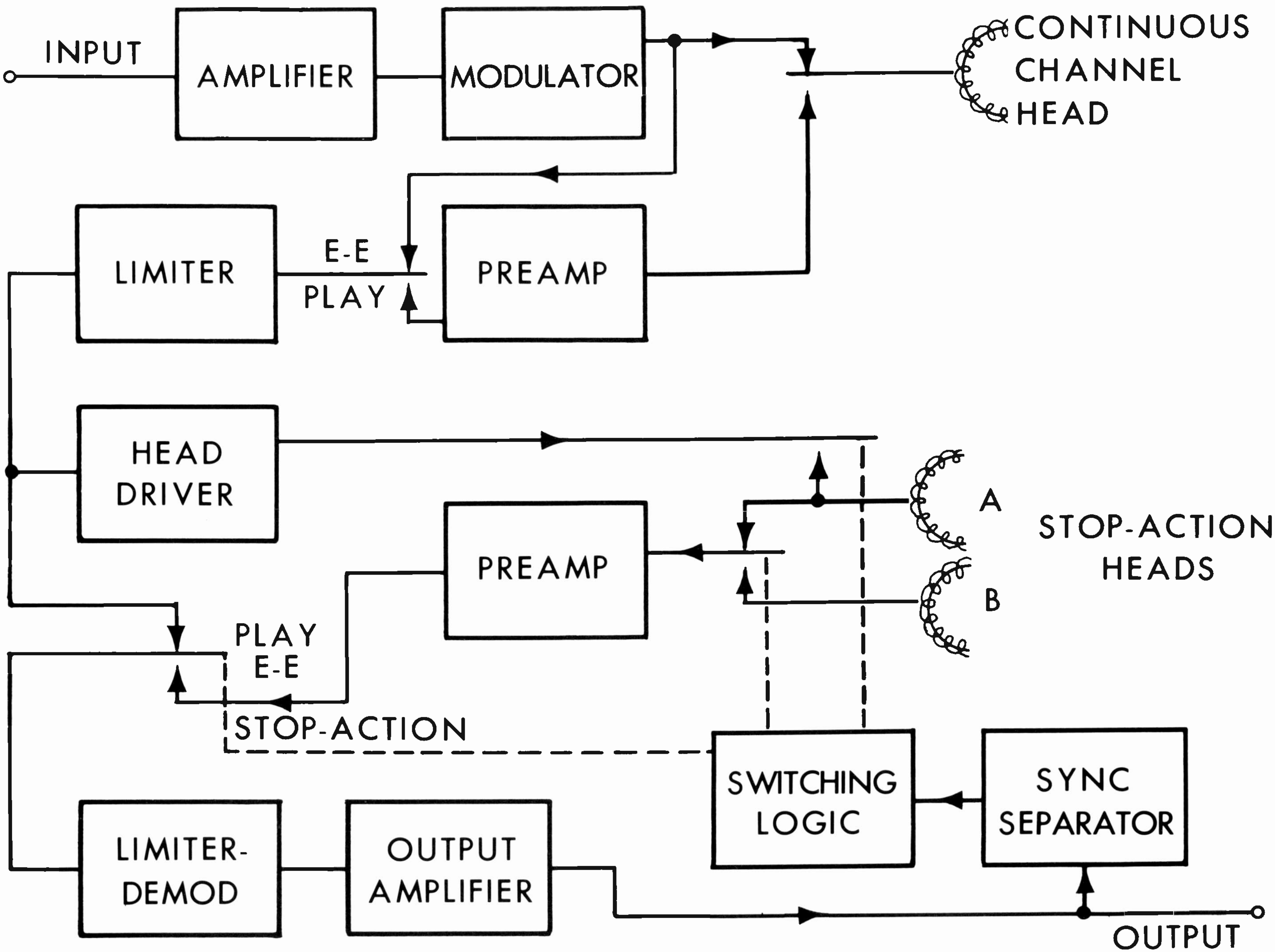


FIGURE 4 BLOCK DIAGRAM

VISUAL ELECTRONICS CORPORATION
356 WEST 40TH STREET, NEW YORK, N. Y. 10018 • (212) 736-5840

a technical paper

Keeps You in View

13 Rowdy

A PULSE ASSIGNMENT SYSTEM FOR MODERN TELEVISION BROADCAST PLANTS

A Paper Presented by

DONALD E. QUINLAN

Video Products Engineering Manager

Visual Electronics Corporation

New York, N. Y.

at the

14th ANNUAL IEEE-GB BROADCAST SYMPOSIUM

Willard Hotel Washington, D. C.

September 25, 1964

Modern television plants require not only isolated pulse distribution and an emergency changeover to standby sync pulse generators, but in addition require the facility to flexibly assign varying groups of equipment to different designated pulse sources for independent remote sync lock and VTR operations.

A simple solid-state pulse switching and distribution equipment has been designed to provide complete flexibility for remotely assigning any one of these sync pulse generator outputs to any group of equipment with no requirement for patching. The system provides undelayed pulses for color equipment and includes a 1.2 microsecond delay in pulses to monochrome equipments to compensate for color encoder delays. Of solid-state modular construction, it is comparable in cost to the old emergency changeover and multiple isolated pulse amplifier systems.

A PULSE ASSIGNMENT SYSTEM FOR MODERN TELEVISION BROADCAST PLANTS

Pulse Distribution Systems have been, up until recently, a somewhat neglected subject in the design and layout of television broadcast plants. Planners for some time merely adopted simple pulse systems which had been used previously without any great pre-thought and assumed that they would be adequate for a station's needs. New requirements for flexibility in modern television broadcast plants have invalidated this assumption. It may be of interest to trace the growing requirements that have evolved and a current unique equipment solution for providing for these innovations.

Early Stations

In the case of early small stations, the simplest pulse systems were used, due largely to the fact that the simple video paths could not possibly introduce much uncompensated delay. In those cases, often a slight pulse delay mismatch was overlooked, since the resultant horizontal shift of picture was small. Often the various cameras, both live and film, as well as switcher pulse requirements, were bridged across a common group of pulses. This, of course, had the added disadvantage that a short circuit in the pulse input of any one piece of equipment would cause that particular pulse to fail on all equipment inputs of the group. Besides this possibility of a common short, another disadvantage was that with every added piece of equipment bridged across the lines, additional capacitance was introduced with the inevitable degradation of pulse waveform.

Because of these reasons, most broadcasters in the past decade have chosen to put separate isolated pulse feeds to feed equipment groups - some even going to the extreme of providing a separate set of pulse amplifiers for individual feeds to each item of equipment. As shown on Figure 1, the usual arrangement has been for two sync generators, a main and a standby, with a changeover switch to select one or the other to feed a bank of pulse isolation amplifiers which in turn feed the separate groups of equipment.

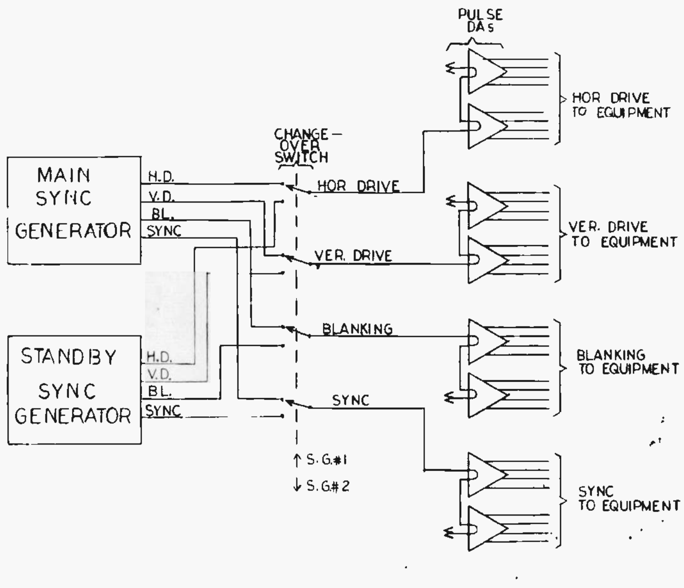


Figure 1. Typical TV Station Pulse System With Main and Standby Sync Generators.

Remote Genlock Requirements

Increased interest in pulse distribution and switching grew with the advent of more complicated programming of remotes such as ballgames, the political conventions, etc., with production requirements calling for superimpositions and effects such as split screens, etc., between remote locations and the station. In studio plants where individual pulse selection was not provided this involved genlocking of the entire plant to that remote location. In the past, if it was not desired to genlock the entire plant, it has often been the practice when such an occasion has arisen to physically disconnect the particular coaxial cables in question and on a "jury rig" basis make the proper connections. In the more sophisticated installations individual pulse output DA's for each pulse source per location have sometimes been used, for if both station pulses and genlocked pulses were to be handled at the sametime , two separate systems were required. Then, individual switches or patching were installed to select between the DA outputs.

