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ENGINEERING DEPARTMENT
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PROCEEDINGS OF THE 18TH ANNUAL NAB ENGINEERING CONFERENCE

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*A film
**Paper not furnished by speaker

LUNCHEON SPEECHES

at the

18TH ANNUAL NAB BROADCAST ENGINEERING CONFERENCE

Monday, April 6

Francis C. McLean, Director of Engineering,
British Broadcasting Corporation

Tuesday, April 7

Francis K. McCune, Vice President, Engineering,
General Electric Company

Wednesday, April 8

Dr. G. C. McVittie, Director, University of
Illinois Observatory

Presentation of NAB Engineering Achievement Award to
John H. DeWitt, Jr., President, WSM, Inc.

Conrad Hilton Hotel
Chicago, Illinois
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UHF AND COLOUR TELEVISION

by

Francis C. McLean, Director of Engineering,
British Broadcasting Corporation

A speech delivered at a Luncheon at the National Association of Broadcasters Convention, Chicago
6th April 1964

Mr. Chairman and Gentlemen,

It is a great honour to be invited to speak to you today, especially as by so doing I am following in the footsteps of my predecessor, Sir Harold Bishop, who spoke to you at this meeting two years ago. At that time he gave you a very comprehensive review of the engineering side of the BBC. Today I do not propose to cover anything like such a wide field, but to deal with only two subjects but in greater detail. These subjects are UHF television and colour. I would like to deal with them in the general European context but particularly with regard to our operations in the United Kingdom. In the U.K. they are inextricably mixed as it has been decided that colour shall be carried only on the 625-line standard which means that for very many years it will in our case be only on UHF, as our 405-line transmissions completely fill the VHF bands.

UHF television is not in general use in Europe but has been in service use in Germany on an extensive scale for more than two years. Initially, it was used to supplement the coverage of existing programmes carried on VHF but has fairly recently come into service for an additional programme. In Italy, UHF has been used for direct coverage of their service and also as a distribution means for feeding relay stations which re-radiate on VHF. In other countries in continental Europe, the transmissions so far on UHF have been only of an experimental nature. In the United Kingdom we have made experimental transmissions for some years and are about to start in a few days' time the BBC second programme which will be only on UHF. Initially it will carry black and white only but we hope colour will not be long delayed. This new service on 625 lines has already been on the air on an experimental basis carrying both black-and-white and colour transmissions for some months past. The existing services, both BBC and commercial, are on VHF and are carried on the 405-line standard. It is intended that at some time in the future and by some method still to be determined, these existing services will be transferred to 625-line operation.

We have followed with great interest over many years the fortunes of UHF in the United States and have followed the argument for and against inter-mixture. Our position is however different, and we cannot avoid inter-mixture and are going into it in quite a big way. Moreover we have no option but to make it work, and somehow or other we have got to persuade the public to like UHF as well as they like VHF, and to like it well enough to pay the extra cost. How far we shall do this in the early years, I do not know. It is clear however that it will be difficult, and we are doing everything possible in the planning stages to ensure that we shall achieve our aim. The first stage in the programme of work was to carry out propagation service trials. Initially, these were done on black and white on a single channel in 1957/58. Then, because of the vagaries of UHF transmission as established in these trials, we repeated them in 1962/63, this time using two $12\frac{1}{2}$ kW transmitters radiating in the London area from a common antenna system on two channels spaced 80 Mc/s apart from a 650 ft tower on high ground giving a height above the mean terrain of the order of 900 ft. Gap-filling was used in the antennae. By this means we were able to compare the variations in signal strength from one frequency to another and to convince ourselves that it would be possible to radiate up to four channels from a given site and achieve more or less equal performance from all of the channels. Our plans cover that we shall eventually be radiating four transmissions from each site. From the work done, we think that in an area such as London the signal strength variations between the two channels will, for about 92% locations in the area, be not greater than about 6 db, or not greater than about 10 db for 99% of the locations. These figures we think are within the range of a normal receiver. We have experienced of course some very heavy shadow effects on UHF, but in general it has turned out better than we feared in spite of the fact that the London skyline includes a fair number of buildings which, although not on the New York size, still in many areas give conditions approaching those in that city. We think that some 99% of the population within the + 73 db contour should receive a good service. These transmissions were carried out on black and white and on colour using all three of the proposed colour systems. In all this we followed with keen interest the findings of the F.C.C. on their transmissions in New York as they became available, and in general we find ourselves in agreement. A full report on all our tests is due to be published shortly, although some of the information obtained has already been submitted to the C.C.I.R. The results of work done in Europe, in particular in the Moselle Valley in Germany, in mountainous areas in Switzerland and in Italy, have not differed to any great extent from the results we have obtained in our tests in an area having only slight hills. The Moselle Valley results show a difference of 10 db for 95% of the locations. The effects are however accentuated in other respects and particularly in reception of colour signals, as I will mention later.

A secondary purpose of the tests was to examine the design problems involved in the transmitter, in the combining circuits, filters and antennae, but the main emphasis was on the propagational aspects.

The UHF plan for the whole of the United Kingdom, which is already in hand, envisages that when completed we shall have 64 main stations - that is, stations between 100 kW and 1000 kW e.r.p., using towers of various heights up to 1250 feet - 250 relay stations having e.r.ps from 2 to 10 kW and tower heights of the order of 250 feet, and 1,000 fill-in stations having e.r.ps of the order of 10 to 100 watts with towers of the order of 50 feet. At each of these stations, transmitters will be operating on four channels. The relay stations are to serve the large area gaps within the contours of the main stations and the fill-in stations are to cover local blind spots.

It is interesting to consider the capital cost of providing a single-programme service as the coverage figures increase. The first eighteen of the 64 main stations will give 62% coverage of the 52 million people in the United Kingdom at a cost per head of $1.15. The relay stations corresponding to the eighteen main stations will increase the coverage to 64% and the cost per head to $1.40. The low-power fill-in stations will increase the total coverage by a very small amount indeed and the cost per head will undoubtedly be very high, but we are not yet sufficiently far ahead to be able to say what this will be. This heavy increase in cost to provide a complete service is clear and the final small increase in coverage is uneconomical. Under our system however we have to do this. We have a uniform license fee over the whole country and people in all parts are entitled to demand, and do demand, a service. The anticipated total cost of the transmitting stations for a single-programme coverage of the United Kingdom, but with provision for extension to four programmes, is of the order of $85 M as compared with the known cost of the VHF network giving 99.5% coverage of $17 M. UHF is therefore for approximately equal coverage of the order of five times more expensive than VHF. If a less than complete coverage could be accepted, the UHF costs fall considerably. The running costs of UHF are higher but not proportionately so. The cost of adding the second, third and fourth programmes to the above will be much less, but I need hardly say that we would never have gone to UHF had there been adequate space in VHF. The cost of operating such a large number of transmitters and the virtual impossibility of finding adequate manpower for attended operation is compelling us to design these stations for unattended operation.

Part of the need to go to UHF is however imposed by our major problem of somehow changing over from 405-line television to 625-line television. One way of doing this would be to duplicate the service in the UHF bands. To do this however, does mean that we must be able to give a service in UHF which is as complete and as satisfactory to all the viewers as the service that we give in VHF. In fact of course, we have to make the UHF service so attractive that the public will voluntarily choose UHF. The attractions we have to offer are aless evident line structure, increased definition, and low interference levels. We hope that we shall be able to persuade the public to make this choice. Our test transmissions in the London area are fairly promising, and the continuous fall in the noise factor of receivers and improvements in the stability of receivers give us further hope. We feel however that we cannot be sure of this until we have had some little time of direct operational experience, so that this question of standards changeover is in abeyance for the time being.

The transmitter side of the problem is of course only half of the story. Appreciable improvements in UHF receivers have been made and current designs have noise factors of the order of 11 - 16 db, while the tuner units have high stability, very good second channel rejection and low oscillator radiation. In a very high proportion of the locations, and I would not at the moment like to say how many, the UHF picture definitely looks better than the VHF picture. Part of this is due to the change of line standard but a larger part of the improvement is due to the low noise levels.

UHF receivers are also selling well. All designs of sets in the U.K. are suitable for the inclusion of a UHF tuner, and some 25% of the deliveries of receiver are so fitted at an extra cost of the order of 10%.

I would now like to turn to colour. We have taken an interest in colour since the early 1950s, and our first experimental transmissions on colour on the NTSC system, adapted for 405-line operation, were made in 1955. Since then we have intensified our work, and over the last two years have made a considerable effort both in terms of men and money expended in this field. There has also been a very appreciable amount of work done on colour both in Western Europe and, although I cannot say the extent of it, in Eastern Europe. Pressure to start a colour service exists in quite a few countries in Europe, but I think it would be fair to say that, probably because we in the United Kingdom have the highest saturation of black-and-white television receivers - we have TV sets in 13 M of the 15M households in the U.K. - the pressure is greatest with us. About a year-and-a-half ago, a coordinated programme of work on investigations into the various colour proposals was put in hand in Western Europe by the European Broadcasting Union, and arrangements were made to keep Eastern European countries informed of what we were doing and to receive from them any information which they had available. This cooperation of the Western European countries has been very profitable, and a most intensive survey of the various problems has been made. The work organised by a technical committee which was divided into sub-committees dealt with general principles, receivers, propagation, transmitters, distribution and origination. The report on this work has been published by the E.B.U. and also incorporated in the Proceedings of the C.C.I.R. meeting held in London in February. Very considerable work both in the form of laboratory and field trials was carried out in France, Germany, Italy, Switzerland, Holland the United Kingdom but as far as I know very little elsewhere. I think it would be quite impossible here to give anything like a comprehensive statement of the situation but I will try to give some of the highlights as I see them.

The natural starting point was the NTSC system, and it was clear that any other proposals must be judged by reference to that system, and let me say what a wonderful achievement the formulation of the NTSC system was. In spite of the fact that it was originated so many years ago, that it was produced in a comparatively short time and that it was of such a novel character at that time, it has stood up remarkably well to the searching examinations which have been carried out in Europe. While other proposals have advantages in some respects, it is very much open to question as to whether their advantages in specific directions are sufficient when counted against their disadvantages.

In the opinion of a number of countries, amongst which is the United Kingdom, NTSC is the most suitable system for adoption as a European standard. The other two systems - SECAM and PAL - follow of course the basic concept of the NTSC system. Both send a full definition luminance signal and use the basic principle of the NTSC system, that it is unnecessary to send high definition in the chroma signal. The PAL system is closest to NTSC in that its parameters are the same, but the I signal is inverted in phase every alternate line in the same field. The system uses a delay line and synchronised switching in the receiver. The receiver then takes an average between the phase of the signal in the present line and the phase of the signal in the preceding line. In this way phase errors of considerable extent are corrected, and the loss of definition is minimal but the complexity of the receiver and its cost are increased considerably. The SECAM system also is basically similar to NTSC but, instead of sending the I and Q signals simultaneously quadrature modulated on the same sub-carrier, it sends them in sequence and uses a delay line to ensure that at the decoder both the I and Q signals are simultaneously obtainable to enable the three colours to be resolved from the luminance and chroma information. The SECAM system uses frequency modulation of the colour sub-carrier, and by so doing avoids the use of either the hue control or a saturation control on the receiver. Whether this is an advantage or not is open to judgment. By avoiding the use of synchronous detection, the system is however independent of errors due to phase distortion.

It is, I think, an undoubted fact that, as far as the broadcasting and programme distribution authorities are concerned, both SECAM and PAL would represent a considerable casement as compared with NTSC. They simplify appreciably the programme distribution problem and particularly the problem of magnetic recording. When looked at from the point of view of the receiver, however, we find that the NTSC receiver is definitely the cheapest, has the fewest components and will give the best black-and-white compatible picture. The NTSC system also has the advantage that it is most readily applicable to the single-gun tube whenver this arrives. In locations where strong multi-path signals are evident, both SECAM and PAL show advantages compared with NTSC, PAL being the better of the two. On resistance to interference, NTSC is the better. The general assessment could be that, except in very mountainous areas, NTSC is somewhat the better signal, and the service area of an NTSC colour signal is about the same as the black-and-white service area. On the other systems, and particularly SECAM, the service areas is reduced. I should here, however, make it clear that the remarks I have made refer to the SECAM system as its development stands today. Whether the situation will change in the future I cannot say.

We believe that the broadcaster must accept the greater care and cost on his side, and that the interests of the viewer must predominate.

The balance we draw therefore is that, while all systems have advantages in one way or another, the overall advantage, particularly to the viewers, lies with the NTSC system. The principal reasons leading to this view are:

(a) the NTSC signal gives colour pictures that are marginally better under conditions of no distortion or moderate distortion than the other systems, and pictures which are acceptable under conditions of appreciable distortion;

(b) the black-and-white compatible picture from the NTSC system is better than that from either of the other two systems and is not appreciably worse than that obtained from monochrome transmissions. This we regard as particularly important because, for a considerable period of time, it is probable that the great majority of our thirteen million viewing households in the United Kingdom will be equipped for monochrome only;

(c) the major problems associated with the NTSC system are in video tape recording and long distance point-to-point transmission, but the burden of these difficulties falls upon the broadcasting and transmission authorities, and not the viewing public. Furthermore if necessary until such time as the techniques are perfected, the signals can be recorded and transmitted from point-to-point on a different signal, the final broadcast signal being of NTSC form;

(d) the receiver required for the NTSC system is the least expensive and the most rugged;

(e) the NTSC system seems to have the greatest potential for further development in the receiver and, in particular, could be applied most easily to a single-gun tube when such a tube becomes available;

(f) the fact that the NTSC system is established in certain parts of the world means that a considerable amount of experience of this system is already available to countries wishing to start a colour service;

(g) the choice of the NTSC system would bring us nearest to the achievement of a uniform standard of colour television throughout the world.

At the London meeting of the C.C.I.R., the Netherlands, Austria, Denmark and the United Kingdom came out definitely in favour of the adoption of the NTSC system in Europe. Sweden said it would accept NTSC or PAL, while Norway said it would prefer the PAL system. The remaining thirteen countries said they were unable to reach a conclusion on the basis of evidence available and that they would need to do more work. Some countries said that they would be able to reach a decision by the date of the next C.C.I.R. meeting due to be held in Vienna in April/May 1965, but other countries said only that they would be prepared to discuss the matter further at that meeting. In the U.K. we are however very anxious that the Vienna meeting shall reach a decision and will do everything possible to urge this decision and in due course to start a colour service - we hope on NTSC. However if we do not reach agreement on NTSC, we should hope to reach agreement with Europe on another system. We would like to have the best agreement possible on a worldwide basis but the majority of our programme exchange is of course with the 50-field areas and only within these areas can we exchange without a system of standards conversion. Agreement with these areas is therefore of the greatest importance to us.

In the meantime we are carrying out the detailed equipment planning involved in starting a colour service in all respects which are not determined by the system used. We are actively considering the camera problem. Should we go ahead on RGB cameras or should we go to the constant luminance or separate luminance type of equipment? We are of course aware of the investigations and proposals made here, and we await with more than usual interest an indication of the action you will take.

The EBU will continue to consider all these problems, and further investigations will continue to be coordinated. We understand that at their meeting in the summer the I.B.T.O. - the Eastern European Broadcasting Union - are also considering these problems, and perhaps after this we shall get some indication of their viewpoint. With all this work in hand, we hope we are justified in feeling hopeful that the Vienna meeting in the spring of 1965 will reach a decision.

I referred to the international exchange of programmes. This must surely come in colour as it has in black and white. The satellite transmissions first by Telstar and later by Relay have been the outstanding events of the last two years. The picture quality has been quite extraordinary, and the feeling of downright participation given by instantaneous transmissions across the Atlantic has been most moving. This was of course particularly so in the transmissions following on the death of President Kennedy. To watch the funeral at the time it was taking place was indeed a most moving experience. Perhaps the time will come when we shall have direct exchange of programmes and perhaps even the time when 50 and 60 field transmissions will be radiated in both continents.

Thank you very much for inviting me to speak to you today and for inviting me to take part in your discussions at this most interesting Convention.

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UNEXPECTED DIMENSIONS

By
Francis K. McCune
Vice President, Engineering
General Electric Company
at the
NAB Broadcast Engineering Conference
Conrad Hilton Hotel
Chicago, Illinois
Tuesday, April 7, 1964

"Where do we go from here, boys? Where do we go from here?"

It won't take long for my contemporaries in this audience to remember where that question comes from. The doughboys sang and marched to it back in 1916-1918, and it's still a good question. It's a specially good question for people like you and me to think about -- people whose jobs depend on how various sectors of the public exercise their free choice of what they will do with their money and their time.

It's a good question because in our times we're seeing such extraordinary technological progress, and so many new freedoms of choice linked with that progress. Going back to 1918 for example, the soldiers came home to another hit tune, asking a different question: "How are you going to keep them down on the farm, after they've seen Paree?"

Well, we know the answer to that one. They didn't stay down on the farm; and the farm changed almost beyond recognition. In fact, the whole matter of farming and feeding people has taken on totally new dimensions. Let me stress this point: Most of them were totally unexpected dimensions.

It's this matter of unexpected dimensions that I'd like to explore with you today. Every field of activity has them; and, if you don't mind a small commercial, we've had a good bit of experience at General Electric with both the new and the unexpected. This is the result, naturally, of doing a good deal of work at the frontiers of engineering and research. This is why we've been closely associated with the field of your interests and commitments from the days of the Alexanderson Alternator down through sound recording on film, television, high fidelity phonograph pick-ups and FM Multiplex -- to mention a few milestones.

First, I'd like to unfold a rather famous example of what I mean by "unexpected dimensions." The electric power industry as we know it today began with one man and one idea. Thomas Edison was the man, and the idea was -- illumination. To be sure, Edison faced many unfamiliar ramifications in building a system based on distribution from central generating stations -- cables, wires, sockets, meters, switches to cite a few. He also had hold of a very widespread customer demand for the service he was going to offer. Both these dimensions were roomy -- a great deal of expansion could take place within them. Nevertheless, those were the dimensions: Central stations and electric light.

Actually the new industry was around for quite some time before these dimensions changed. Many famous operating companies which date back to the early days still carry in their corporate titles the words "illuminating" or "lighting." The lighting industry did indeed grow and prosper and extend its service to customers. But think, if you will for just a moment, of the unexpected dimensions that were lurking in the woods all the time.

In business and industry see what has been happening ever since the power and flexibility of electric motors have become available to turn the wheels. See the results of the speed and accuracy with which electric devices can sense and control. Look at what electricity can do in processes -- as a heat source or in electro-chemical reactions. Here, for example, remember that the basic process -- and therefore the whole industry -- by which we now enjoy plentiful, low-cost aluminum is actually a dimension of the electric power industry, and one which the pioneers certainly didn't expect.

Obviously, too, we might remind ourselves of the new dimensions in living -- and in our economy -- which began to open up when electric power offered new comfort and convenience for the household. A good many of you younger people here today may not remember, for example, that a great many 1920 kitchens had just two appliances: A sink, and a range to cook on. A good number of sinks boasted running water, but there were still a lot of hand pumps around, too. Many ranges burned coal or oil. Some kitchens had "ice-boxes," but very few -- even in wealthy homes in big cities -- had any form of mechanical refrigeration. Electric percolators and toasters were available, but were still luxuries to own and operate.

The home laundry was even more backward. Washing machines were around; but they were a long, long way from automatic. A lot of them were still hand-powered. In the great majority of households the mainstays of washday were the washtubs, a clothes boiler, a washboard and a hand wringer. An automatic supply of hot water was a relative rarity. Some people had electric irons, which were considered marvelously convenient -- even though they had no automatic controls and would get red hot if you forgot to watch them.

Finally, in the early twenties, books and periodicals were about the only way information and entertainment came into the home. For education or entertainment beyond your own library and taste in reading, you had to go outside your home -- often many miles. The ultimate in on-the-spot news was the newspaper "extra."

Well, we needn't re-examine all the changes that have taken place in the home or in activities that serve the home -- including, very prominently, your own activities. Instead I'd like from this point on to concentrate on your industry. I'd like to speculate with you on some possible new dimensions ahead. It seems appropriate because, as we noted at the start, we're living in the middle of a great technological ferment. History would strongly suggest changes are very likely and very possibly imminent.

Here are four samples of what I'd call at least mildly fantastic technological advances. They're drawn partly from what's happening on the general engineering scene and partly from what we've done in General Electric. They've also been picked with two other points in mind:

- O Each is real -- that is to say, it has moved off the drawing board or out of the sketch-book and is operational somewhere.

- O Each is more important as a general technique than as an individual device -- that is, each could eventually open up possibilities for many specific kinds of equipment or operation bearing on your interests and commitments.

To start as a spectacularly far out point, radio astronomy will show basic radio technique has been refined since the days of the cat-whisker. We hear of it mostly when the world's great radio telescopes join in the tracking of satellites -- either during manned flights, or for intercontinental television relays.

The United States has a fixed radio telescope 1000 feet in diameter in Puerto Rico. There is a "steerable" scope 140 feet in diameter at Green Bank, West Virginia; one 210 feet in diameter in Australia; and the largest steerable scope is the 250 footer at Jodrell Bank, England. Their basic purpose is not tracking satellites but probing space.

The impressive technical aspect is that radio signals are being received -- at Jodrell Bank for example -- from 5 billion light years away. In other words, radio signals are linking points which are

5 billion x 365 x 24 x 3600 x 186,000 miles apart -- approximately.

Or, in another form:

5 billion x 5.9 trillion miles -- approximately.

I said "approximately" just now for a reason very much to the point of the sort of technical advances we're thinking about. Radar equipment designed and built by General Electric has been in use for quite some time now tracking missiles on the TITAN program. The over-all accuracy of all the equipment involved allows us to know at any instant of time the range (that is, the straight-line distance) from a given point to, say a satellite, for example, within 5 inches.

The "approximately" comes in this way: The present 5-inch accuracy is not limited by the system itself. What does limit is the accuracy of our knowledge of certain physical constants, such as the velocity of light in free space. 186,000 miles a second just isn't a good enough answer any more. Again, please note, this equipment represents essentially a further refinement of the electronic techniques used in broadcasting.

Moving now from radio into a different basic technology, another prominent item in the news is the laser. Lasers have already performed a good many eye-opening stunts, such as drilling diamonds with a light beam. The interesting point, though, for this meeting is that in theory a single laser system easily has the ability to replace all the present communications systems between the East and West Coasts of the United States.

How to put this particular theory into practice, no one knows yet. Actually, it's hard to see how laser devices might displace present systems, but these developments do illustrate and point up the possibility that the type of radio waves now used may not be the basis of systems of the future.

Now for the last sample. General Electric has built for the Signal Corps very fast large-storage memory equipment. To illustrate, this equipment is capable of recording every item of available Signal Corps equipment, plus the information how to procure the item. To find any single item in the catalog takes just one-thousandth of a second.

At the heart of the system is a new recording principle which was first announced by the General Electric Research Laboratory a number of years ago. Thermoplastic Recording, or TPR for short, records on plastic film or tape using an electron beam. A later relative of TPR records by means of a light beam and is known as PPR -- short for Photoplastic Recording. Both systems record pictures, words, or binary data. Both can record equally well in black and white or color. Both systems offer theoretical storage density of information which was simply unimaginable before. In one square inch of recording surface, there is the possibility of storing, for example, 100 books of 30,000 words each. Here again, theory isn't yet ready to go into practice, but some seeds of change from present disc or tape recordings are surely at hand.

No one knows what such general technologies as these samples may come to mean specifically. The specifics lie ahead in the unsuspected dimensions. I could, though, share with you some results of a scouting expedition into not-yet-but-maybe-land.

At the Seattle World's Fair of 1962 the General Electric exhibit included -- by a remarkable coincidence -- an all-electric home for modern living. In it we showed not only available products, but also in a dramatized presentation we suggested other products and services which might be possible.

One of the main items was a hypothetical information processing center in the home. This home computer and library equipment was to be useful in ways like these:

- Subscription magazine and news service

- Subscription service for special shows and TV coverage of unusual world events

- Recording of broadcast shows for audio or video playback later

- Income tax and checking account banking service

Immediate playback of home movies or still pictures taken by an electronic camera on thermoplastic recording tape.

The people who put the show together had a lot of fun doing it; so did the audiences who saw it. We provided a number of individual recording booths at which people could speak their minds about the show. The response was very strong -- in terms of the number of people who commented, and their desire to have those hypothetical new products and services.

As you know, every one of those hypothetical products or services I described is already feasible -- by one technical means or another. All that has to happen is for the possibility of providing something like them to become so attractive that someone decides to take a business gamble on it. Then, no matter how far out it was yesterday, it's here now.

In point of fact, that's very nearly what happened right while I was thinking out these remarks to make today. According to a report in TIME a big new apartment complex in the Southwest has wired each apartment for closed circuit TV. Housewives can find on one channel news items, class-ified ads, and "unclassified gossip." On another channel they can inspect and order groceries; watch the weighing and checkout; then sit back with only a short wait until the order is delivered.

It seems to me that developments along technical and service lines like these are truly a portent for broadcasting as we've known it up to now. I made my first crystal set in 1919; and in the same year my friend up the street got a deForest tube. It was the kind with two filaments, so if you burned one out you could still use the other. The first broadcast I remember was from the Del Monte Hotel - now gone. And what was that broadcast? 5 watts of news and records.

This is no audience for which I have to describe the heights which radio reached. What it brought to people in terms of unique entertainment, eye-witness coverage of great events, and useful information is a matter of historic record. But so is another fact: Today radio is -- largely news and recordings.

Of course we can simply say radio was affected when TV came along, and color TV followed. But maybe we shouldn't stop there. As I see broad-casting, it is rooted in two very basic fields -- entertainment and selling. Only in a socialistic society do people try to get along without selling -- and in no society do we find people who don't want news and entertain-ment. But these two things are very different; and it may very well be because of this very difference that change will come -- if technology is in fact to have a profound effect on your industry.

Let's go back to that information processing center in the home that is now just a gleam in our eyes. What might it do, for example? If -- and it's perhaps a big "if" -- the home is to become a real information storage and processing center: If -- again a big "if" -- tremendous information storage and recall capacity becomes inexpensive

O Will this capacity be used to store commercials?

O Mightn't news and entertainment be piped in by some other means than broadcasting?

If those questions look like a gloomy prospect, then how about this bright one: Wouldn't there be a bonanza for whoever provided such service -- even though selling and entertainment were no longer combined? What would it feel like, as members of the audience, to be cut off from the impact of selling and advertising? Would we miss it so much we'd be willing to pay for information about what is for sale and where to go for good values?

Finally, do you suppose some day some successor of mine in General Electric might speak to your successors about unexpected dimensions in your industry the way I spoke today about those in the power industry? Who knows; he might even point out to them that some of their older operations still keep the words "radio" and "broadcasting" in their titles!

I just don't know; but of this I am reasonably sure. Technology will help and not harm you if you keep your eye on fundamentals. As a reminder, I'll leave with you this illustration which an associate of mine used some years ago to a group in our Company. "If," he said, "You insist on thinking you're in the buggy-whip business, you're in a shrinking field, for sure, but try thinking you're in the accelerator business -- and it's still go - go - go!"

XXX

LUNCHEON ADDRESS

by

Dr. G. C. McVittie
Director, University of Illinois Observatory
Urbana, Illinois
at the
NAB Broadcast Engineering Conference
Conrad Hilton Hotel -- Chicago, Illinois
Wednesday, April 8, 1964

It is indeed a great honor for me to appear on the same program with Mr. John DeWitt. Astronomy has always benefited by the interest of (if Mr. DeWitt will pardon the word) the gifted amateur. By that, I do not mean a man who dabbles, but a man whose main interest in life is not astronomy but whose side interest is astronomy; and Mr. DeWitt is at present one of a long line of such men to whom astronomy, both optical and radio, owes a very great deal.

I want to tell you something about radioastronomy because I understand that although you are members of the broadcasting industry, many of you don't know what it is. This is indeed astonishing, as it always is when one finds that one's fellow human beings do not know about something which is very familiar to oneself.

Grogrieber, in the town of Wheaton, Illinois, and Yansky in New Jersey, discovered in the United States about 30 or 35 years ago, with the crude radio-telescopes of their time, that certain of the astronomical objects emitted radio waves; and since then we have of course found, with better instruments, that most of the objects we are familiar with in the sky-- at least we would be familiar with them if we ever raised our eyes to the heavens, which I don't suppose many of you do, if I can judge from the questions that often come in from the public to the Observatory: "What is that big light in the sky?" You tell them it is the planet Venus, and they say, "Oh", as if it was really something very astonishing and unusual.

The sun, for example, sends out not only light and heat by which we live, but it sends out radio waves, too. So do some of the planets--Jupiter and Venus. The moon even sends out radio waves, at least from the side which is heated by the sunlight, and all the stars presumably send out radio waves in various degrees of strength. The entire system of stars, which is known as a galaxy--perhaps 2 billion stars like our Milky Way system--each individual object in it sending out its contribution--the entire galaxy in some cases can be a source of strong radio emission. Even the gas that is found in great clouds here and there between the stars of a galaxy does send out radio waves also.

These objects send out, so to speak, continuous emitters of radiation. Most of you, I imagine, attempt to make your radio stations send out one frequency, or at any rate a frequency in a very narrow band. Nature is more lavish. The sun, for example, and most of these natural sources of radiation, send out at the same time, simultaneously and all the time, radio waves in all frequencies, and the ones that have been mostly studied run from what I believe you call super-high frequency band down to or up to (whichever way you are looking at it) the high-frequency band.

That is to say, observations have been made with wavelengths of 1 to 2 centimeters to many meters in length.

It is a bit galling to humanity to realize that something we have only been able to do perhaps for 30 or 40 years, namely, to put up a transmitting station which sends out radio waves--to realize that this trick of which we are so proud is something that nature has been doing for billions of years without turning a hair.

These natural objects emit radio waves in just the same way--not by the same mechanism--but they do emit radio waves, just as the sun and the stars, and so on, emit light. That is to say, if you like, radio waves of extremely high frequency.

These astronomical objects, then, have been studied for a long time from the point of view of the light that they emit, and for a comparatively short time--in fact, really not more than since 1945, barely 20 years--systematically from the point of view of the radio waves that they emit.