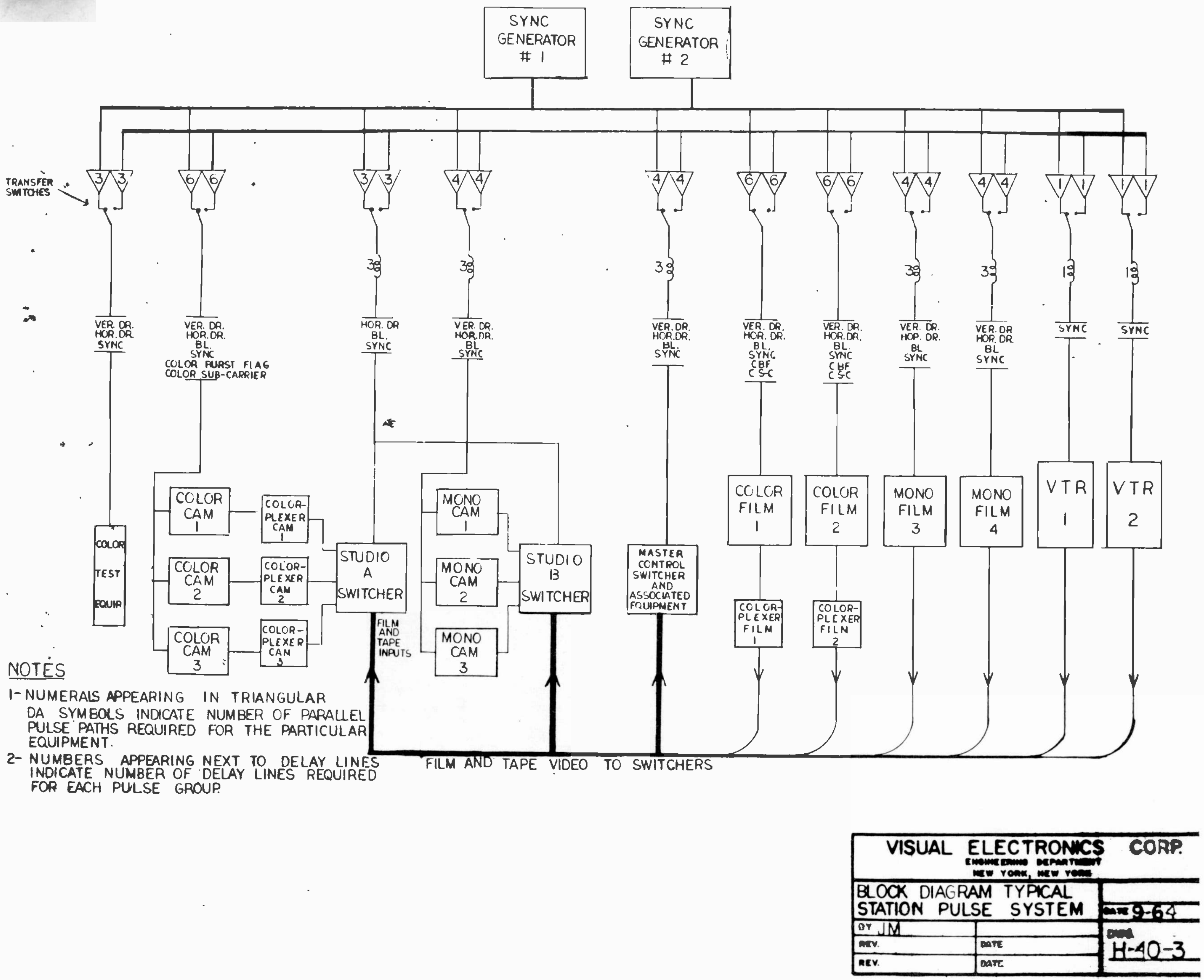
VTR Production Genlock

In addition to this remote genlock requirement, which was not too complicated to handle in one manner or another, next came the requirement of genlocking for video tape production. If the VTR machine could not be operated synchronous to the production facility, and if it was desired to mix or wipe the signal with a local production signal, the video tape production studio required a complete separate genlock group of equipment of its own for intergrating video tape, film, etc., into its production. In active stations, there was no assurance that this requirement would not occur at the same time at the remote genlock requirement. In fact, many stations with heavy video tape production schedules required the ability to flexibly assign varying groups of equipment to different designated pulse sources to provide for two or more independent simultaneous genlock operations. Thus, what could be accomplished with a simple "jury rig" now required a very complex "jury rig" or patching system. One early such system of pulse assignment by a relay switcher has previously been described in a SMPTE detailing the CBS local plant installation at KNXT Hollywood.

Pulse Delay Considerations

A further consideration in laying out pulse distribution and switching systems arises from the fact that although many new studios may now be planned to begin without color, none should be planned without providing for additon of color facilities, live, film and video tape in their future use. Let us consider some of the problems which should be recognized and dealt with in planning typical system.

Figure 2 shows a hypothetical single line pulse diagram of a typical two-studio television plant, one studio equipped for color and the other for monochrome. This particular plant contains four film chains and two tape machines. Two of the film chains are color chains while two are monochrome chains. The plant also provides for a master control switcher. Studio A is equipped with three color cameras with their colorplexers, while Studio B is equipped with three monochrome cameras. The plant is provided with two synchronizing generators, presumably a regular generator #1 and a standby generator #2. The standby generator could at times be utilized as a genlocked generator. Output switching for station pulse or genlock pulse feeds to each equipment is provided. As can be seen from Figure 2, each of the 11 pulse requirements - color test, Studio A color cameras, Studio A and B switching system, Studio B monochrome cameras, master control switcher, Film 1 (color), Film 2 (color), Film 3 (monochrome), Film 4 (monochrome), VTR 1, and VTR 2- can accept pulses from either sync generator #1 or sync generator #2, depending upon the conditions of the particular pulse assignment source select switch. (This is not a recommended system, but will serve to analyze the requirements being considered.)



NOTES

1- NUMERALS APPEARING IN TRIANGULAR DA SYMBOLS INDICATE NUMBER OF PARALLEL PULSE PATHS REQUIRED FOR THE PARTICULAR EQUIPMENT.

2- NUMBERS APPEARING NEXT TO DELAY LINES INDICATE NUMBER OF DELAY LINES REQUIRED FOR EACH PULSE GROUP.

Figure 2. Block Diagram of Typical Station Pulse System

Let us analyze this situation from the standpoint of pulse delays. It is necessary that all video signals, which are to be integrated together by a given switching system, be in phase with respect to the various synchronizing drive pulses if they are going to be processed together; i.e., mixed or combined in any type of effects. The video output signals of color camera chains as mentioned, pass through colorplexers where the color sub-carrier signal is added to the video. These colorplexers have considerable delay inherently built into them. Standard colorplexers commercially available today have built-in delays of approximately from 0.65 microseconds to 1.2 microseconds. These are equivalent to approximately 433 ft. or 800 ft. respectively, of standard video coaxial cable. Inasmuch as the pulse relationship of the video signal, after having gone through the colorplexer, should be in phase with that of the monochrome signals as well as with the processing signals; i.e., switching system, etc., it is necessary to delay all these other signals by an amount equivalent to that of the colorplexer delay. This can be seen on the diagram where we see delay lines inserted in the appropriate pulse feeds to all but the color cameras, both live and film, and the color test equipment pulse feeds (used in conjunction with color cameras).

Figure 2 shows as a single line each group of pulses to be routed to any given piece of equipment; i.e., in the case of the color camera chains, all six pulses - vertical drive, horizontal drive, blanking, sync (assuming a composite output is desired), color burst blag, and color sub-carrier. With respect to the studio switching equipment, three pulses are shown - horizontal drive, blanking, and sync (this will depend somewhat upon the processing equipment utilized), while only sync is shown as being provided for the VTR machines. By studying Figure 2, one therefore can appreciate that in order to determine the total number of pulse distribution amplifiers required for such a system, it is necessary to multiply each distribution amplifier, shown on Figure 2, by the number of pulses required by the specific equipment. The figure shown on the slide inside each DA triangle is that number of required parallel paths represented pictorially by that DA. If one totals the number of DA's on Figure 2, one discovers that there are a total of 84 such DA's. Similarly, one notices the large number of pulse transfer switches. The number of them in actuality is 42. We see also that a considerable number of delay lines is required - 17 to be exact. If one were to use coaxial cable, as many people do for delays, and if we assumed that the delay of the colorplexer was approximately 1.2 microseconds, there would be a total of 13,600 ft. of coaxial cable required. It can be appreciated that this configuration of equipment would occupy a considerable amount of rack space.

If we review such a system comprising tube-type DA's similar to what were in general use when most TV stations were initially set up, and which are still in use today by many broadcasters, we find almost 6 complete racks of DA's and power supplies required. To this is added perhaps another rack of transfer switches. The above does not account for the 2 1/2 miles of coaxial delay lines required. It is appreciated that it is now possible to cut down on the above equipment complement by utilizing some of the more recent multi-output transistorized pulse DA's, and/or perhaps by switching the inputs of the distribution amplifiers rather than the outputs and even by delaying some of the input pulses to certain whole groups of DA's. Even so, the total system would be cumbersome and would have to be specially engineered. It would include a considerable amount of time-consuming cabling and wiring both for the actual pulses and for the control wiring. Such a system, due to its complexity and size would be impractical for all but the most elaborate installations and still would not provide separate simultaneous genlocking of more than the two generators or the selection of other than these two generators as the pulse source for equipments. Many plants anticipate operations that will require at least 3 separate pulse sources and it can be seen that such a system as described would then become even more impractical.