As you perhaps know, the astronomer of course studies these objects. He cannot go to them, of course, so he has to study them by means of these electromagnetic waves, light or radio waves which they emit and which eventually reach his telescopes, either the ordinary optical kind in the case of light or the radio-telescope in the case of the radio wave. From this radiation that reaches him he can draw an enormous number of conclusions.

Astronomy, you realize, is rather like archeology--that is to say, you have very little information coming to you, but you have got to draw an awful lot of conclusions from very little. That is why so many astronomers are also avid readers of detective novels, because there again you have to trace from very small clues to find out a great deal.

I am afraid in some cases colleagues of mine, who have very vivid imaginations, supplement the information that they receive by drawing freely upon their imagination. It is an occupational hazard in astronomy to keep your head and to see what the evidence really is, and to separate that from what you imagine might be the case.

From the information that comes to us by these light waves, and nowadays radio waves as well, we can find out a great deal about remote objects--the materials that are to be found in them, for instance--distances, sizes, whether the object in question is coming toward you or receding from you.

Those of you who were engaged with radar in the war recognize the famous Doppler effect which is now a feature of trying to find out whether a missile that has been detected on the radar screen is coming toward you, in which case you had better duck, or is going away from you, in which case you can hope that some other character will receive it on his head. The same technique essentially is applied in the astronomical problem.

Of course, we can find out a great deal about the physical properties of stars and galaxies and whatnot from this information, from these radio waves of all wavelengths and all frequencies which are coming to us from each of these objects; but whether we can ever use them to find out whether any of them is being emitted by intelligent beings--perhaps I ought to say beings like ourselves, because it is a moot question as to whether or not we are intelligent, I suppose; but let us not be too rash--so we will say by beings like ourselves, able to produce artificially these radio waves. I think the chance of such a spotty emission would be very slight indeed. However, what we can find out by the physical properties of these objects is extremely interesting at least for astronomers and, I hope, to the general public as well.

Let me now just say what a radio-telescope is. It consists essentially of three parts. First of all, a reflector which collects the radio waves that are coming in from these remote objects to the earth. It collects them and focuses them upon one or more antennas. For example, in the case of the radio-telescope at the University of Illinois, our mirror, our reflector, which gathers all the waves together and concentrates them on the antennas, has an area of about 5 inches.

It soon became evident, when radio-telescopes were being built, that the way to reckon the cost of a radio-telescope was "Megabuck per acre", "megabuck" being slang for $1 million, so you could calculate the cost in megabucks per acre.

Our telescope is a very cheap one because, although it has a mirror of 5 acres, it only cost altogether about $750,000. Those of you who are good at arithmetic might divide $750,000 by 5 and then by $1 million and tell us at the end of my discourse what the answer is, but you can see that it is certainly less than one megabuck per acre.

The second part of the telescope is the antenna--that is to say, the thing that picks up the radiation that has been collected and reflected onto it, and in it--well, you know more about these things than I do. I believe what happens is that very slight electrical currents form in the antenna, and then by means of transmission lines and other devices these currents are brought to the third part of the telescope, which is a radio receiver.

It is a radio receiver of extreme sensitivity, of course. All this apparatus usually has to be made at the extreme limit of the state of the art. For example, the radiometer we have on our radio-telescope is the best that is to be found, by far and away the best that is to be found in the whole State of Illinois. Therefore, if we have interference from some unknown source we are unable to get another radio receiver even to detect the interference, let alone tell us what it is.

Why is this? Why do you need these immense reflectors, this supergagetry, these antennas which have to be developed especially in a laboratory, as ours had to be, by two or three years of very hard work, plus a radio receiver of such extreme excellence? The reason is that the objects one wants to study are possibly so remote that although some of them are very powerful emitters of radio waves, by the time this radiation reaches us the signal is extremely weak; in fact, it is so weak that we used to have great difficulty in persuading you engineers who are concerned with the broadcasting industry that we were not simply talking science fiction. Many of you would not believe that signals of this degree of weakness could be recorded and, even if they could be recorded, that any information worthwhile could be got out of them.

Let me give you an example. This radio-telescope we have down near the city of Danville operates at 610.5 megacycles and has a bandwidth of just under 5 megacycles. The objects we are trying to detect with this instrument are so remote that the signals that come from them mean that by the time they reach us they are so weak that their strength (if you can call it strength, and I would prefer the word "weakness") is such that it amounts to 0.004 microvolt per meter. This is the kind of strength we are trying to detect and record.

Looking up the reference data for radio engineers, I believe in ordinary broadcasting you regard a tolerable level of interference as 100 microvolts per meter--that is to say, instead of 0.004, which is what we are worrying about, you are interested in around 100 microvolts per meter.

To us, even 1 microvolt per meter is 250 times too strong. That is to say such a radiation produced by the ignition system of the farmer's tractor in the neighboring field, or by a distant television station of 1 microvolt per meter, would be sufficient to blot out, to jam out, the signals we are trying to study.

This brings me to a touchy subject. I may say that this excellent lunch which I have eaten, I have eaten with great trepidation. I carefully watched the men on each side of me, and every time they took a mouthful of something I thought, "This is safe; I can eat it, too", because I thought to myself that I am really in the lion's den, and after all, I am the man who kept on for three years egging the FCC, egging on my astronomical colleagues and everybody else who would listen to me, urging that some protection for radioastronomy should be made in the United States. And in particular, of course, by a curious accident I was more interested in the band in which our radio-telescope was going to operate than I was in other bands. It happened that this band coincides with television Channel 37, 608-614 megacycles.

I have remarked that the emission of these objects we want to study is continuous throughout the radio spectrum. What the radioastronomers would like would be to have small bands here and there, about once every octave, which would be clear of all man-made radio transmission--silence bands, because we are only receivers of naturally-emitted radiation. We do not put out any radio waves, of course, with our radio-telescopes.

One of these bands happened to be somewhere in the 600-700 megacycle region, and it seemed that Channel 37, which was not being used by anybody, was the best one to pick from the point of view of creating the least amount of disturbance to people who are already using UHF television channels.

As a result of much activity and much lobbying in Washington--that, incidentally, is an occupation I would not like to adopt permanently--oh, dear! But I respect those men who make their living out of it, after one week's personal experience. It is very, very hard work, ladies and gentlemen.

As a result of very much lobbying, and of course eventually the help of most physical scientists in the United States, the FCC agreed that for ten years there should be a moratorium on the use of Channel 37 by you people in your broadcasting. As radioastronomers, we are extremely grateful to you that you did not put up more opposition than you did to this proposal. I think probably you felt that one channel out of seventy was probably no very great loss (I think there are about seventy UHF channels, aren't there? perhaps seventy-two), and that for the benefit of science ten years out of the history of television was no great loss.

I would like to say something about what we as radioastronomers give the industry in return. Since our object is to study these signals which are so extremely weak, so difficult to detect, we are continually urging on the research groups in the industry and elsewhere to improve their instrumentation. For example, we owe a great deal at the University of Illinois to the Zenith Corporation, and Dr. Robert Adler, for his parametric amplifier. The generosity of his company has given us this device which is a very important feature of the instrument.

We are continually, therefore, using and testing out this particular kind of parametric amplifier, and other radioastronomers in other parts of the country are seeking to develop more and better instrumentation from the point of view of more sensitive receivers, masers, parametric amplifiers and what-have-you, each one of which will eventually, I am sure, be of value to you in television and for other communication purposes.

So, it is a two-way operation. If you allow radioastronomy to continue, then radioastronomy, by the fact that it forces electronic engineers and antenna engineers to develop better and better gadgetry, will profit you in the long run just as much as it profits us.

Let me finish by telling you a little about one of the things (by no means the only one) that radioastronomy has done, because it is very much in the papers at the present moment. It is a development which has come about in the last year or so. It is these peculiar and very remote objects--in fact, the remotest objects--in the universe that have been detected, called radiogalaxies with stellar-like images.

When the radioastronomers identified these objects, the optical astronomers, particularly with the 200-inch telescope, took pictures of these radio sources, and they said, "But these objects look exactly like stars, small bodies like the sun, in our pictures." But clearly these things could not be individual stars because at the great distances they are they would then not be visible at all, and they must be the equivalent of at least 100 million and perhaps 1,000 million objects like our sun. And yet, they are in some way jammed so closely together that they look like a single object to an optical astronomer.

They are extremely powerful emitters of radio waves and also of light. It is a clear blue light which indicates that they are in a great state of commotion. Some of them flicker, which is even more incredible. If an astronomer had been told this five years ago, that a body or a collection of bodies equal to 100 million suns could flicker together in unison, he would have said, "Science fiction! Nonsense. Go away...you've had too many beers." But here we see it happening, so to speak, under our eyes.

What these objects are--that is, what the physical conditions in such things are--is still an unsolved problem. It shows that for the first time in forty or fifty years, ever since the 1920s, the interplay of radioastronomy and optical astronomy has revealed something in the universe, the like of which we have never seen before, and to which at the present moment we have really no clue in the sense that we have no theory which will tell us how a mass of material, such a large amount of material, could be jammed together into so small a space and behave in this fashion--that is to say, throw out light and radio waves in this extraordinarily intense fashion.

Furthermore, these objects have, I think, confirmed a hunch which many people, including myself, had when we urged that radio-telescopes of large size should be built. These have confirmed our hunch that radio-telescopes enable you to look farther away to the remotest parts of the universe, not because the optical telescopes cannot see there (because in fact they can), but because the radio-telescopes enable you to identify those objects among the multitudes that you can see with an optical telescope which are indeed very, very far away.

I think during the next ten years we shall probably have quite a revolution in our theories about how matter can behave in the universe, though at the moment we are still in the stage of being completely baffled by what is going on.

I would like to conclude with what I began with, namely, a reference to John DeWitt. It is perhaps not generally known to you that Mr. DeWitt is one of the few men who have bespattered the inside of the Kremlin in Moscow with his own blood, and yet escaped to tell the tale. Some years ago, he and I and about 1,000 other astronomers were meeting in Moscow and were given a party in the Kremlin, in great St. George's Hall, which is extremely beautiful and is entirely white. It is white marble...I don't think it's paint. Anyway, the impression you have when you see it is that everything is white.

John, as you may or may not know, is an ardent amateur photographer, so at the height of the party he decided to scramble up onto some eminence from which he could take a photograph of the proceedings. He got up there, but he came down rather more rapidly than he had anticipated, and split the skin of his skull on some part of the Kremlin. You know, when you make a small cut in your skin an immense, an incredible amount of blood comes out. It is not that you are really injured, but it is just like the law of nature--like Murphy's Law. Well, this is what happened. We were very much interested to see that the Kremlin possesses a first-class medical service who came into action at once and John's head was sewn up. He was all right the next day, I think, except for the loss of a bit of hair. We won't go into the rest of the details. Above all, I request that John should not proceed to spoil a good story by sticking too closely to the truth.

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PRESENTATION OF NAB ENGINEERING ACHIEVEMENT AWARD
TO
JOHN H. DEWITT, JR.

By
George W. Bartlett
at the
NAB Broadcast Engineering Conference
Conrad Hilton Hotel -- Chicago, Illinois
Wednesday, April 8, 1964

Ladies, 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 loved in our industry. A man who has dedicated an entire lifetime to the betterment of broadcasting and has contributed so heavily to the electronic storehouse of knowledge in our common field of endeavor.

Broadcasting has been the all-consuming career of John Hibbett DeWitt, a native of Nashville, born the son of Judge DeWitt of the Tennessee Court of Appeals.

Jack became a wireless operator while still in short pants and at the age of 16 built Nashville's first radio station at the Ward-Belmont School. Three years later and at the tender age of 19, he was instrumental in the installation of the original equipment for station WSM, and a list of Jack's technical accomplishments is indeed a bewildering array for such a young fellow.

From 1929 to 1932, he was employed by the Bell Telephone Laboratories where he developed the first crystal-controlled oscillator and the application of synchronized motors to broadcasting - a principle widely used in FM. At the conclusion of this assignment, he rejoined WSM as chief engineer, and perfected such things as vertical radiators, feedback systems, methods of determining station coverage, and directional antenna performance.

During World War II, he returned to the Bell Laboratories for fulltime work in developing radar equipment for the military. A Lieutenant-Colonel in the Army Reserve, he is an expert consultant to the Signal Corps on both ground and airborne radar and holds the Army's Legion of Merit. He was indeed the first man to successfully bounce a radar signal off the moon.

At the conclusion of World War II, he returned to WSM where, in 1947, he was named President - a position he still holds.

A long-time consultant on engineering matters to some 50 broadcast stations and the Clear Channel Broadcast Service, he is also a former advisor to the Voice of America, a past chairman of the NAB Engineering Advisory Committee and a member of the NAB Board of Directors.

Maybe it's a little hard to believe that a man who works so hard in broadcasting has another interest - astronomy. From his early interest in 1932, Mr. DeWitt is presently a research associate on the staff of Vanderbilt University where he works with the Department of Astronomy on the application of TV techniques to astronomy. He holds numerous patents and has published many articles and books on the subject of broadcasting and astronomy. He is a member of countless organizations, among which are the American Astronomical Society, the American Physical Society, and he is a Fellow in the Institute of Electrical and Electronic Engineers.

In recognition of his continuing efforts to foster the advance of broadcast engineering over the past three decades...for his outstanding leadership in directing a great station in a manner consistent with the highest ideals of his profession...for his many contributions to our nation's knowledge in the fields of Radar and Radio Astronomy...for his generous assistance to those who have sought his guidance and council in their search for knowledge and understanding...and for his pioneering spirit which has so richly contributed to the forward progress of broadcast engineering...it gives me great pleasure on behalf of the National Association of Broadcasters and the entire industry to present to Mr. John H. DeWitt, Jr., the NAB Engineering Achievement Award for 1964.

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MR. JOHN H. DeWITT, JR.:

I am deeply touched and honored by this occasion and the fact that I have been selected to receive this NAB Award. For it and your confidence, I shall be forever grateful.

I am not unmindful that the spotlight is not necessarily a one-way device. To paraphrase a favorite expression of my country music store friend, Roy Acuff, "The higher you climb, the more your posterior shines."

Satchel Paige said, "Don't look back; somebody may be gaining on you," and I might add they usually are.

Having been in broadcasting since 1922, you would think that I might have some words of wisdom to pass on to this assemblage. At the moment, I can't think of anything that sounds sufficiently pontifical, and engineers don't like this anyway. I have learned a few home truths, such as don't turn the knobs to get that last 1 per cent when the program is going along well enough, for you may experience a demonstration of what the physicist calls Murphy's Law. Murphy's Law states that the worst thing that can happen will happen.

I have also learned that the surest way to have your management or board of directors appreciate a magnificent engineering achievement is to have a good profit and loss sheet at the end of the month.

On the more serious side, it is most rewarding to see more and more technical directors and engineers turning to a part of the management team in radio and television stations. In the old days, the engineer was a voodooman to most owners and managers. Their languages were so different, their outlooks so far apart, that there was little understanding between them.

Today the successful engineer is the one who is able to translate his engineering talents and language so as to be not only a manager of some very expensive equipment, and in many cases the leader of a large number of highly skilled and specialized people, but also a member of the advisory group in management.

As for equipment, the emphasis is no longer on making something work by the skin of its teeth, but in the selection of equipment and planning layouts for reliability. We can't afford breakdowns when spots sell in the thousands in large cities and in the hundreds in small ones. Fortunately, the solid-state art which has interested me for the past four years seems to be the answer to the reliability problem as well as several others. When all things are considered, I believe radio and television engineering can be the most rewarding, and at times exciting, of occupations - but you have got to like it.