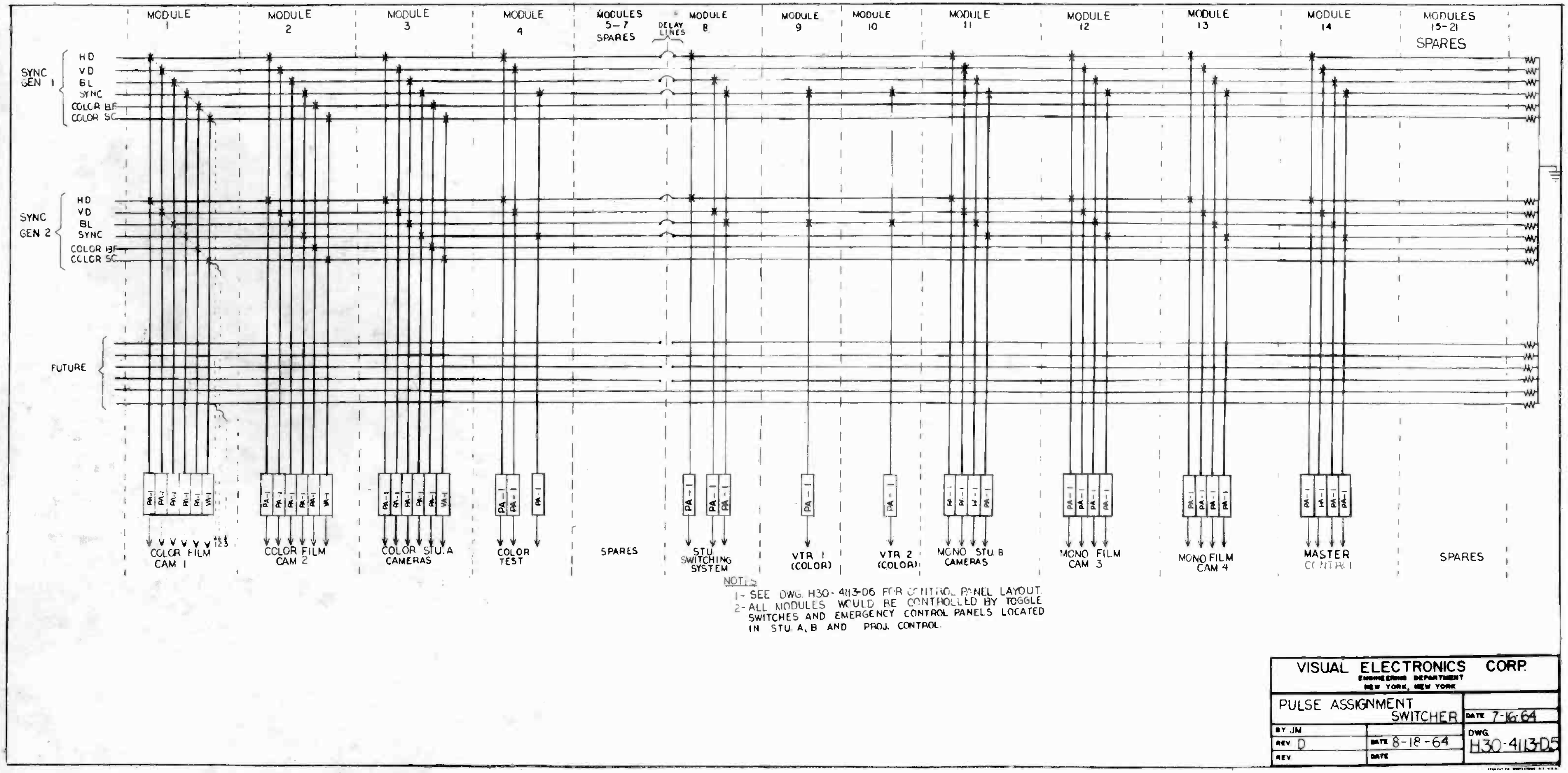


Figure 3. Functional Diagram of Visual's Pulse Assignment Switcher

A New Flexible System

In keeping with its policy of studying the problems of broadcasters and endeavoring to provide flexible, economical solutions, Visual Electronics Corporation has devised a system which will satisfy these requirements and provide for maximum flexibility at a reasonable cost.

The functional diagram of such a system is shown on Figure 3. It will be noted that the pulse output configuration provided by this system is identical to that required by the typical system shown on Figure 2.

We see that the six pulses from both sync generator 1 and 2 are carried by the sets of 6 input buses shown on the figure. Provision is provided, as can be seen, for the future addition of a third generator. Physically, these input pulse buses are on a printed circuit board. Tapping off from these buses are shown various high-impedance bridging crosspoints which when turned on feed the pulses to the inputs of pulse amplifiers. Figure 3 shows that the tap-off crosspoints are arranged in groups to feed to any one given piece of equipment tha group of pulses from any one of the sync generators. Modular printed circuit output boards contain the crosspoint groups and individual pulse output isolation amplifiers. As can be ascertained from Figure 3, up to 21 such modular output boards with feeds of up to 6 pulses each are accommodated. It will be noted, however, that only 11 output modules are utilized for this particular pulse assignment configration. Modules 5 - 7 and 15 - 21 are designated as future and can be added by simply plugging in an additional modular output board. In order to compensate for the previously mentioned colorplexer delays, the pulse buses for horizontal drive, blanking, and sync are broken and a suitable delay line inserted in each. All feeds being tapped off the buses subsequent to the delay lines thereby posses the necessary delay.

The output board incorporated sub-modular circuitry mounted on it to provide the number of crosspoints and output amplifiers required for that particular equipment. Each module output board can accommodate up to 18 crosspoint modules and 6 output pulse amplifiers which would provide for switching a complete group of 6 pulses from any one of three sources for feeding color equipments (color sub-carrier, color burst flag, H, V, BL, and sync). Groups of 4 pulses (H, V, Bl, and sync) are normally used for monochrome equipments. One pulse (sync) is usually all that is required for VTR feeds.

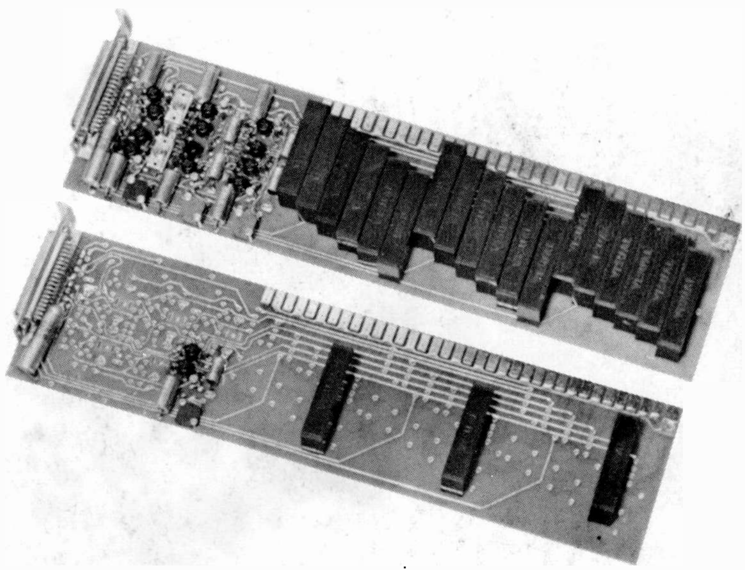


Figure 4. Module Output Boards in Two Different Sub-Module Configurations.

Figure 4 shows the module output boards in two different sub-module configurations. The board, shown at the sop, shows the crosspoints mounted on the board to handle the full six pulse complement. The circuitry for the six individual output units may be seen on the connector side of the board. This connector accommodates the output and control voltages, whereas the board printed circuit connectors accommodates the pulse inputs. The module board shown at the bottom of Figure 4 shows the configuration required for the selection and distribution of only one pulse from three sources. These would be utilized for feeding equipment requiring only a single pulse such as in the case of VTR machines requiring only sync pulses.

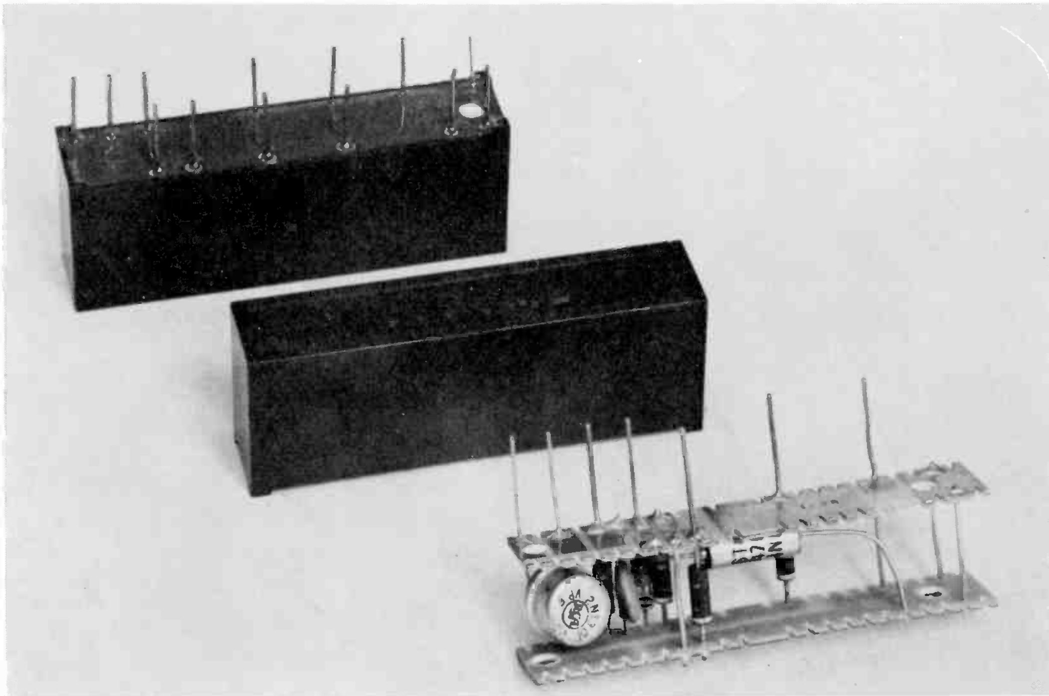


Figure 5. Type PSM Lap Switching Crosspoint Module

These crosspoints, shown on Figure 5, are the same patented transistorized bridging crosspoints used for some time with proven reliability in Visual Electronics' Type LS/8 Video Switching System, except that they provide a somewhat faster transfer.