It is with deep humility and gratitude that I accept this Award. I think there are many friends here who deserve it more, and others who likewise have labored in the electronic vineyards.

Thank you very much.

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ENGINEERING
DEPARTMENT
PUBLICATIONS
CBS TELEVISION NETWORK

CBS Broadcast Center

RICHARD S. O'BRIEN
JOSEPH A. FLAHERTY
K. BLAIR BENSON

PRESENTED AT 18th NAB BROADCAST ENGINEERING CONFERENCE
CHICAGO, ILLINOIS APRIL 6, 1964

CBS BROADCAST CENTER

PART I. INTRODUCTION

A. BACKGROUND

CBS in New York is undertaking what many U.S. television broadcasting stations have been doing; namely, replacing its original plant to provide a modern, more efficient and flexible facility. The original CBS Television plant, like many others built at the time, was installed quickly during the early days of television broadcasting and expanded piecemeal to meet changing requirements. In this case, the oldest portions of the plant are over 15 years old.

In replacement and modernization, the objective is to bring about a more efficient operation and one which is capable of producing a higher quality product. This may be achieved in part by taking advantage of current technology, particularly in the utilization of more stable and reliable equipment. It may be achieved by designing a plant to meet the known operating and production patterns which have evolved through years of experience and by building in the flexibility needed to meet unknown future requirements.

The concepts which have been followed in the design of this plant to meet operating requirements, although influenced by the sheer magnitude of a network headquarters operation, are consistent with those currently being applied in new television broadcasting plants of all sizes. The approach is more evolutionary than it is radical in concept.

In the case of CBS, New York, an important additional gain in efficiency is afforded through further consolidation of what had become a far-flung, city-wide, plant. The extent of the CBS television plant at its most dispersed, in the mid-1950's, is indicated in Figure 1A. Changes in the program schedule, production techniques, management methods, and above all, the advent of video tape, have made possible a considerable reduction from this extreme. Given the existing program schedule in the final consolidation, after completion of Broadcast Center, CBS Television will occupy only five locations in New York, as illustrated in Figure 1B.

Most production studios and all central support facilities and services will be consolidated in Broadcast Center on West 57th Street. Off-premise studios will be retained to accommodate audience shows and to provide supplementary production space, as required to handle the inevitable peaks in the production schedule.

B. BROADCAST CENTER

Broadcast Center has been created by conversion of a building, owned by CBS since 1952, but originally built in sections between 1906 and 1939. For many years, designated "Production Center," it has housed CBS television functions such as scenery and property construction and storage; film editing and storage; field, construction and technical maintenance shops, and Operations management. The building was acquired with the thought of ultimate conversion to a centralized broadcasting plant. Studies were undertaken as early as 1955, and in 1961 approval was given for the project now nearing completion.

Upon completion, Broadcast Center will house the CBS Television Network and WCBS-TV local station New York operations, most of the Radio Network operation, the entire CBS News Division, and many related functions. In its 500,000 square feet of floor space, it will contain six television studios, with all related back-up facilities, such as dressing rooms, viewing rooms, and rehearsal halls; the local and network Newsrooms, including two small television origination facilities; five radio studios; show production units; scenery shops and storage space; central technical equipment; services ranging from a cafeteria to corporate data processing; and related administrative and management functions. The plant will provide a fully integrated, balanced production complex, equipped to deal with all phases of television program production, from script to output signal.

In this paper, only the television portions of the plant are described, with emphasis on the technical facilities and the areas in which they are housed. As indicated in Figure 2, these facilities and areas are located on two floors of the building.

1. Studio Floor of Broadcast Center

The six larger television studios occupy what was formerly the top floor of the western portion of the building. Headroom was created by literally "raising the roof". As shown in Figure 3, new structure was placed, a new roof was finished, and then the old roof and its structure were removed to form the studio blocks. The photograph of Figure 4 shows the interior of one of the studios thus formed (Studio 42) which, with over 6,000 square feet of floor space, has a lighting-grid height of 19 feet. The smallest studio has 3,300 square feet of floor space; the largest, 8,500 square feet, with a grid height of 25 feet.

Because of the fact that the studios are elevated and thus susceptible to sound conduction through the building structure, the floor of each studio is an isolated, spring-supported, reenforced concrete slab. The inside walls of the double-wall construction are supported on the floor slabs. Also, as shown in Figure 5, buffer space is provided around each studio further to insure acoustic isolation. Some of the space between studio blocks on two floor levels was utilized for dressing rooms, conference rooms, offices, scenery ready areas, and, on an upper level, a central area housing the magnetic-amplifier, dimmer units for all six studios. A truck ramp in the original building was retained for scenery handling.

Associated with each of the six studios is a control room. Each control room is on the same floor level and is located immediately adjacent to its studio, providing direct access. Studio-to-control room windows are not provided. To the greatest possible extent, each studio and its control room has been made a self-sufficient production unit. Operational control of all program sources assigned to a studio has been delegated to the control room, but, on the other hand, equipment requiring only set-up adjustment has been placed in a central equipment area.

2. Central Technical Area

As indicated in Figure 2, the Central Technical Area is located on the floor below the studios. This area, shown in more detail in Figure 6, is divided into two principal sections, designated Equipment Center (or rack room) and Operating Center (or "machine" room).

On the periphery are the Telephone Company terminal room, the television maintenance shop, closely-related technical operations offices, and three Program Control rooms.

a. The Equipment Center, occupying 4,500 square feet, houses 265 racks containing studio and telecine camera channel equipment, relay-type studio switcher matrices, the sync pulse system, central intercom and audio facilities, and multiple-function computer control equipment. Included is a Transmission Center, which provides for overall technical surveillance of incoming and outgoing programs and serves as a technical communications center. In the Switching Center, a multiple-channel switching system, with 109 inputs and 197 outputs, provides a computer-controlled interconnection among program sources and control rooms, and remote-controlled selection for monitor and cue channels.

b. The Operating Center initially houses, in its 12,000 square feet of space, 27 film playback channels, six film recording channels, and 24 video tape machines. Related supervisory, assignment control, closed circuit (audition) control, and first echelon maintenance functions are centrally located in the area. Both film and tape material are supplied from a common ready area.

3. Program Control Rooms

Program Control rooms are of two types. One, patterned after a studio control room, will be used to produce News shows originating in the adjacent News area.

The other two Program Control rooms are functionally designed to handle the transmission of a continuous sequence of programs to network circuits and to the local station. In each of these, a two-man team, with the aid of computer memory, can select and control related program continuity for two different destinations.

This has provided a brief orientation as to the location of the Broadcast Center television technical areas. In the next section, attention will be directed to the functional layout of some of the more important operating areas, with emphasis on the underlying operational philosophy.

PART II. TELEVISION OPERATING AREAS

A. PLANT DESIGN

From an operating philosophy viewpoint, the general design targets for the new plant were to increase its efficiency and flexibility through consolidation and modern design, improve the technical quality of the product through improved equipment and operating conditions, and reduce the operating costs through the efficiencies effected. In short, the objective was the goal of any business -- to produce a better product at a lower cost. At the same time, the new plant is designed to open logical avenues to accommodate tomorrow's expansion and change.

The specific plant design was developed by relating these general design targets to individual operating areas and fitting the "design" to the operating "job-to-be-done". Broadly speaking, television broadcasting activity can be divided into two operations: (a) production of programs (recorded or live), and (b) broadcasting of programs in an integrated continuous sequence. The operating control areas are designed specifically to meet the requirements of these two operations and to provide for efficient and convenient utilization of common support facilities.

B. PROGRAM PRODUCTION FACILITIES

Program production is basically a creative operation. Thus, the studio and control room design should provide an atmosphere which aids the production crew in this creative effort. To this end, the Broadcast Center studio control rooms were arranged to group the entire production team close to the program director and to make them relatively independent of outside support by giving each man control of those program elements for which he is responsible. On the other hand, unnecessary equipment, set-up control, and loading tasks were removed from the control room. Terminal, switching, and power equipment were located in a central area away from the creative activity, and remote control of necessary functions was extended to the control room.

Within the control room itself, there are three closely interrelated jobs to be done during the production of a television program: (a) picture pick-up, (b) sound pick-up, and (c) camera editing.

(a) The picture pick-up is the combined responsibility of the lighting director and the video operator, who are assisted by the lighting crew and switchboard operator.

(b) The sound pick-up is under the control of the audio man who is assisted as required by mike boom operators, sound effects men, audio tape and turntable operators.

(c) The camera editing operation is under the direct control of the program director, who works through the program switcher, or technical director, assisted by the cameraman, dolly pushers, and crane operators.

Of course, all these interrelated jobs are ultimately under the control of the program director.

In recognition of these relationships, the Broadcast Center control room design provides separate picture, sound, and production control areas arranged so that they can be isolated from one another by sliding glass panels, yet all be within line-of-sight with the program director.

The layout of a typical control room, which is about 38 feet long and 20 feet wide and one the studio floor level, is shown in Figure 7. The picture control area is on the left, with the production control area in the center, and the audio control area on the right.

The audio man is at the audio console with the turntable and audio tape machine operators to his right. The lighting director sits between the video man and the lighting switchboard operator and shares a single set of picture monitors with the video man. The program director and his assistants sit at the central console with the technical director, who handles the video switching, and are provided a separate set of picture monitors. These monitors are arranged to provide the best possible viewing display, which is made possible by the elimination of the little-used control room window. Quick access to the studio floor was found to be of far more value than direct line-of-sight in modern production work.

The continually increasing complexity of sound pick-ups in television shows has resulted in the need for additional space and facilities in the sound control area. The audio console required more microphone inputs, more high level inputs for film, tape, and remotes, a greater number of improved equalizers, special effects filters, two completely separate reverberation channels, and seven separate output channels, each able to select any combination of the mixing channels. This latter requirement has resulted from the need to record simultaneously a composite audio track, a separate dialogue track, music track, effects track, and still provide pre-hear facilities and sound reinforcement for the studio and an audience, if present. As shown in Figure 8, these audio facilities were arranged in a console which can be conveniently and effectively operated by the single audio man.

In the picture control room, shown in Figure 9, the lighting director and video man share a common responsibility for the picture quality and, therefore, share a common control console. The lighting director controls lighting balance and artistic mood of a scene, and the video operator sets the exposure of the camera. The lighting director controls the lighting balance through the lighting switchboard operator to his left, and the video operator controls the camera exposure, black level, and white level through the remote controls extended to his operating console. Together, they observe the final results on a common set of camera monitors, preview monitors, and a line output monitor.

To insure optimum blending and control of all picture material used in a production, the exposure, video level, and black level controls for all supporting picture sources assigned to the studio have also been extended to this console. Thus, the video operator has direct control of the telecine film and slide cameras, playback video tape machines, and processing amplifiers for remote signal sources. These controls are grouped together with those for the studio cameras within the reach of the single video operator.

In the production control room, present-day program requirements make it necessary to be able to handle a large number of sources without enlarging or complicating the switching panel. The video switcher, shown in the foreground in Figure 10, has twelve inputs for live cameras and remote signal sources and six output switching rows plus preview and special monitoring busses. However, as many as 80 different sources can be assigned to a given studio, and the technical director can "call up" any combination of eight at one time. When selected by the technical director, using a keyboard control, the source is automatically routed to the video control, video switching, and audio control positions, complete with its associated audio, video, intercom, interphone, transport control, video level control, audio level control, and indicating read-outs.

The program director and his assistants are the focal point of the production effort. To simplify their task, a complex and comprehensive intercom and interphone communications network was required. This system has to provide the ability to communicate with a great number of people, singly, and in groups, with as little effort as possible and with maximum clarity.

The "flexibility" design approach was carried into the studio itself and, in fact, many operating features have been introduced whose detailed discussion is beyond the scope of this paper. However, because of its importance to the "picture pick-up" problem, the new studio lighting grid should be mentioned. In Figure 11, a typical broadcast studio lighting grid is shown. The grid is a network of fixed channel struts and walkways arranged to permit a lamp to be hung in virtually any location in the studio. As shown in Figure 12, the lighting crew works in the grid and hangs the lamps from horizontal supporting channels at the operator's waist level. With this system, the scenery can be "loaded in" and "set up" on the floor while the lighting is being set from above. In the past, these operations were done in sequence in most studios, and, therefore, this system will require less "turn around" time between shows. A light can be raised, lowered, tilted, or re-focussed during a rehearsal or program without disturbing the performers or the production staff. In the past, it was often necessary to wait for a "rehearsal break," when a ladder could be moved into the scene to adjust a lamp. Thus, this system should not only be faster and more flexible, but should also provide higher quality results.

C. PROGRAM BROADCASTING FACILITIES

As contrasted with the creative job of producing programs, the broadcast of programs in an integrated, continuous sequence is more an exercise in accurate scheduling, precise timing, and error-free integration. Therefore, a system which simplifies the assembly, timing, and error-free broadcast of programs with the ability to make last-minute changes, is required. Once the material is assembled and timed, the signal selection and program sequence control is a mechanical and repetitive task. In the Broadcast Center, these operations have been automated through the use of computers.

The actual broadcast operation takes place in a control room designed specifically to handle this function. The layout of a typical Broadcast Center automated Program (continuity) Control room is shown in Figure 13. This control room is operated by a two-man team, a production man, and a technical man. The production man is responsible for the program continuity; the technical man is responsible for audio and video level control and, with the aid of the computer, is also responsible for audio and video switching.

In the view shown in Figure 14, the production man sits on the right side of the console before a set of output monitors and indicating read-outs. The technical man sits on the left side of the console with his set of line output monitors, waveform monitors, indicating read-outs, and test and preview channels.

As in the studio control room, the control console provides remote control facilities to control the audio, video, and transport of the assigned signal sources. However, because of the nature of the work in this case, twelve sources rather than eight may be accommodated. Combined audio-video switching, including fades, dissolves, and special effects, is performed automatically, using computer memory, but a complete switching panel is provided for manual control in an emergency.

Two Program Control rooms of this type have been installed in the plant to service the multiple network feeds that occur, especially during Daylight Savings Time, and each of them can "feed" two output signals when separate "regional" material is fed to different sections of the network within a single show. One room will normally feed the regular network and local New York station WCBS-TV and the other various special networks and the "delayed" network during Daylight Savings Time.

As mentioned previously, a third Program Control room, designed in the manner of a live studio control room, is used to control News programs that originate from the Newsrooms. During other parts of the day, this room can be used for the assembly of pre-recorded material and to serve as an "anchor" studio for programs originating largely from remote locations. With its twelve input channels, it will be especially useful in the assembly of complex multiple-location remote originations.

D. CENTRAL TECHNICAL FACILITIES

The Central Technical Area contains the technical equipment to support the two basic operations described above. In line with the objective of improving flexibility and reducing operating costs, the Broadcast Center design combines like operating functions into a single area and separates operational activity from maintenance activity. As noted previously (Figure 6), the Central Technical Area is divided into two main sections, the Equipment Center and the Operating Center. The Equipment Center is shown in more detail in Figure 15.

The Operating Center, as shown in Figure 16, contains the telecine film and slide projectors, the video tape machines, and the television film recorders. It is the "record" and "playback" factory, which services the studios and program continuity rooms.

The playback operating controls have been delegated to the using facility; thus, the playback operation in this area is effectively a loading and "cueing" operation. The recording operation, on the other hand, is attended and locally controlled in this area. Any given video tape or film recording machine may select any one of 70 inputs from which to record. These recordings are scheduled as part of the daily operating routine. The area is supervised from a Central Operations control room (CO) in the center of the complex. In addition to their supervisory responsibility, the supervisors in this room can override the computer routing assignment in the event of a last-minute machine failure which necessitates a machine reassignment.

The Closed Circuit control area (CC) is an audio and video control point for monitoring and adjusting signal levels for transmission to viewing rooms, thus eliminating the need to tie up a studio or Program Control room for internal viewings and auditions.

The operating specifications for this plant generated a set of unique engineering design problems. The next section of this paper will outline the design approaches employed to solve some of these problems.

for telecine and tape equipment require the maximum number of control circuits. On the other hand, channels fed from on-premise studio outputs require no control circuits.

Of the 197 output channels, 142 provide service to studio and Program Control room switching systems, video tape recording, and film recording. The remaining 55 channels feed outgoing networks, monitors, viewing rooms, and cue circuits. In addition, three channels are allocated for test purposes. Controls for each of the test channels are located at strategic points in the Central Technical Area in order to permit ready operational surveillance of the system performance and maintenance diagnosis of system faults.

To accomplish the many switching functions, two types of relays and one type of motor-driven rotary selector are employed in the Master Exchange system. A total of 35,000 wire-spring relays are used for all signal circuits, audio, video, and communications. Control of input channels is handled by a bank of conventional telephone-type 10-in/10-out, 6-level cross-bar switching assemblies. The 21 control circuits and single tally circuit associated with each channel are switched on 200, 16-deck 51-contact, motor-driven rotary selectors. Figure 18 shows one of the five cabinet racks of rotary selectors.

The switching of audio and video signals is handled at low level in order to reduce to a minimum the number of input amplifiers. Nevertheless, a total of 1,200 video and 309 audio amplifiers are required. Each input video amplifier has a gain of 9 db, three of which make up for the loss in equalization of the input video line. The remaining 6 db permits a level of 2 volts from each of the two outputs to be fed to a splitting network which in turn feeds twelve cross-points. The cross-point level of 0.07 volts, after switching, is boosted up to a standard 1 volt by the output amplifier. One amplifier is provided for each output. Equalization for frequency response losses in the switching system is provided in the amplifiers. Similarly, 24 db of gain is provided in each of the audio output amplifiers in order to permit one input channel to feed several outputs.

Maintenance of a switching system of this magnitude and complexity would pose serious and costly problems if it were not for the extreme stability of the solid-state components and reliability of the relays. Experience to date indicates that gain variations from input to output can be held to 2 percent, or less. The greatest portion of the overall system gain variation is due to variations in terminating and splitting network resistances. To reduce such variations where tolerances in any one path through system are cumulative rather than averaging, resistors have been selected to reduce the overall level error to under 2 percent. Amplifier gains, on the other hand, are holding to well within ± 0.5 percent without any need for periodic adjustment.

Accelerated life tests on the wire-spring relays indicate that at least 30 years of trouble-free service may be expected. Field experience with the cross-bar switchers and rotary selectors in telephone service indicates comparable reliability.

By the use of efficient solid-state components, the power consumption of the complete Master Exchange amplifier system is only 5000 watts. An equivalent load is presented by the relays under normal operating conditions.

The same basic video switching module is used for all of the live studio and Program Control room switchers, thus simplifying maintenance and stocking of spares.

C. COMPUTER CONTROL SYSTEM

The volume of interconnection traffic called for semi-automatic control. Control of the Master Exchange system, as well as other memory and control functions, is handled by two on-line drum-storage computers, each having a total storage capacity of 670,000 bits of information. Normally, the operating load is shared by both computers. However, one unit is capable of handling all of the basic network and local station operations and consequently, the second provides back-up protection. Emergency back-up protection for an hour ahead is provided by a continuing automatic interchange of information between the two computers. The computers serve three basic functions:

(1) The daily assignment of all video tape, telecine, and other source facilities, to control rooms, is recorded on punched paper tape by means of a Flexowriter, at the time the daily operations sheets are typed, and then is fed directly into the computer memory by means of a high-speed tape reader. Any necessary later changes in assignment can be made by punched tape or manually, by means of the digital keyboard in Central Operations.

(2) On-air switching operations of the two Program Control rooms and their related equipment is handled entirely by computer control. Audio and video switching, fading, special

effects, tape and telecine transport, audio tape and turntable transport, and sync-lock, are controlled. The information for control is fed into the computer in the same manner as is the facilities assignment. Changes in the instructions can be made by punched tape or manually, by use of the keyboard in the Program Control room.

(3) Lighting control board presets for all studios can be stored in the computer and recalled to automatically reset the controls as required by actuating a keyboard at the lighting console.

D. REMOTE CONTROL OF ASSIGNED SIGNAL SOURCES

A source assigned to a studio control room may be placed on any of several input channels by the control room operator, and when so placed, provides appropriate signals and control connections to the corresponding channel position on the audio, video switching, and video control consoles. The audio console and the video switching and control panels are designed to accommodate, at one time, a complement of up to eight assigned support facilities, fed through the Master Exchange.

The control circuits are so designed that the same controls interchangeably provide the required control of video tape, telecine, or remote origination channels. The somewhat different control requirements for live cameras, however, dictated that separate controls be provided for the two Master Exchange positions to which live cameras may be assigned.

Figure 19 is a view of the video control and production consoles. The video control panel, shown in more detail in Figure 20, includes individual levers for each live camera channel and each of eight Master Exchange channels. The lever assembly provides control of three functions, viz., (1) video level by movement of the lever, (2) blanking level by rotation of the knob, and (3) selection of the signal for that channel on the preview monitor, by depressing the knob on the lever. The convenience of this method of selecting the appropriate signal makes it practical to omit waveform monitors on all channels. Consequently, the chance of error in levels has been decreased by the use of a single waveform monitor for all level settings, and a more compact monitoring assembly is possible. Auxiliary controls and adjustment for each channel are contained in the 2-1/2-inch wide strip associated with each lever.

Figure 21 is a view of the camera control racks in Equipment Center. Through the use of the simplified remote controls in the studio, and taking advantage of the stability of the camera channels, it is possible to consolidate the set-up equipment in one central area.

E. STUDIO SWITCHING SYSTEM

To the right of the video control panel is the technical director's switching and control panel. This panel, shown in Figure 22, and the accompanying system incorporate several departures from conventional system design practices.

First, all signals in the Broadcast Center are composite. Thus, there is no separation of the functions into composite and non-composite signal switching. This aids materially in simplifying the switching panel and its operation. Signals which are synchronous with the studio camera sync pulses are stripped of sync and set-up after switching and before being fed to faders or special effects equipment. Sync is then added after the effects operation. In the event that signals are not synchronous with the studio generator, a sync comparator unit detects this condition, automatically bypasses the faders and special effects equipment so that a direct switch results if the operator erroneously attempts to fade or wipe, and indicates the non-sync condition by means of a warning light on the control panel.

In addition to the use of composite-only video signals, further simplification of the control panel has been achieved by the use of mode selection on the preview row of buttons and on the tape and telecine transport controls. The preview row can be used for any one of several preview and monitor control functions or as an emergency air channel by appropriate mode selection. Similarly, forward, rewind, or slide change controls, where applicable, can be assigned to any one or any grouping of tape and telecine equipment.

Any of the input signals can be selected for controlling sync-lock of the generator in Equipment Center assigned to the studio, or the studio can be switched to the generator assigned and designated as the main plant sync source. When a change in sync-generator is made, the sync signals fed to all of the in-plant support facilities assigned to the studio, through the Master Exchange system, are automatically changed so that the sources remain in sync with the studio.

An auxiliary video switching panel is provided at the left of the video console for handling occasional, unusually complex, special effects. This can be seen in the foreground in Figure 19. In addition to the usual wipes and montages, this panel provides a joy-stick positioner for special effects inserts. The technical director, at his discretion, can assign control of the third pair of switching channels to this auxiliary special effects switching panel.

F. STUDIO LIGHTING CONTROL SYSTEM

The lighting console control shown in Figure 23 is a basic three-scene preset system, with provision for computer storage of lighting presets. The console shown is for the smallest studio and consists of thirty, 12 kw dimmer, and thirty, 12 kw non-dim circuits. The largest studio has 100 dimmer circuits. The dimmer circuits can be assigned to any of four master dimmer controls in any desired combination. An additional ganged dimmer control can perform any combination of fades among three preset scenes.

For computer storage of lighting presets, the analogue information corresponding to each dimmer setting is converted to digital coding and stored on the magnetic drum of one of the computers. Recall of lighting presets and automatic setting of the individual dimmers are accomplished merely by punching up the lighting preset identification number on the digital keyboard at the console. The digital data is used to drive the motor-operated dimmer quadrant controls to the proper setting. The lighting preset data developed on rehearsal can be printed out in hard copy from the computer, thus avoiding the need to use the computer memory for long-term storage.

The lighting console controls the studio lights through magnetic amplifiers and a patch panel. All of the magnetic amplifiers for the six studios are located in a single room, situated in the center of the studio complex on the same level as the studio lighting grids. The patch panels are mounted on the lighting grid level in each of the five large studios.

G. STUDIO AUDIO SYSTEM

As noted previously, the audio requirements for present-day network television program production are extremely complex. In the newly designed console shown in Figure 8, a total of 24 microphone inputs are available through twelve low-level channels and fifteen submixer inputs. Ten additional inputs are available for telecine, tape, and remote studios. Outputs include four program, two reverberation, and three utility or special effects channels.

In order to provide increased capacity without increasing the size of the audio control console over the older, standard CBS console, it was necessary to employ different design concepts. First, the conventional rotary attenuator has been replaced by the vertical quadrant assembly to enable a more compact control array. Second, transistors are used in place of vacuum tubes for all circuits. Third, in order to simplify the ganging of fader functions in submixer channels, use has been made of d-c controlled, light dependent resistors in the variable attenuator networks.

A word should be said for the communications system. Invariably, the ultimate requirement is for anyone to be able to talk to anyone else at any time, without interference and with lifelike quality. By the use of carefully allocated area coverage, specific local coverage, and the use of broadcast components, the Broadcast Center facilities come close to this ultimate. The most striking characteristics of the communication system, other than its flexibility, are uniformity of level and high quality. Communication is made appreciably more effective by the ability of personnel to recognize voices and inflections. This is achieved by the use of fast-acting AGC and broadcast-quality components.

H. CONTINUITY PROGRAM CONTROL ROOM EQUIPMENT

The facilities in the two Program Control rooms (Figure 14) differ from those in production studios in several significant ways:

1. Video and audio normally are switched or faded together. However, variations are easily set up, such as separate announce, tape, or turntable audio at various levels, or in various sequences.

2. Two independent and duplicate output channels, as well as two announce booths, are provided so that split feeds can be accomplished. A common example is the insertion of two different, regionally-oriented commercials into a common network program.

3. All of the switching and fading operations can be controlled from the computer memory system. A precheck of all computer-controlled sequences can be made at any time prior to operation of the sequences, without interference with the program outputs, and changes can be introduced manually as desired.

The program switching panel, located to the right, and shown in more detail in Figure 24, provides full manual switching control in the event of computer system failure. The keyboard serves the multiple purposes of communicating with the computer and channeling Master Exchange assignments into the desired PC input channels. The technical operator's normal position is to the left, in front of the lever controls for the twelve input channels. The controls for these channels are identical to those in the studio control rooms, except that an audio level control is included on each strip.

The left wing assembly of racks and consoles contains the cartridge tape equipment, turntables, and audio switcher. This is shown from one of the announce booths in Figure 25. Incidentally, it is of interest to note that d-c controlled, light-dependent resistors, rather than relays, are used as the cross-points in the audio switcher.

I. CENTRALIZED SUPPORT FACILITIES

Figure 26 shows a work-in-progress view of the telecine area. In the foreground is 35mm equipment; in the rear, slide projectors. Figure 27 is a view of a continuous-motion, 16mm projector. Except for two 3-Vidicon color channels, each projector is provided with its own camera. In network operation, unlike local station programming, film equipment is assigned to production studios for long periods of time. Thus, for this service, a uniplex set-up is most economical. The uniplexed cameras are mounted on the projectors, thus simplifying installation and providing a stable optical assembly. Auxiliary equipment, including monitors, is housed in two-faced racks, placed to provide convenient operating and maintenance access from two projector/camera units.

Figure 28 shows three of the bank of six transparent-slide projectors.

These units have available complete remote control of random, sequential, or reverse presentation of slides in a choice of direct takes or variable-speed dissolves. Registry of picture material, using special molded slide-mounts, is as good as the sprocket holes in the slide film.

The 24 video tape units are arranged in pairs with each pair fed from an audio and video channel in the recording section of the Master Exchange system. The same assembly of auxiliary equipment is used for both RCA and Ampex pairs. Figure 29 shows three pairs and Figure 30 a close-up of one pair of tape machines.

IV. SUMMARY

This paper has provided an orientation and an introductory discussion of area and equipment highlights in the television technical portion of the CBS Broadcast Center. Although partially obscured by sheer magnitude, many of the basic concepts closely parallel planning considerations followed in new broadcasting plants of all sizes. It is believed that the design concepts employed may provide further stimulus to a more rational split between production and continuity operations, and between operating and set-up functions in many future plants.

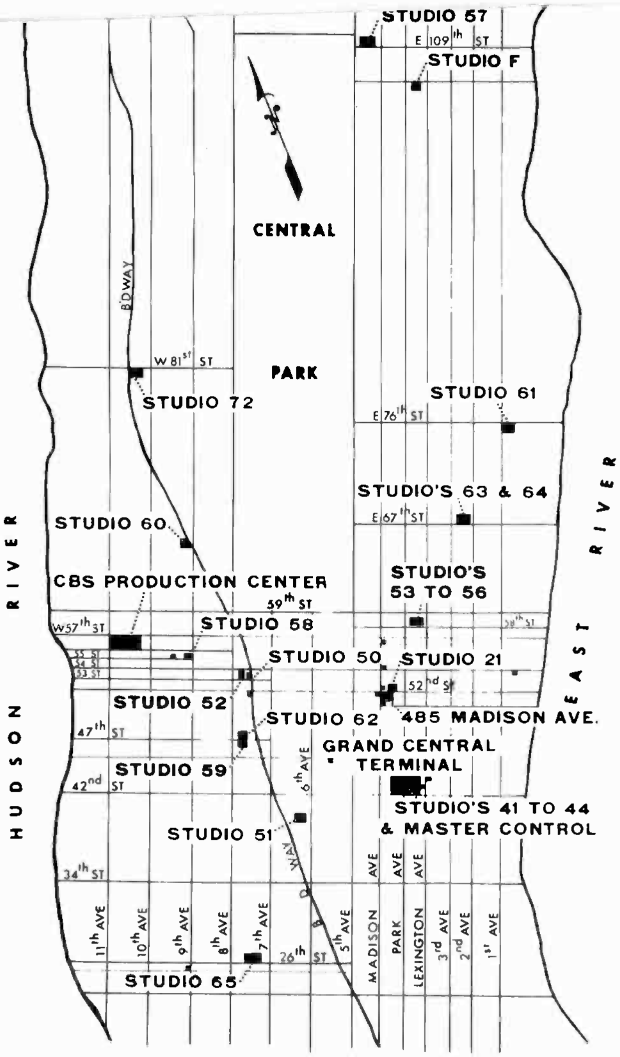
The authors have served here as mere reporters for the numerous persons whose individual contributions are built into this new plant. It is anticipated that many of these individuals will, in the future, provide the more detailed descriptions necessary to describe fully the many new and widely-applicable features of the CBS Broadcast Center.