Thus, the boards are made up with the crosspoint modules and pulse amplifiers mounted only where specifically required on the printed circuit output module board which contains the printed circuitry for the full crosspoint capacity. A 6 volt DC control voltage is all that is required to turn on the crosspoints. Control cabling is such that three individual DC circuits control three groups of 6 crosspoints, each associated with a sync generator input, thus providing a simple flexible remote control ability.

It should be noted that a video amplifier configuration, the VA-1 unit, rather than a pulse amplifier is required for the color sub-carrier. This is, of course, due to the fact that the color sub-carrier is a sinusoidal waveform whereas the other five signals are pulses. These amplifiers are single emitter-follower-type circuits with a low-impedance pulse driving source.

After appraising the requirements of many new and existing TV broadcast plants, it was believed that a total of 21 groups of pulses would fulfill the requirements of most broadcasters, and so it was decided to standardize on packaging the Pulse Assignment Switcher for 21 pulse output groups, each individually controllable.

Figure 6 shows such an equipment system rack mounted with the door shut and a remote control panel mounted below it. The switching and distribution system as shown, less control panel occupies only 31 1/2 inches of rack space.

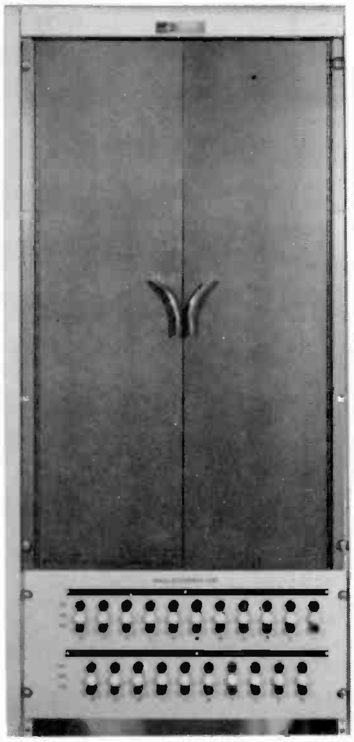


Figure 6. Visual Pulse Assignment Switcher Equipment Rack Mounted

Figure 7 shows the rear view of the switcher with standard U.H.F. type connectors mounted on the rear, as well as the required power supply to power the complete unit. As an optional feature in order to provide for complete protection should a power supply fail, a dual power supply configuration with a changeover between the two supplies is available. In this instance, the changeover unit is placed between the two rack-mounted power supplies. This changeover unit provides for feeding the system from either power supply # 1 or power supply #2. An automatic changeover feature is also provided, whereby if the supply feeding the system should fail, the changeover switch will automatically shift the load to the other supply.

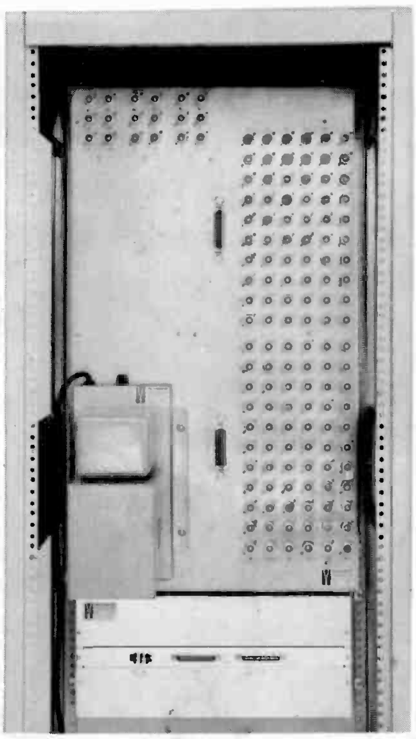


Figure 7. Visual Pulse Assignment Switcher Equipment Rack Mounted. Rear View.

In addition to the protection provided by the dual power supply configuration previously mentioned, additional protection is provided by separately fusing the main pulse assignment chassis in three parts; each fused portion would consist of seven output module boards along with its harness wiring. A short circuit, therefore, in either a board or the wiring between the fuse and the board will only disable a portion of the system and not the entire system.

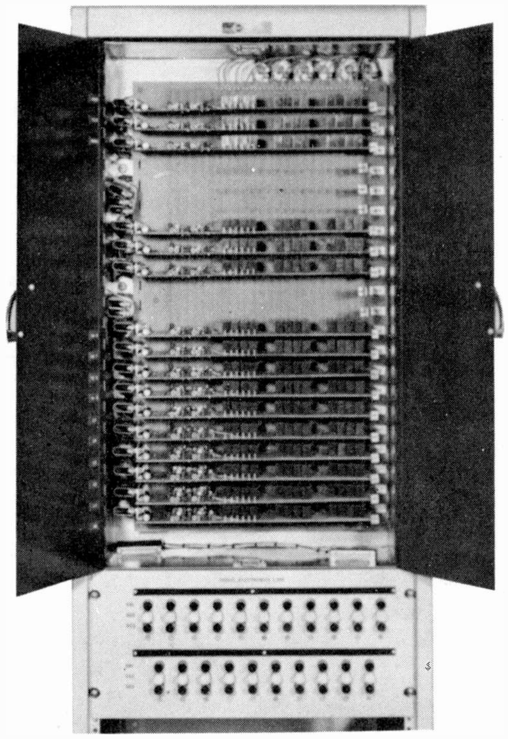


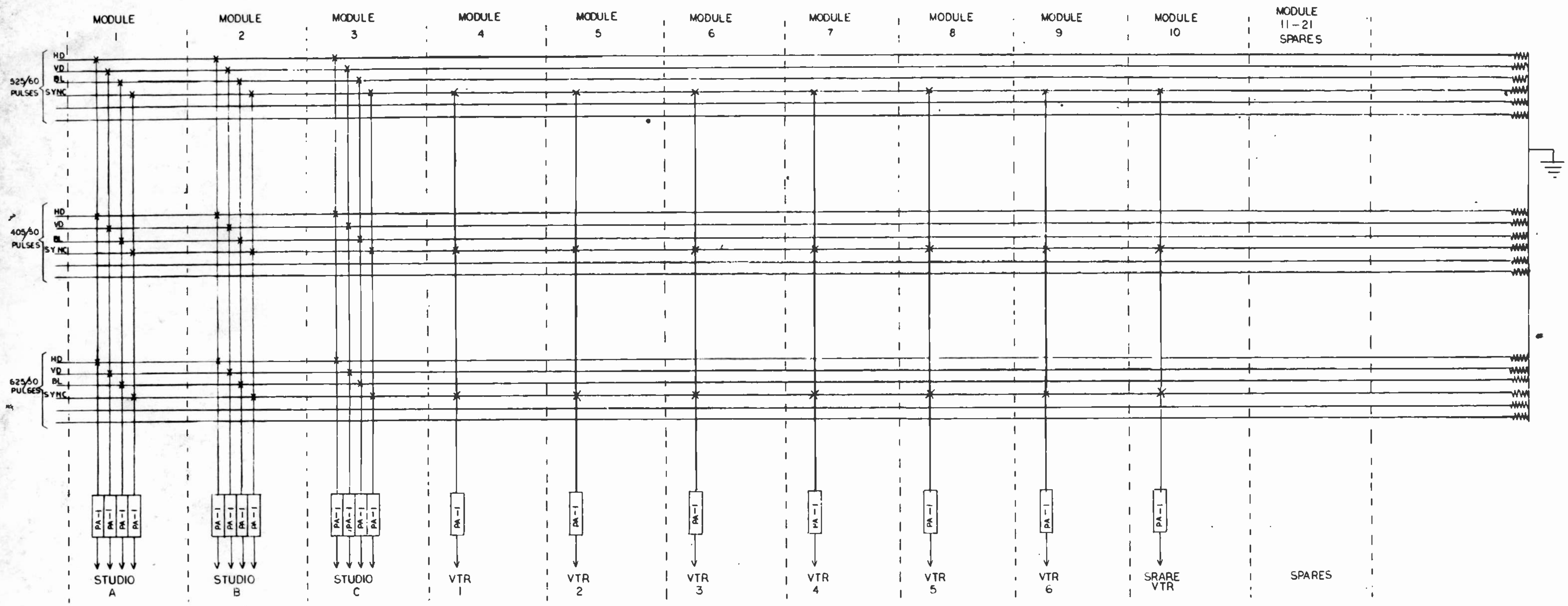
Figure 8. Visual Pulse Assignment Switcher Equipment Rack Mounted. Front View with Doors Open.

Figure 8 shows the front view of the Pulse Assignment Switcher with the cover doors open. The horizontally mounted printed circuit plug-in cards are the output module boards previously described. The red components are the PSM crosspoint modules. This particular picture shows capabilities for supplying the standard four pulses from any one of three sources and for individual isolated feeds to 16 different equipment locations.

The control panel configuration can be made up to suit the requirements of individual stations; here single three-position latching switches are utilized to select the particular group of input pulses to feed a specific output. These DC control switches may, of course, be located on a central master control panel as shown, or they may be located on a remote studio switcher panel to permit the control room operator to select his own source of pulses.

From the above discussion, the flexibility of the system is apparent and it may be seen how the system could later be expanded by adding additional output module boards or even by adding additional PSM crosspoint modules and output amplifiers to the boards.