ILLUSTRATIONS

FIGURE NO.	TITLE
1A-B	N.Y. Map, Showing CBS Television Locations.
2	Location of TV Technical Areas in Broadcast Center.
3	Photograph of Studio Roof Framing.
4	Photograph of St. 42 Interior.
5	Studio Floor Plan.
6	Central Technical Area Floor Plan.
7	Studio CR Layout.
8	Photograph of Audio Console.
9	Photograph of Picture Control Room.
10	View of Control Room From Director's Position.
11	Photograph Showing Lighting Grid.
12	Photograph Showing Lighting Man in Grid.
13	Floor Plan of PC Room.
14	Photograph Showing PC Room Console.
15	Equipment Center Layout.
16	Operating Center Layout.
17	Master Exchange Video Switching Racks.
18	Master Exchange Rotary Selectors.
19	Studio Video and Production Consoles.
20	Studio Video Control Panel.

ILLUSTRATIONS (cont'd)

FIGURE NO.	TITLE
21	Studio Camera Control Equipment in Equipment Center.
22	Studio Production Switching Panel
23	Lighting Console and Adjacent Video Special Effects Control.
24	Program Control Room 32 Switching Panel.
25	Program Control Room 32 Audio Console and Racks
26	Telecine Area.
27	16mm Projectors.
28	Slide Projectors.
29	Video Tape Area.
30	Video Tape Module.



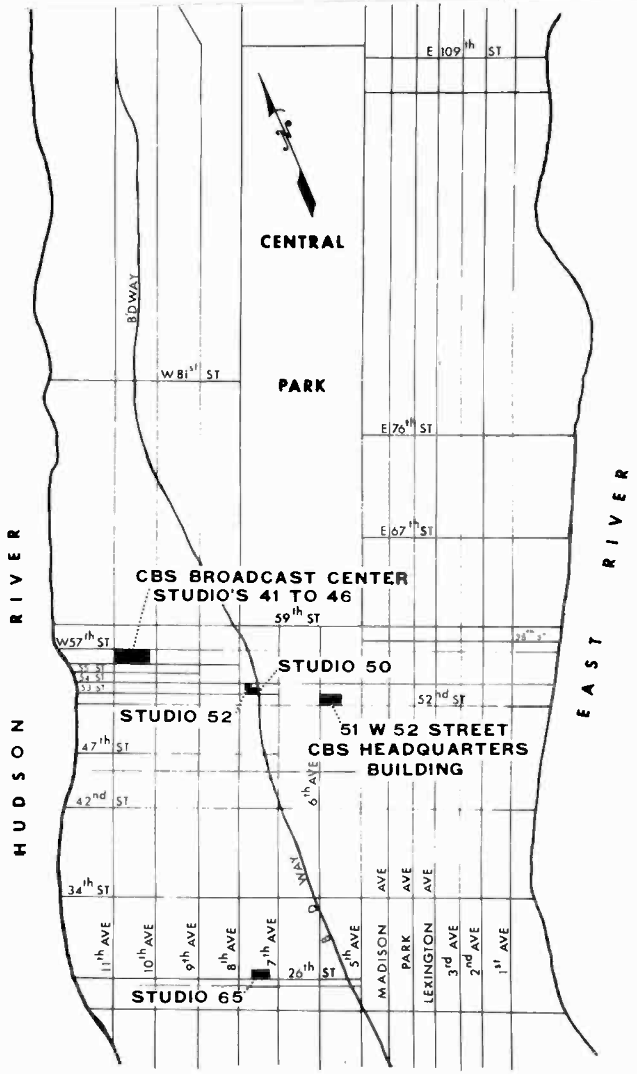


FIGURE 1A - LEFT   FIGURE 1B - RIGHT

The city-wide dispersion of the New York CBS television broadcasting facilities during the mid-1950's, as shown in Figure 1A, is contrasted with the consolidated plant which will exist after completion of Broadcast Center (and the new CBS Office Building), Figure 1B. Off-premise Studios 50 and 52, located in the Broadway area, are retained for audience shows. Studio 65 provides supplementary production facilities to handle peaks in the schedule. Broadcast Center will accommodate the bulk of program production, provide all central facilities and service, and handle the continuity of twenty-four hour per day program transmission.

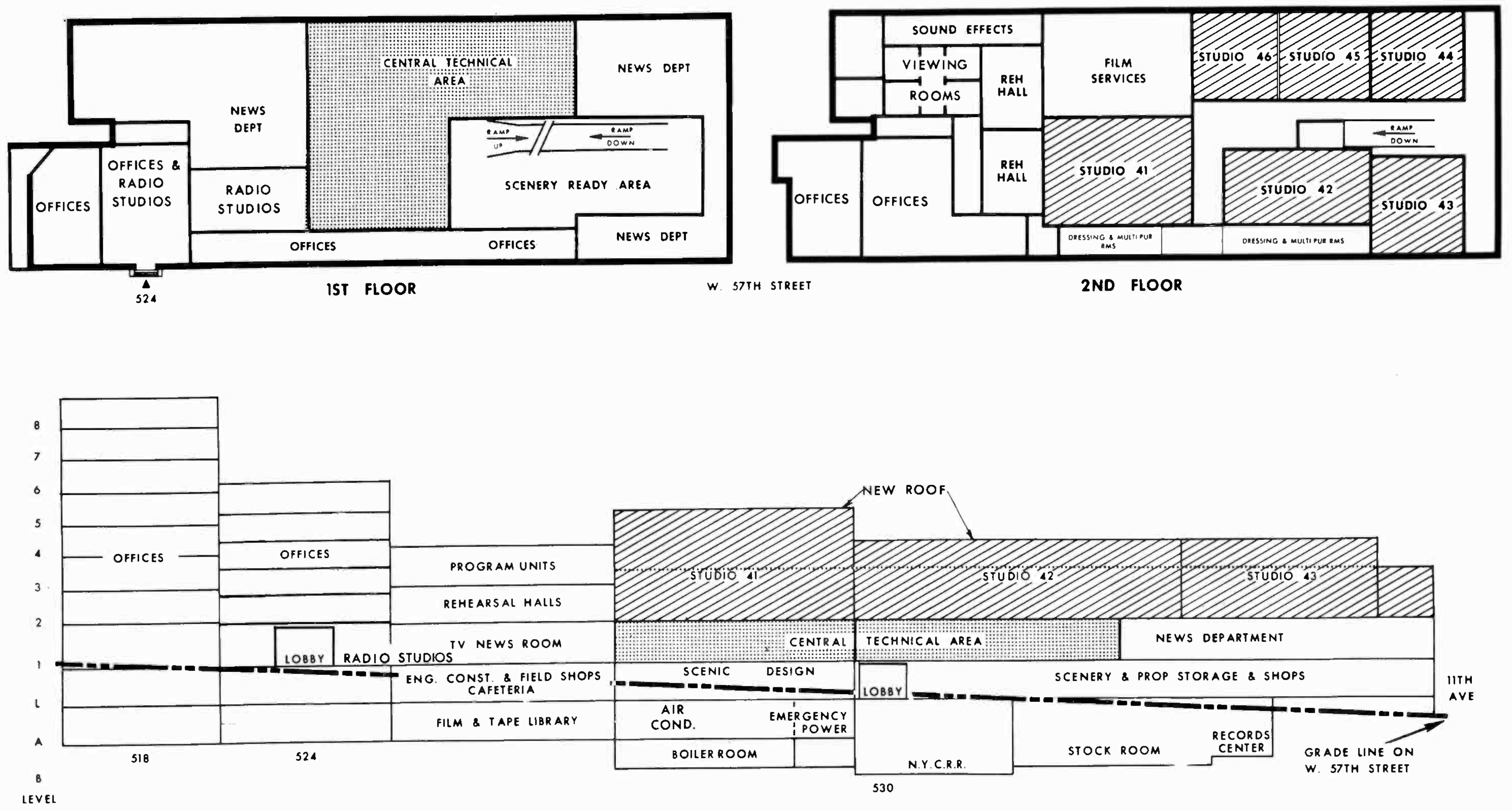


FIGURE 2

The location of television technical areas (shaded) and their relationship to other portions of the Broadcast Center is indicated. The roof was raised from the level shown by the dotted line, to provide headroom for the six studios.

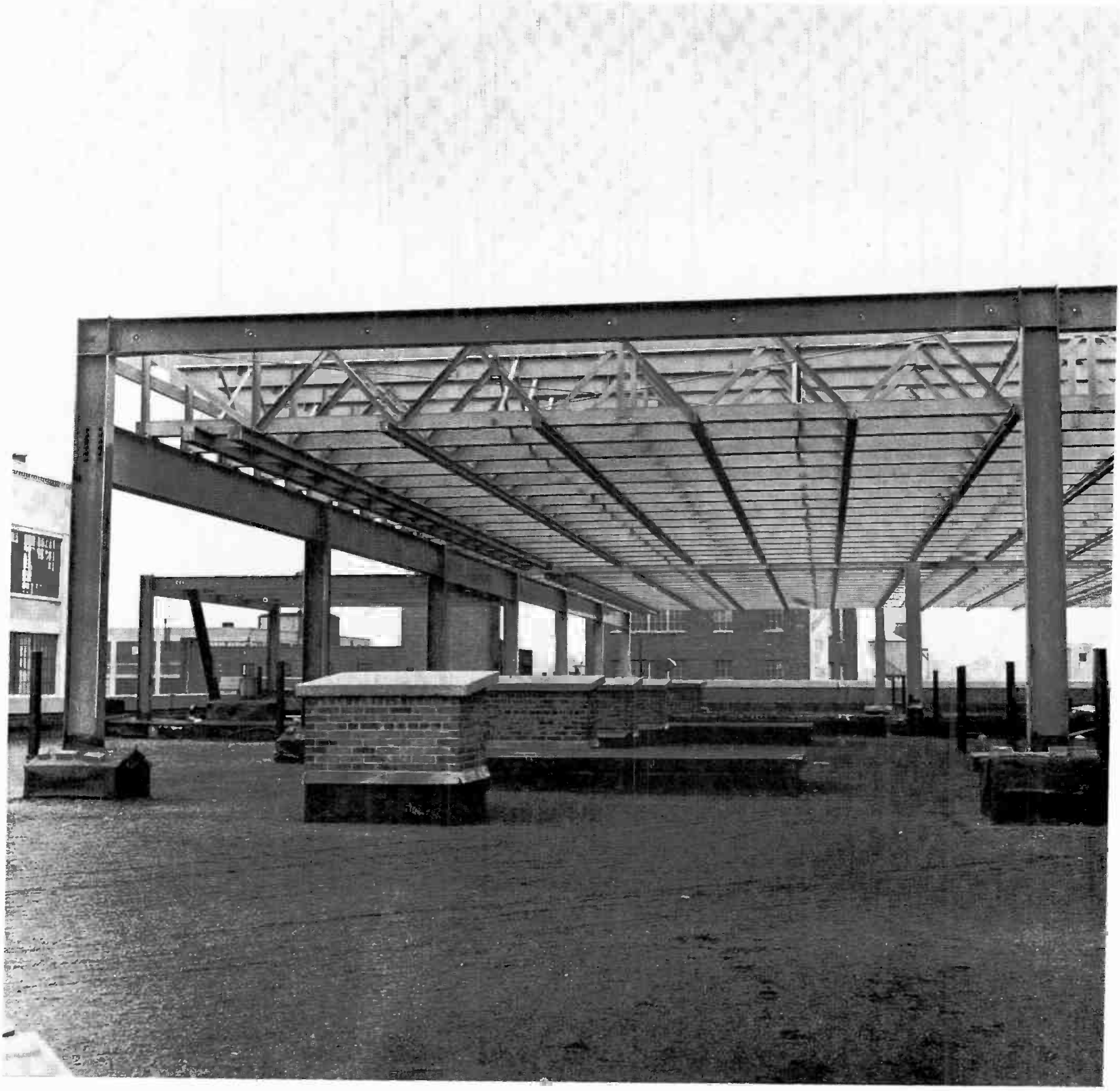


FIGURE 3

A portion of the new steel framing, extending from the foundation level up through the old roof level, is shown prior to application of a new roof and removal of the old, to provide headroom for the studios.

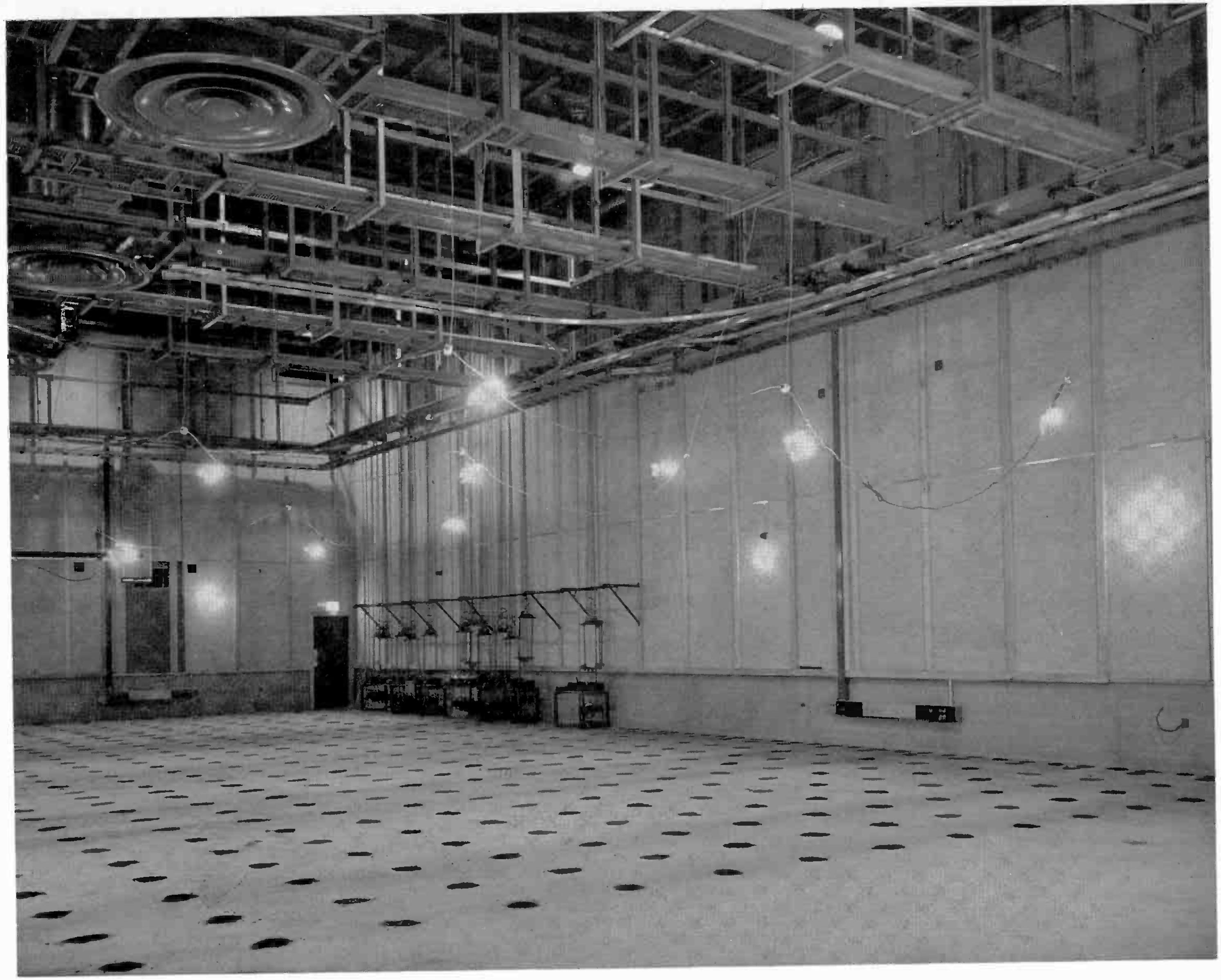


FIGURE 4

Studio 42, showing floor-slab patches applied after the final adjustment of special isolation-spring supports and just prior to application of Monoprene floor covering. The inside studio walls are supported on the isolated slab. Low frequency cue system antenna loops are buried in the floor slab, above the top layer of reenforcing bars.