Another possibility for the use of a Pulse Assignment Switcher is shown on Figure 9. This particular Pulse Assignment Switcher would provide pulses of the three basic standards: namely NTSC 525/60, BBC 405/50, or the CCIR 625/50 systems.



NOTE
1 - SEE DWG H-40-4292 FOR CONTROL PANEL LAYOUT.
2 - COMPLETE PULSE ASSIGNMENT SWITCHER LESS SELECTOR BUTTONS MOUNT IN 3½" OF RACK SPACE.

VISUAL ELECTRONICS CORP. ENGINEERING DEPARTMENT NEW YORK, NEW YORK		
PULSE ASSIGNMENT SWITCHER		DATE 8-12-64
BY JM		DWG. H-40-4129-4
REV.	DATE	
REV.	DATE	

Figure 9. Pulse Assignment Switcher Application to Provide for Selection between several Pulse Standards.

Thus, it has been possible to achieve a versatile system of pulse distribution coupled with pulse assignment capabilities at an economical utilization of rack space and price. With this pulse assignment switching system, a television station is able to take advantage of having separate individual pulse feeds for each camera (live and film), switchers, etc., and to be able to individually select these feeds from any one of three pulse generator sources.

This system also incorporates the required delay line compensation for equalizing the pulse delays when utilizing color cameras whose outputs must pass through colorplexers. The system would be equally capable of coping with other pulse equalization requirements, such as those resulting from the requirement of feeding one studio into another, or those resulting from the problems created by not having all the switchers and camera controls (live and film) centralized in one location. Such a system may be remotely controlled from either a master control select panel or controlled at the pertinent studios themselves. If desired, a combination of controls may be provided; i.e., control from the individual studios as well as overriding control from a master control panel.

Numerous variations of this system are possible both with respect to the individual pulse delays and the various means of control.

Already, this sytem has found acceptance in major TV stations both on the West and East Coasts.

A 10 TO 1 ZOOM, SOLID-STATE IMAGE ORTHICON CAMERA

by

Charles E. Spicer
VISUAL ELECTRONICS CORPORATION
New York, N. Y.

Until 1964 Broadcasters have been using television cameras with essentially the same features since the advent of commercial television. This year a new, totally different camera has become available and is rapidly increasing in usage each month for TV station studio production, remote pickup, and for videotape production. It is the transistorized Visual Zoom Camera. We would like to review how such a camera became possible and to describe its completely different design, construction, and features.

NEW DEVELOPMENTS WHICH MADE THE CONCEPT POSSIBLE

When zoom lenses first appeared many years ago, TV Broadcasters began to dream about having a camera with only one lens. The advantages of zoom lens operation, the elimination of the rotating lens turret and the elimination of the complex focus mechanism which moves the image orthicon deflection assembly back and forth were very attractive. But the early zoom lenses had only a limited range of focal length. The ratio of telephoto to wide angle was only 3 or 4 to 1 and they were generally poorer in optical quality than fixed focal length lenses. So the dream was quite impractical.

By 1963, however, lens manufacturers using new glasses, new coatings, and enlisting the aid of new computers for design calculations, had increased the zoom ratio to 10 to 1 and at the same time had improved optical quality to equal the fixed focal length lenses. The dream of a zoom camera was closer, but the size, the weight, and the cost of these new 10 to 1 Image Orthicon zoom lenses left the idea still rather impractical.

Meanwhile, however, further refinements of the 3″ image orthicon tube and new camera design techniques – developed and improved over a twenty-year period – had made it possible for the 3″ camera to outperform, in many ways, the larger, more bulky 4½-inch camera. This had often gone unrecognized in the U.S. because the 3″ cameras in general use lacked the new improvements with regard to image section cross-talk cancellation, ultra-stability, clamp noise immunity, and operation with higher image section and target potentials possible with the recently improved 3″ tubes. These new tubes also provide greater resolution due to higher resistance of the target and improved signal-to-noise due to increased secondary emission coefficients.

Also by 1963 solid-state devices had proven their reliability in TV power supplies, video amplifiers, and sweep circuits, so that a solid-state camera was possible using vacuum devices only for the higher voltage rectifiers and regulators.

While television stations were installing 10 to 1 zoom lenses on their existing cameras at a rapid rate to take advantage of the zoom features, the motion picture industry began changing over to a smaller high quality 10 to 1 zoom lens for their professional 35mm motion picture cameras at an even faster rate. The latter lens produces an image half the size of the image orthicon camera lens, but the lens is about one-third the weight, about half the size, and about one-third the cost.

The proven image section magnification technique of the 4½-inch I.O. tube provided the means of incorporating all of the above elements into a completely new camera. This camera utilizes the 35mm motion picture 10 to 1 zoom lens with image magnification to expand the photocathode image to cover the target. This concept checked out both in theory and in practice to exceed broadcast requirements by a wide margin. It makes possible a truly high-performance TV camera at a reasonable price. Since this optical and mechanical configuration was inherently light and compact, it was only logical to use solid-state electronics to make an extra light and at the same time ultra-stable camera that could serve equally well in the studio and in the field.

Figure 1. CAMERA, FRONT VIEW

The use of a single 10 to 1 zoom lens makes the camera clean and modern in appearance. This concept is enhanced by the use of rugged molded Fiberglas® covers which won't bend or chip. Electrostatic shielding is impregnated on the inside of the covers. The standard color is an industrial blue but a wide choice of other colors is easily provided since the covers are not a basic part of the assembly.

Figure 2. CAMERA FROM REAR, CLOSE-UP OF ZOOM INDICATOR

The lens is operated by one hand for both zoom and focus. The cameraman's right hand rotates the zoom-focus arm for focus and moves it forward or back to zoom in or out. An indicator on the rear of the camera below the control panel shows him the focal length and is marked with seven standard lens focal lengths plus an extra wide angle position.

37.5mm	45° hor.
50mm	35° hor.
75mm	24° hor.
90mm	20° hor.
135mm	13° hor.
8 inch	9° hor.
12 inch	6° hor.
15 inch	4.8° hor.

The zoom-focus arm has a lock on it, thumb-operated, which can lock the zoom at any of these focal lengths. Thus, the cameraman now has the equivalent of an eight-lens turret. In other words, the cameraman and director can operate this camera to select fixed focal lengths exactly as they have always operated their turret cameras. However, they have 8 lens positions instead of 4; the camerman does not have to move his hand to a turret handle and back again each time he wants to change lenses; and the range of focal lengths is much more than can be installed on any turret. A 15-inch lens will get in the picture from a 50mm lens on the same turret. In addition, of course, there are the tremendous advantages of 10 to 1 zoom lens operation. This provides the director with a variety of effects and also reduces dollying by the cameraman. The director can change coverage while the camera is on the air without switching to another camera. He can get the exact coverage he wants, without dollying in or out. The camera can close in without getting in the way of other cameras or casting annoying shadows.

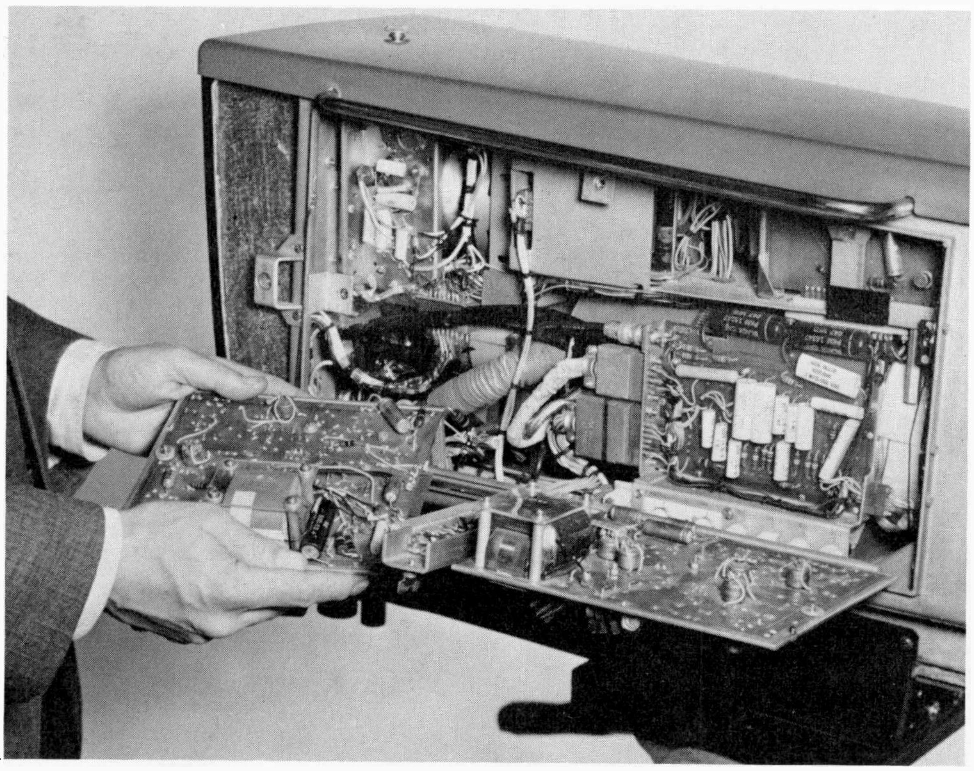


Figure 3. RIGHT SIDE, SIDE OPEN, PLUG IN BEING REMOVED

The solid-state circuitry provides stability with reliability and reduced maintenance cost. It also is the reason the camera is compact and light-weight. The entire camera weighs 85 pounds, including the lens and viewfinder. This is a great advantage to the setup crew on remotes and to the cameraman when fast movement around the studio is called for. The solid-state circuitry also provides low power consumption. The camera consumes only 300 watts. Fold-out construction provides in-operation access to components. You don't have to unplug a board to service it – which sometimes clear the trouble you are looking for.

In addition, the two plug-in boards on each side are removable for replacement. Boards are glass epoxy with etched copper – tin-plated and gold-plated contacts, in accord with MIL specs.

The top chassis, including power supplies, is also removable for easy servicing.

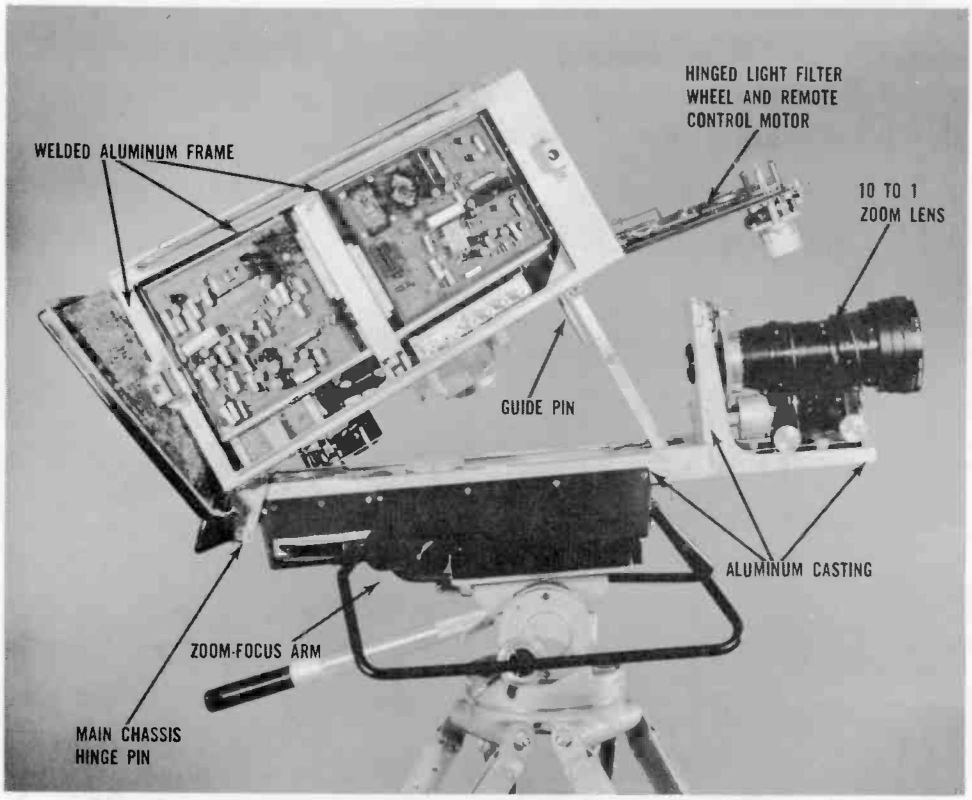


Figure 4. SIDE VIEW, MAIN CHASSIS RAISED

This "exploded" view shows how complete access is provided not only to the electronics, but also to the lens and the zoom-focus mechanism which is housed in the base.

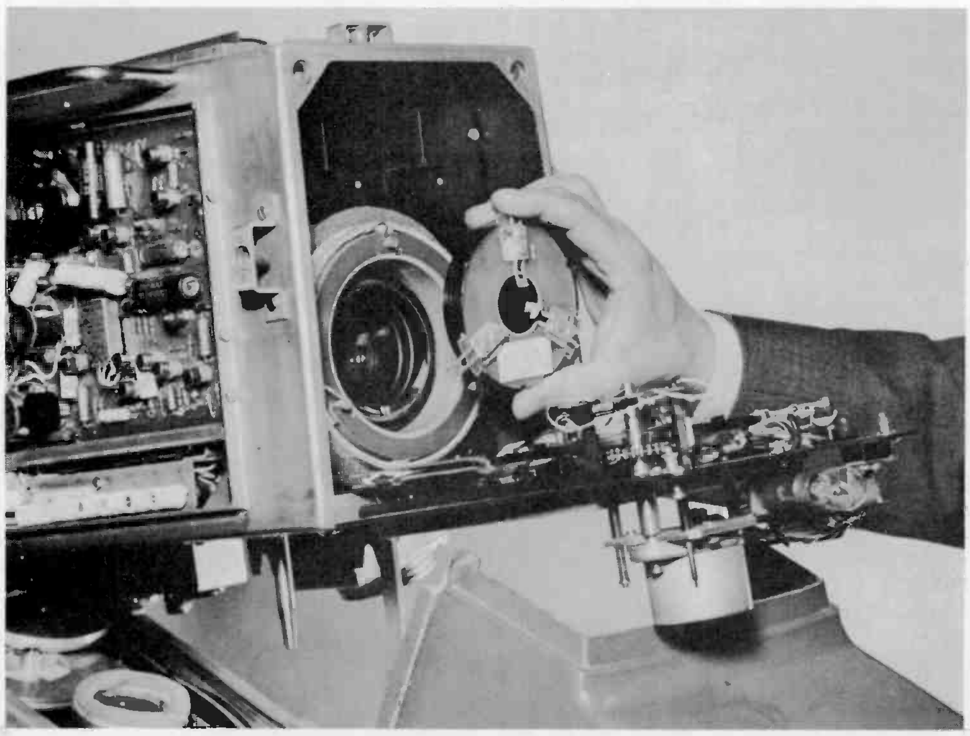


Figure 5. MAGNIFIER BEING REMOVED

The front of the main chassis, which includes the built-in light filter wheel, folds out for removal of the image orthicon tube. The magnifier is snapped out and the I.O. taken out the front over the lens.

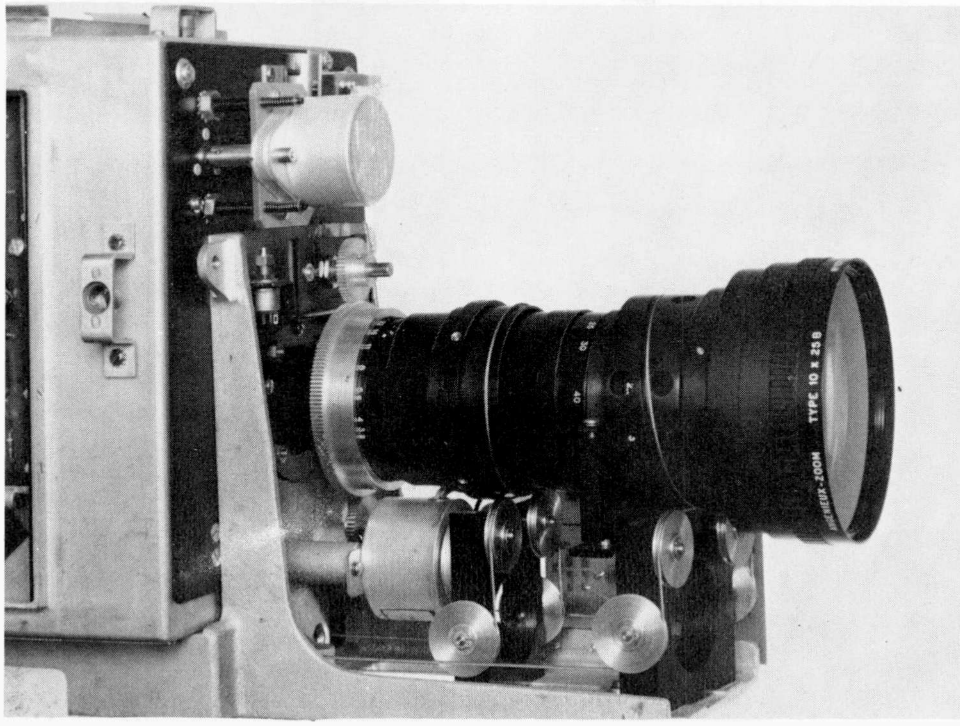


Figure 6. LENS CLOSE-UP

This view of the lens shows the rugged casting on which it is mounted fixed in relation to the I.O. tube. The lens is made by Angenieux in France, the largest manufacturer of quality zoom lenses of all types for many years. The elimination of the turret provides a simple, solid lens mount which withstands the punishment of studio and field use. The remote iris motor engages only the one lens. Cables rather than gears operate the zoom and focus elements to provide positive, friction-free, backlash-free drive. The I.O. tube and its deflection assembly are fixed in position with regard to the single lens and not required to move, thus eliminating many mechanical problems and reducing microphonics.

Figure 7. DIAGRAM, VISUAL ZOOM AND STANDARD 4½-INCH CAMERAS

The zoom lens is smaller than an I.O. format lens because it is a 35mm motion picture format lens, or its image is "single frame" rather than "double frame" size. Its smaller image is then electronically magnified in the image section of the tube using exactly the same technique employed in all 4½-inch cameras.