The lighting grid is supplemented by counterweighted stage rigging at one end of the [illegible] on bleacher seats in this studio and in Studio 41

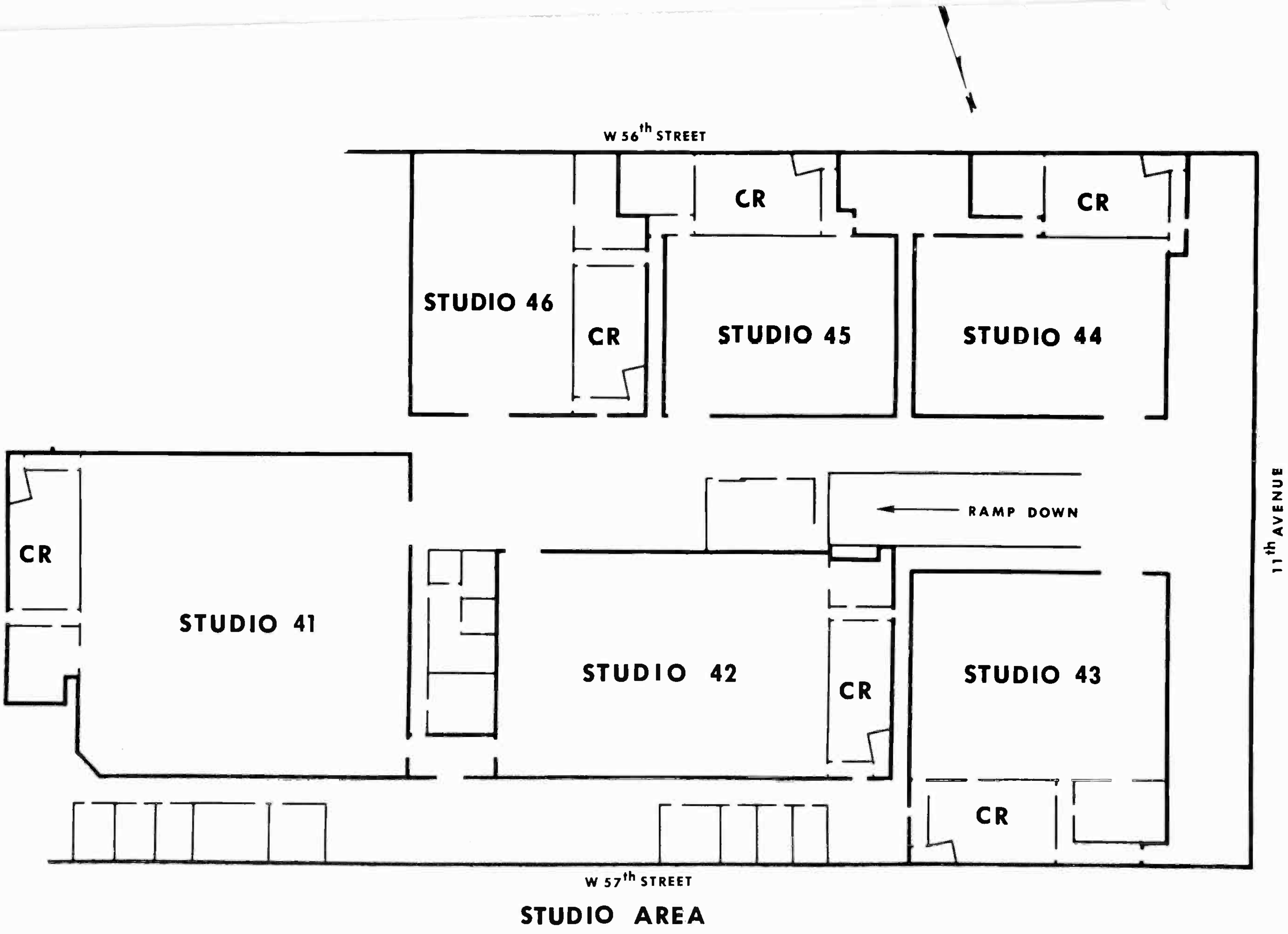
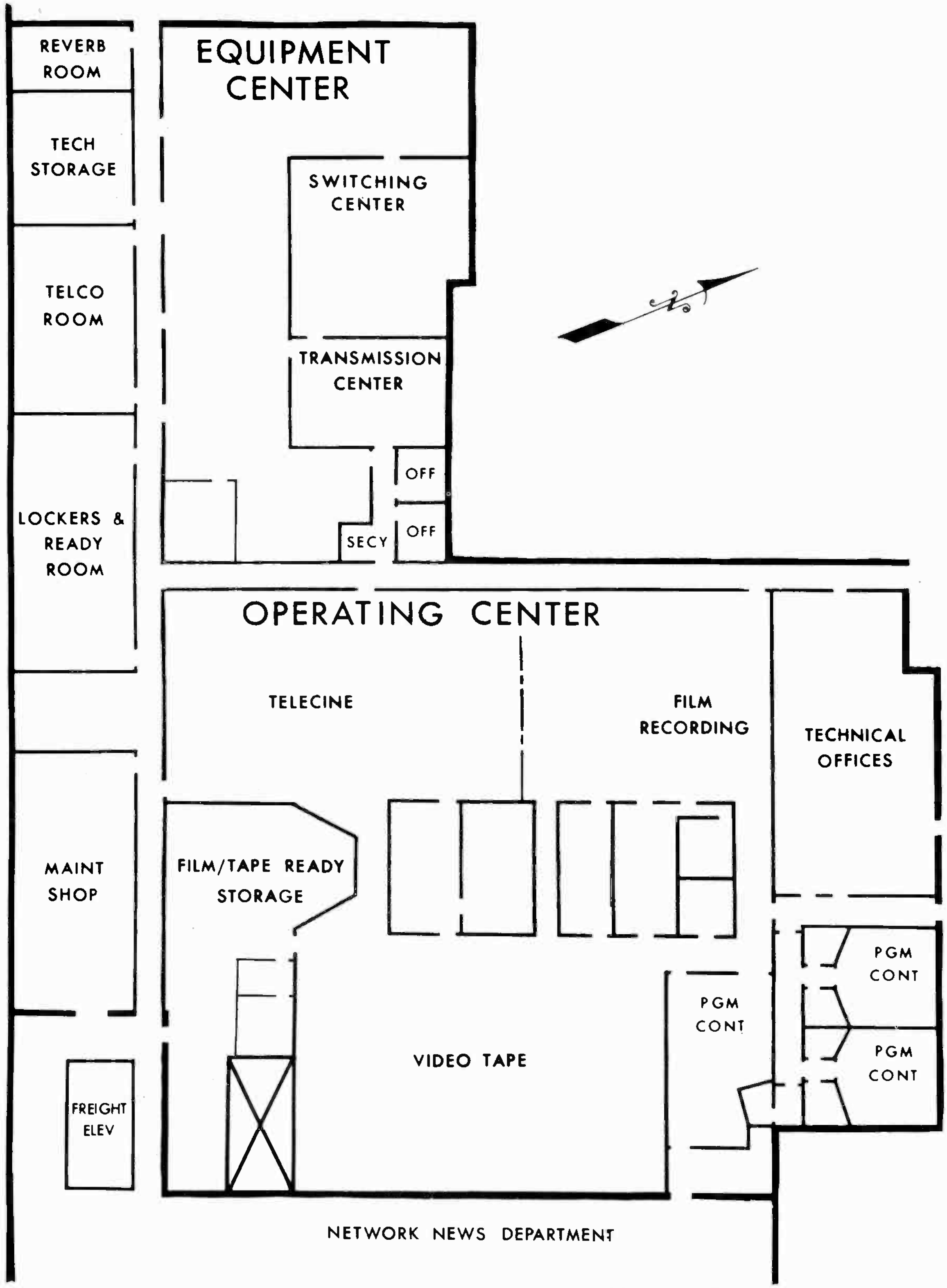


FIGURE 5

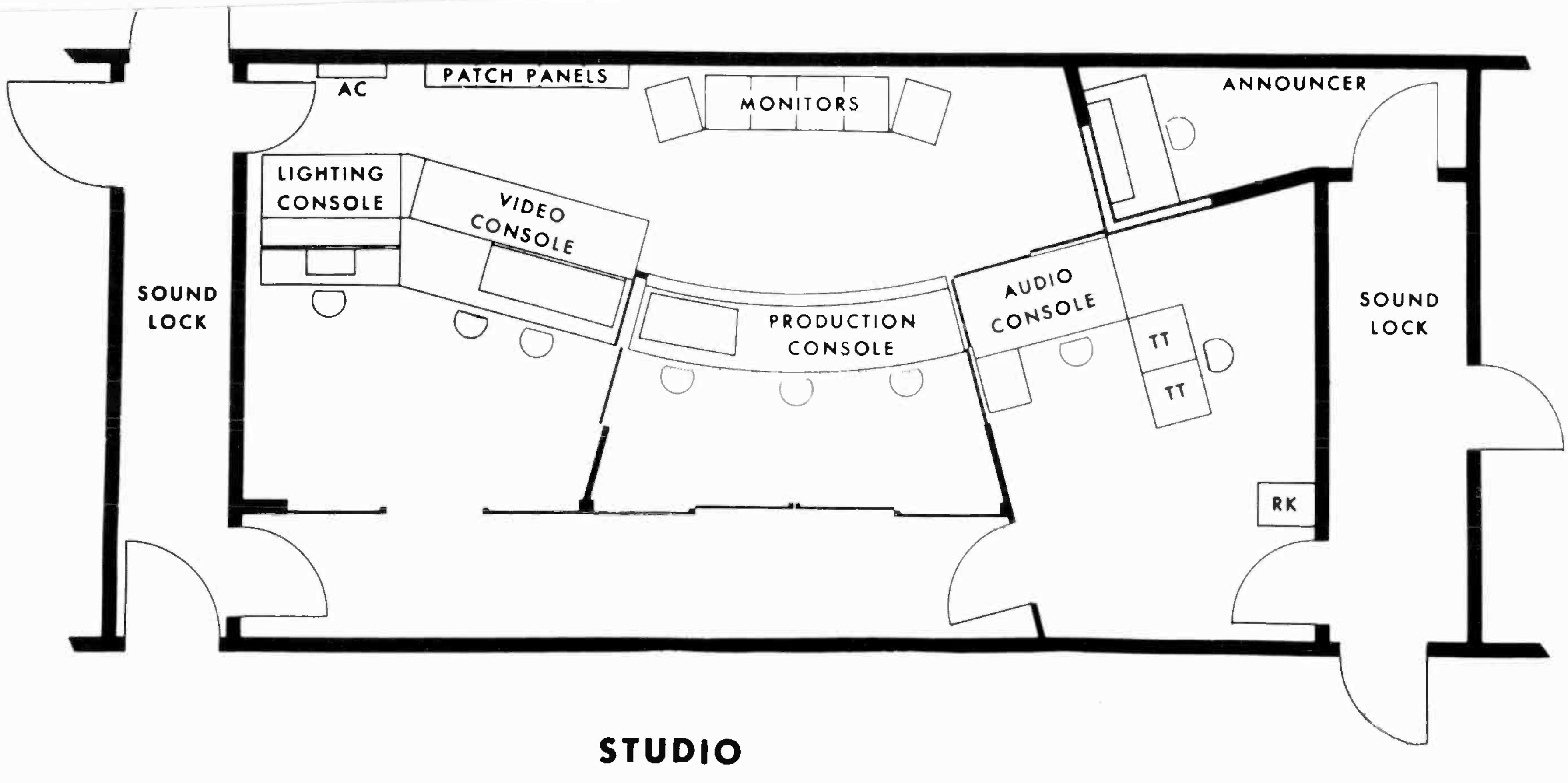
Peripheral space provided around each studio to further enhance acoustic isolation is used for support, storage, dressing room, office, studio control room, and ready areas. Each studio has its own readily accessible control room on the same floor level.



CENTRAL TECHNICAL AREA

FIGURE 6

The Central Technical Area is divided into two principal centers. Equipment Center houses most of the rack-mounted equipment for the television plant. Operating Center accommodates film and video tape machines and related supervisory, control, and storage functions. Related technical and administrative functions are located peripherally with respect to these centers. Two types of Program Control rooms are located near video tape. One, similar to a studio control room, is used for production of news programs originating in the nearby News Room. The two smaller rooms are specifically designed to handle a continuous sequence of programs to network circuits and to the local station.



STUDIO CONTROL ROOM

FIGURE 7

Each studio control room is placed immediately adjacent to its studio. The control room has three sections which can be opened into one, or closed off by means of sliding glass panels. At the left is the picture control section, including lighting control, lighting director, and video control. At the center, in the production control area, is the director, with the technical director at his left and the assistant director at his right. At the right is the audio section. The control room has been designed to provide an optimum view of picture monitors and for convenient eye contact among members of the control room team, but no studio window is provided.

FIGURE 8

The new, fully transistorized, CBS audio console utilizes quadrant type controls to enable the audio operator to conveniently reach and control its unusually extensive and flexible facilities. Placement in the control room allows an unimpaired view from the operator's position of all monitors in the production area, line-of-sight contact with the director, ... with the announcer, located to the right.