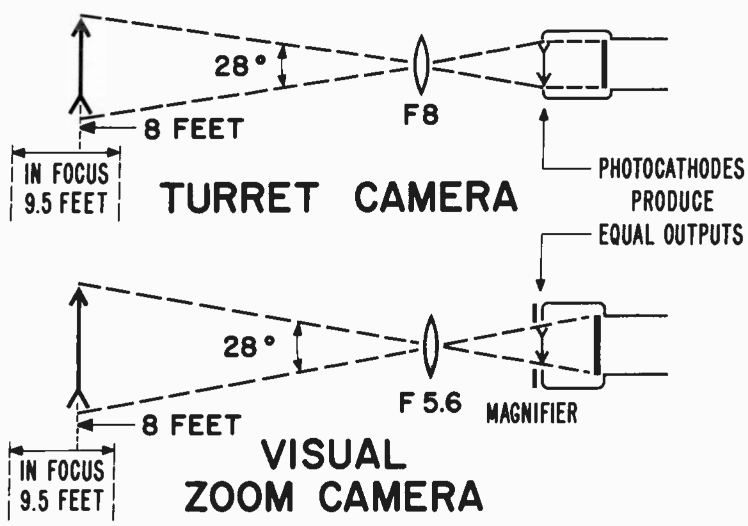


Figure 8. DIAGRAM, TURRET CAMERA AND VISUAL ZOOM CAMERA

Although the smaller zoom lens uses only half of the area of the photocathode, the corresponding reduction in sensitivity is exactly overcome by the greater light concentration of the smaller format lens. For example, a 50mm lens on a turret camera at f8 has a depth of field of 9½ feet when it is focused 8 feet away. The 35mm format zoom lens has the same depth of field at f5.6, one whole stop open from f8. This means the resulting single frame image on the I.O. tube has twice the light level, while the cameraman has the same depth of field with which to operate.

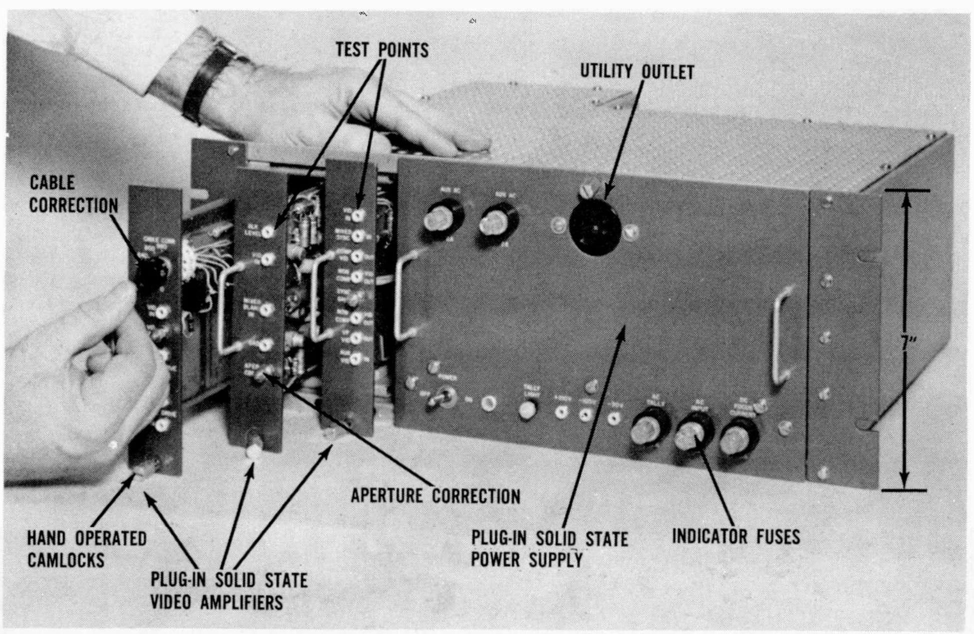


Figure 9. POWER SUPPLY AND PROCESSOR, PLUG-IN UNITS OUT

The power supply and processor is a compact rack-mounted unit occupying only 7 inches of rack space. There are no operating controls on this unit, so it can be mounted out of the way in a rack room.

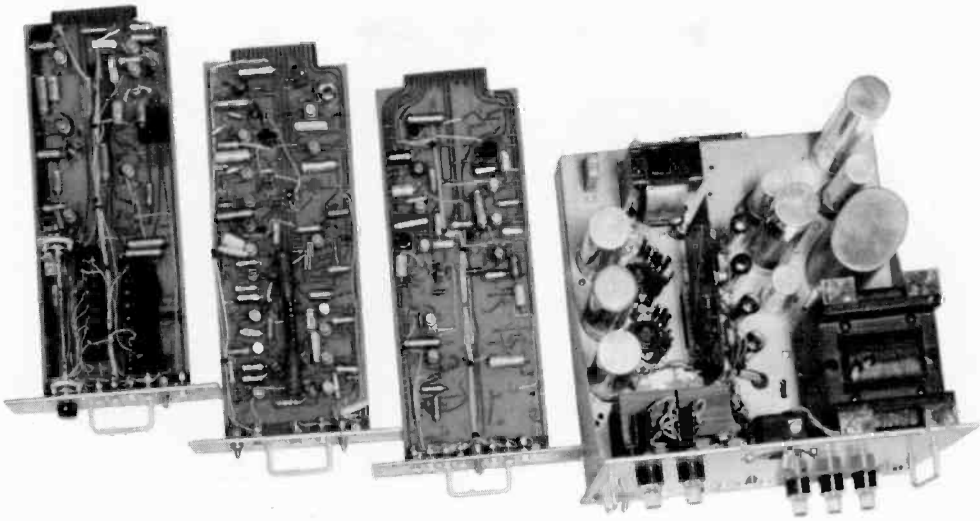


Figure 10. PLUG-IN UNITS SEPARATE

All circuits are on plug-in boards, including the complete power supply on the right. The power supply has saturable reactor regulation to accommodate power line changes from 95 to 130 volts without tap switching. All voltages and currents are carefully regulated including the I.O. filament. AC and DC emitter degeneration throughout the camera stabilizes the operating point and gain of the transistor stages to produce ultra-stable operation.

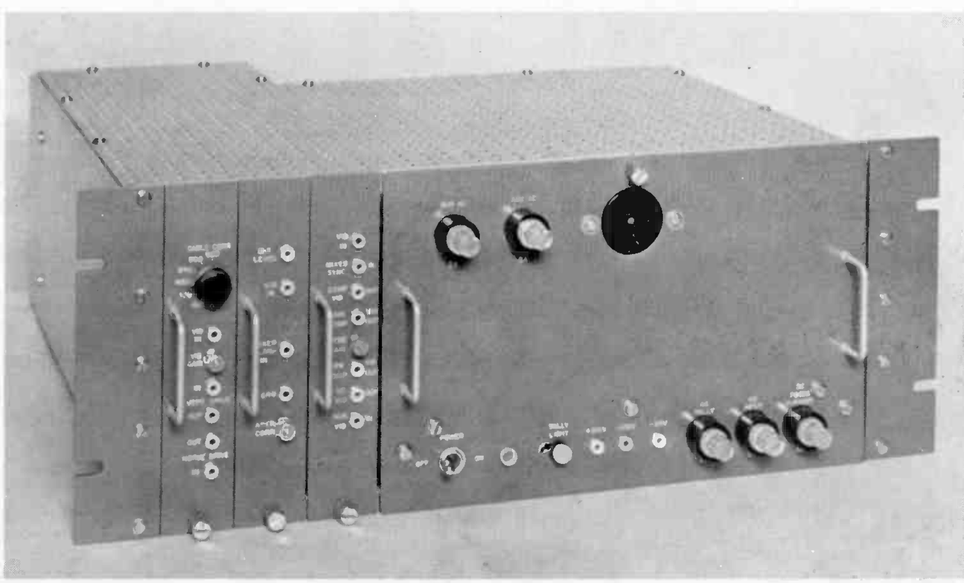


Figure 11. POWER SUPPLY AND PROCESSOR

Preset controls such as cable length compensation, white clipper, and aperture correction are on the front panels. Ample test points are provided. Fuses are indicator types on the front. A utility outlet is included. The unit is bolted in the rack or base of a console without sides, because circuits are plug-in.

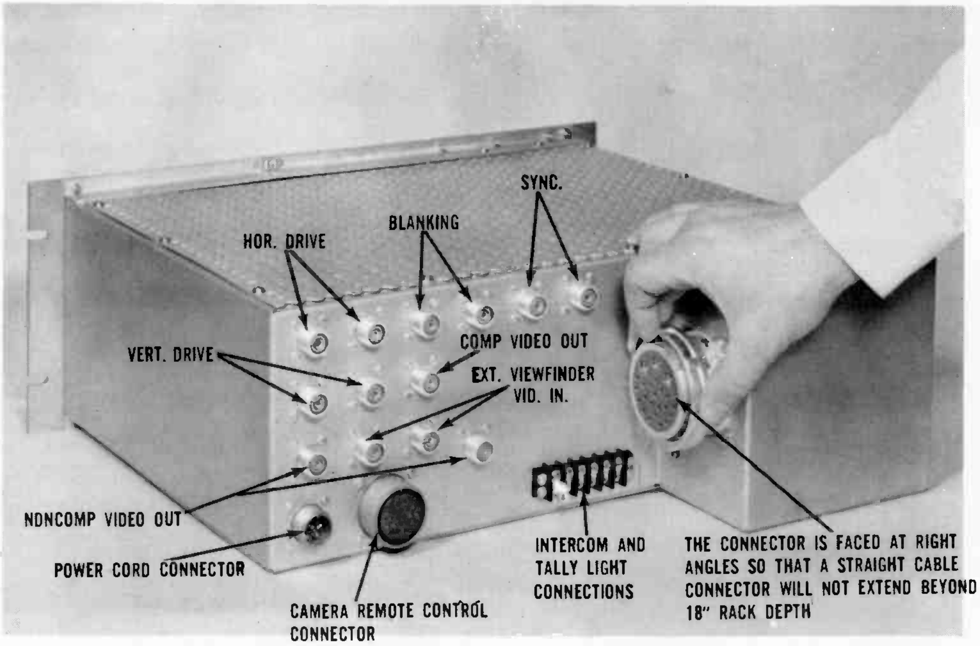


Figure 12. REAR OF POWER SUPPLY AND PROCESSOR

The rear of this unit shows the standard U.S. camera cable connector. It is faced at right angles. This makes it possible to plug in a straight cable connector without having it extend back past 18 inches where it would prevent closing the rear door of an 18-inch deep rack. The other connectors are for the Remote Control Panel, the power cord, external viewfinder input, 3 video outputs, and coax pairs for loop-thru bridging inputs for H Drive, V Drive, blanking, and sync. The terminal strip is for intercom and tally light connections.

Figure 13. FRONT, REMOTE CONTROL PANEL

The Remote Control Panel is simplified to contain only the important operating controls exposed. A hinged panel covers the upper recessed controls. Thus the operator has available remote iris, pedestal, contrast, and his own intercom listening volume. He has a lens cap switch, an intercom private switch plus tally lights. Under the upper cover, however, he has Beam, Target, Target Set Switch and Orth Focus. Although all these controls are also located in the camera itself to make one-man alignment possible, they are repeated here for those operators who prefer to make such adjustments in the control room. This may be to match I.O. tubes using one monitor or may merely be the station personnel's personal preference. The viewfinder external input switch is also located on this panel. The panel is 9½ inches wide so two panels can mount side-by-side in a 19" console or rack beneath twin 8" Conrac Picture Monitors and a pair of Tektronix Waveform Monitors. It is 5¼ inches high.

Figure 14. CAMERA REAR PANEL CLOSE-UP

To refer again to the camera, the rear panel shows besides viewfinder and intercom controls, switches for driving the built-in light filter wheel with indicators for the 4 filters, the electronic lens cap tally light and switch, the orbiter on-off switch, the overscan switch, and the viewfinder overpeaking switch.

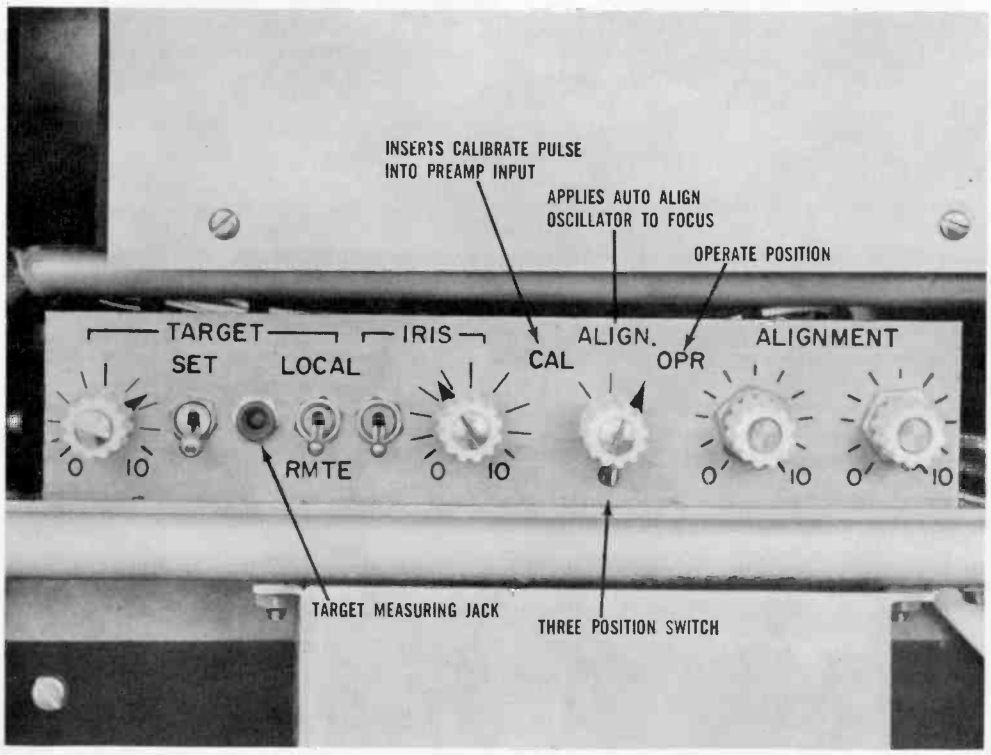


Figure 15. CLOSE-UP, LEFT SIDE CAMERA SETUP CONTROLS

Inside the camera, conveniently located on both sides of the camera for two-hand operation by the operator watching his viewfinder, are all the controls necessary for aligning the camera. No operator is needed in the control room for alignment. Controls include Target, Target Set Switch, and Iris Control. There is a switch to a built-in-calibrate signal for the preamp input and auto-align oscillator on the focus electrode.

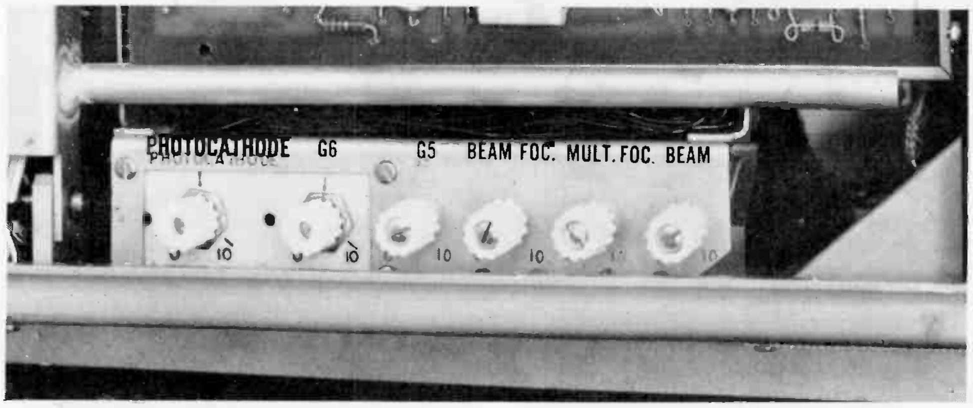


Figure 16. CLOSE-UP RIGHT SIDE CAMERA SETUP CONTROLS

The right hand operates the remaining setup controls including photocathode, G6, G5, Orth Focus, Multiplier Focus and Beam current.

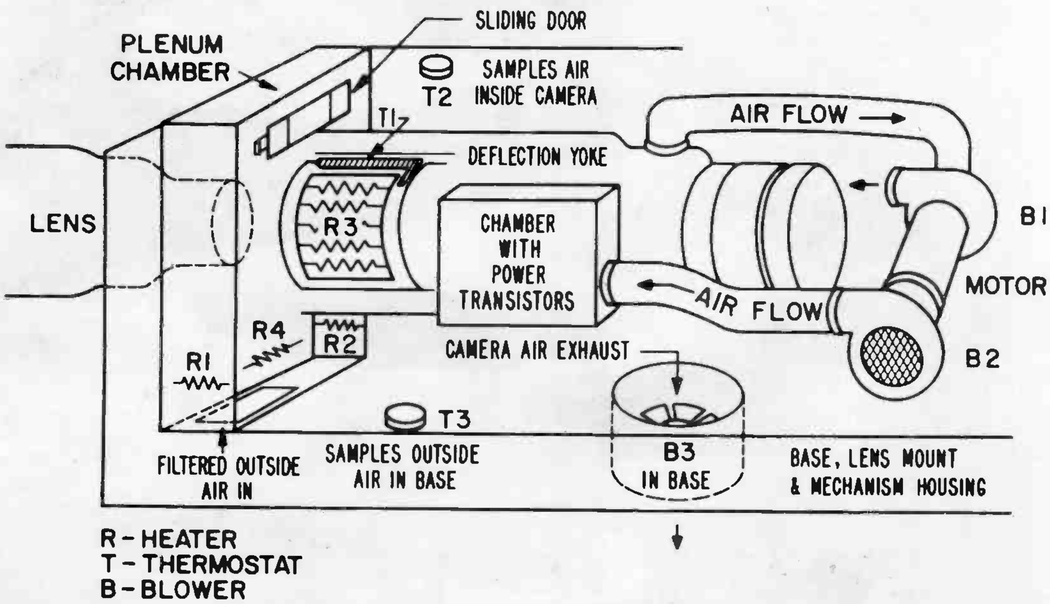


Figure 17. DIAGRAM OF AIR SYSTEM

A rather sophisticated automatic temperature control system is used for fast warmup of the image orthicon and accurate control of its temperature as well as the inside temperature of the camera. The air flow diagram shows a side view of the camera with the lens on the left separated by a plenum chamber from the image section of the I.O. tube. The zoom lens has a relatively long back focal length, so there is ample room in front of the I.O. photocathode for this chamber which contains, besides the light filter wheel, heating elements, and the outside air intake.

A mercury contact thermometer is located adjacent to the image section inside the focus coil with its bulb near the target. When the camera is first turned on, three heaters are turned on for fast warmup: R3 surrounding the image section, and R1 and R2 in the plenum chamber. When the temperature reaches 40°C the thermometer turns off the three heaters R1, 2, and 3. Air is constantly drawn in through the filters in the bottom of the camera, through the plenum chamber. through the deflection yoke, and exhausted into the camera interior by blower B1. The motor for this blower is on at all times. This motor also drives blower B2 which blows air through a chamber surrounding the power transistors. Thermostat T2 samples air temperature at the top of the camera and at 30°C turns on blower B3 located in the camera base which exhausts air from the camera. The blower motors have been selected for low noise over a long lifetime.