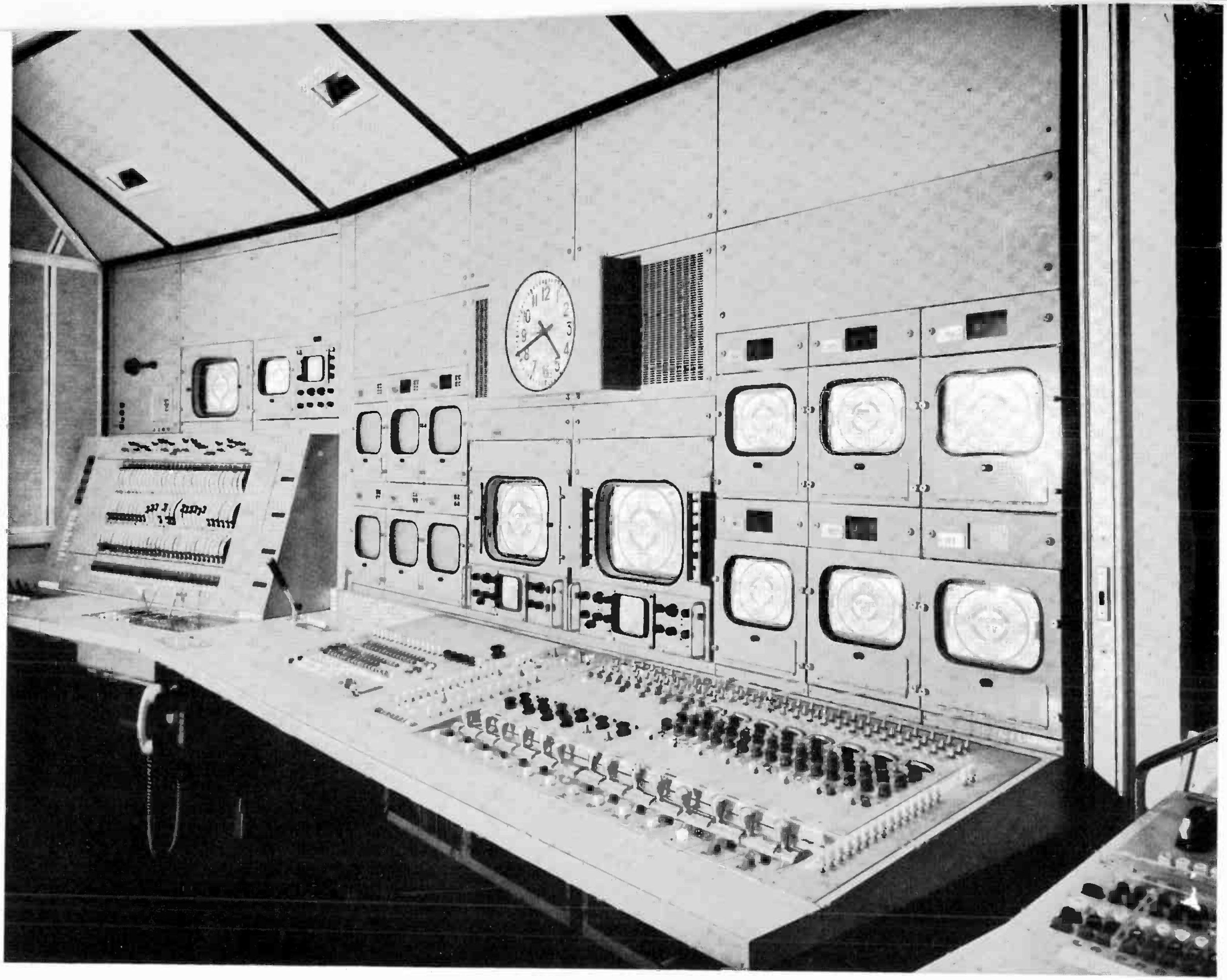


FIGURE 9

The picture control area of the studio control room includes the video camera and source controls in the foreground, an auxiliary special effects panel, a position for the lighting director, and, at the far end, the lighting control console. Close relationship among video control operator, lighting director, and lighting control man, and ability to observe the same monitors, are important to achievement of optimum picture quality.

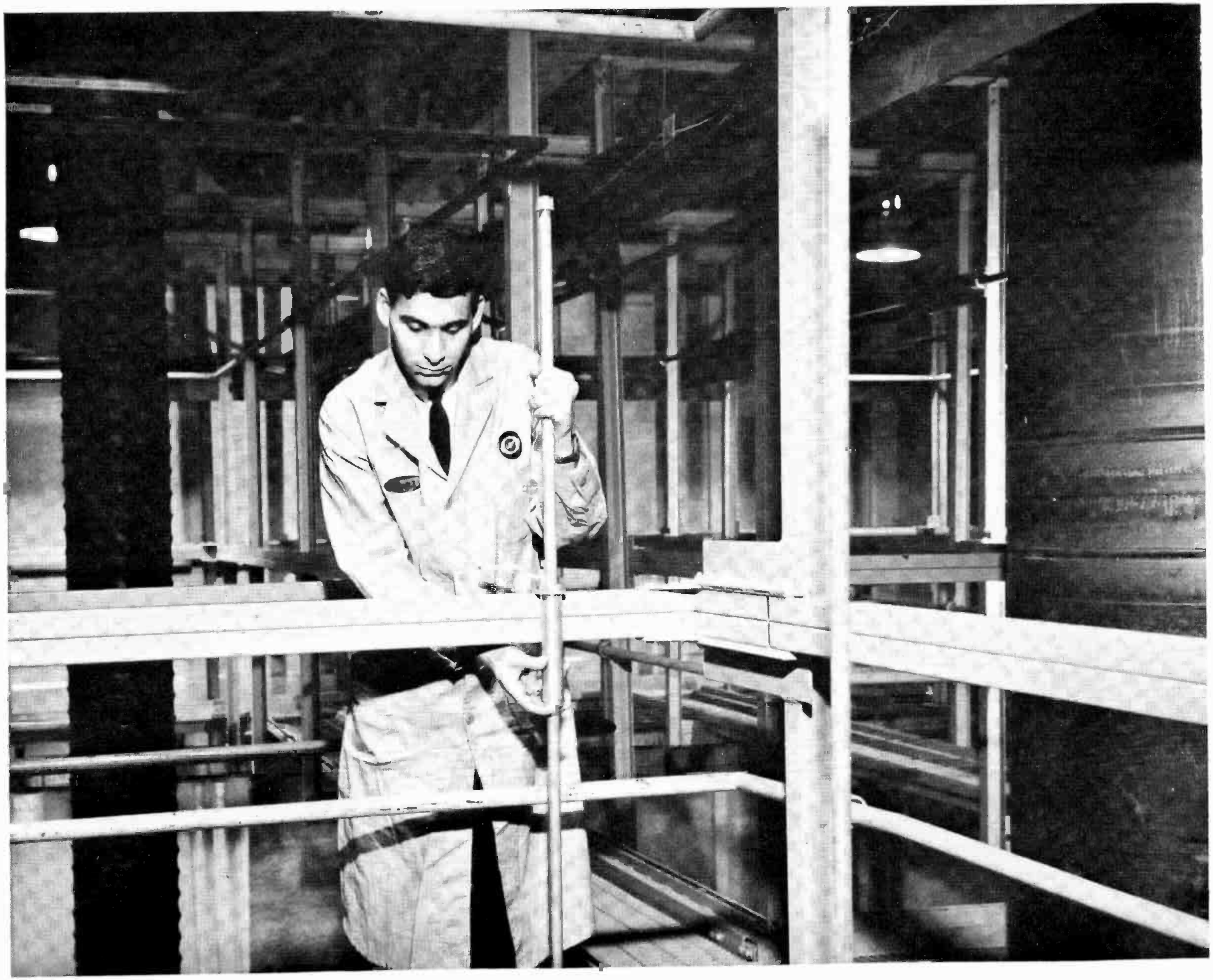
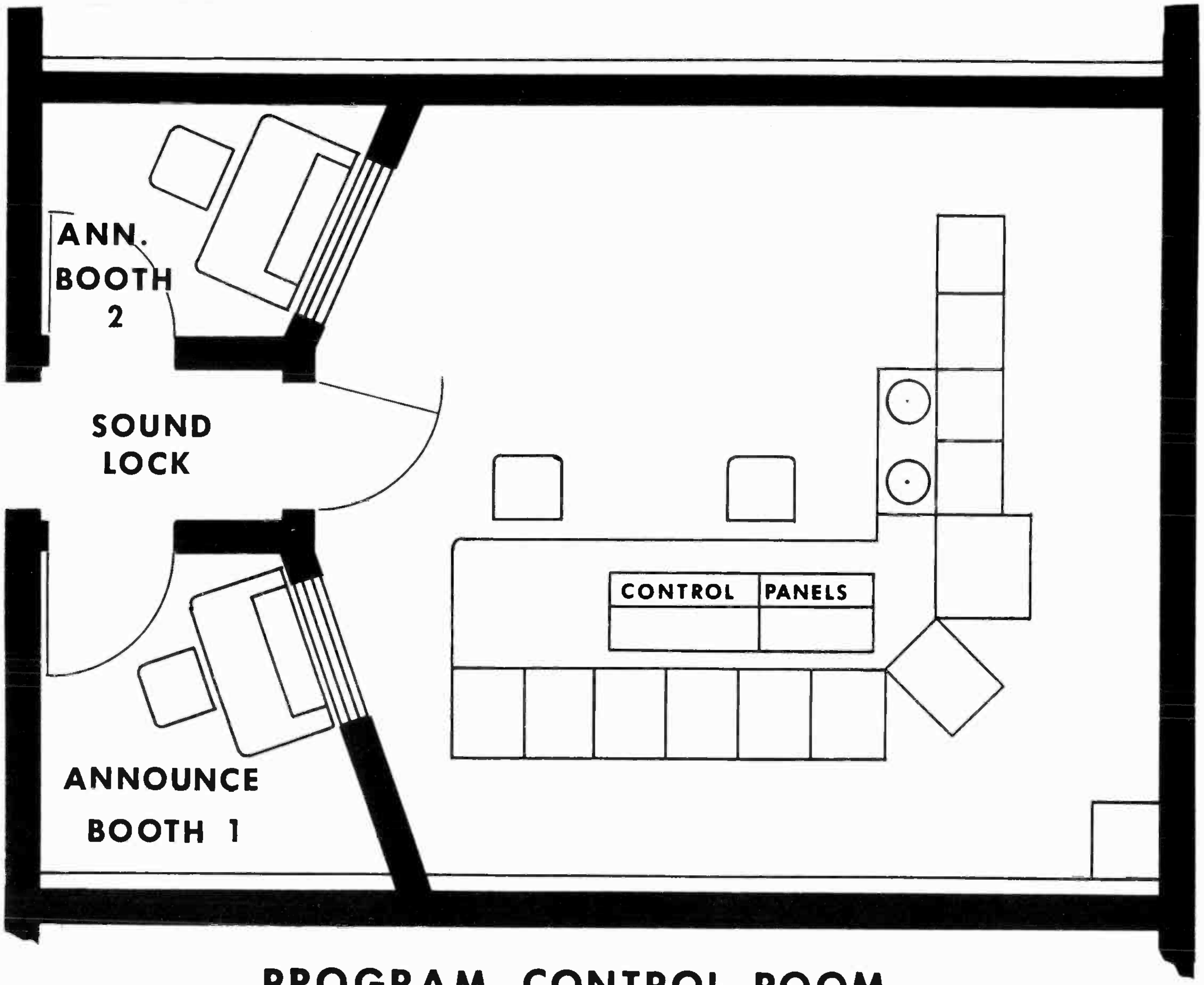


FIGURE 12

A new, quick-release, lighting fixture support fitting, based on the principle of the Indian finger grip, can be operated at waist level by a lighting man standing on the grid catwalk. Clamp is designed to hold the fitting securely with a one-quarter turn on the prefabricated



PROGRAM CONTROL ROOM

FIGURE 13

Floor plan of continuity-type Program Control room shows technical operator position in front of the control panels and program man position to his right. Both announce booths are used when it is necessary to insert different live announcements for two regional branches of the network to which a program is being fed.

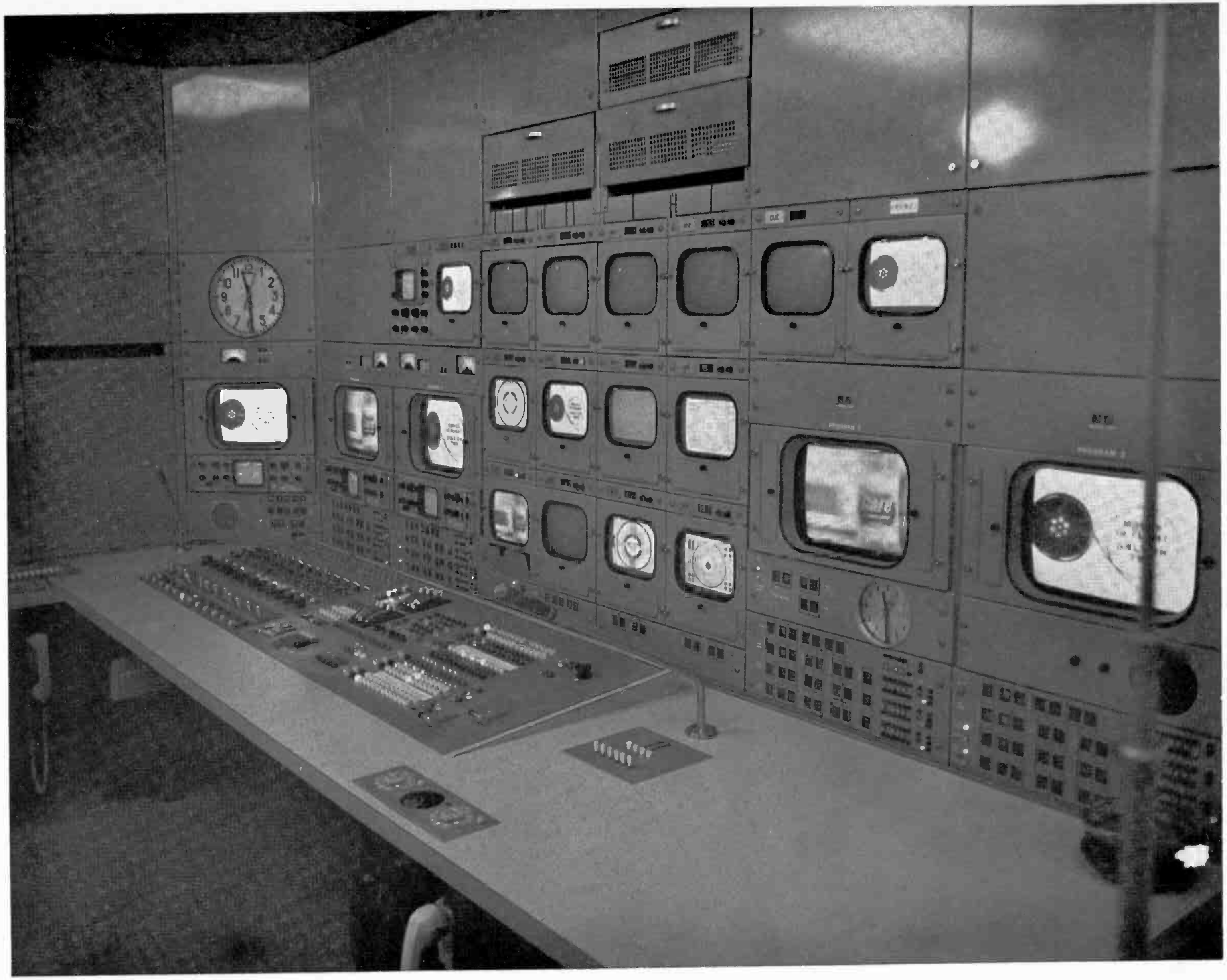
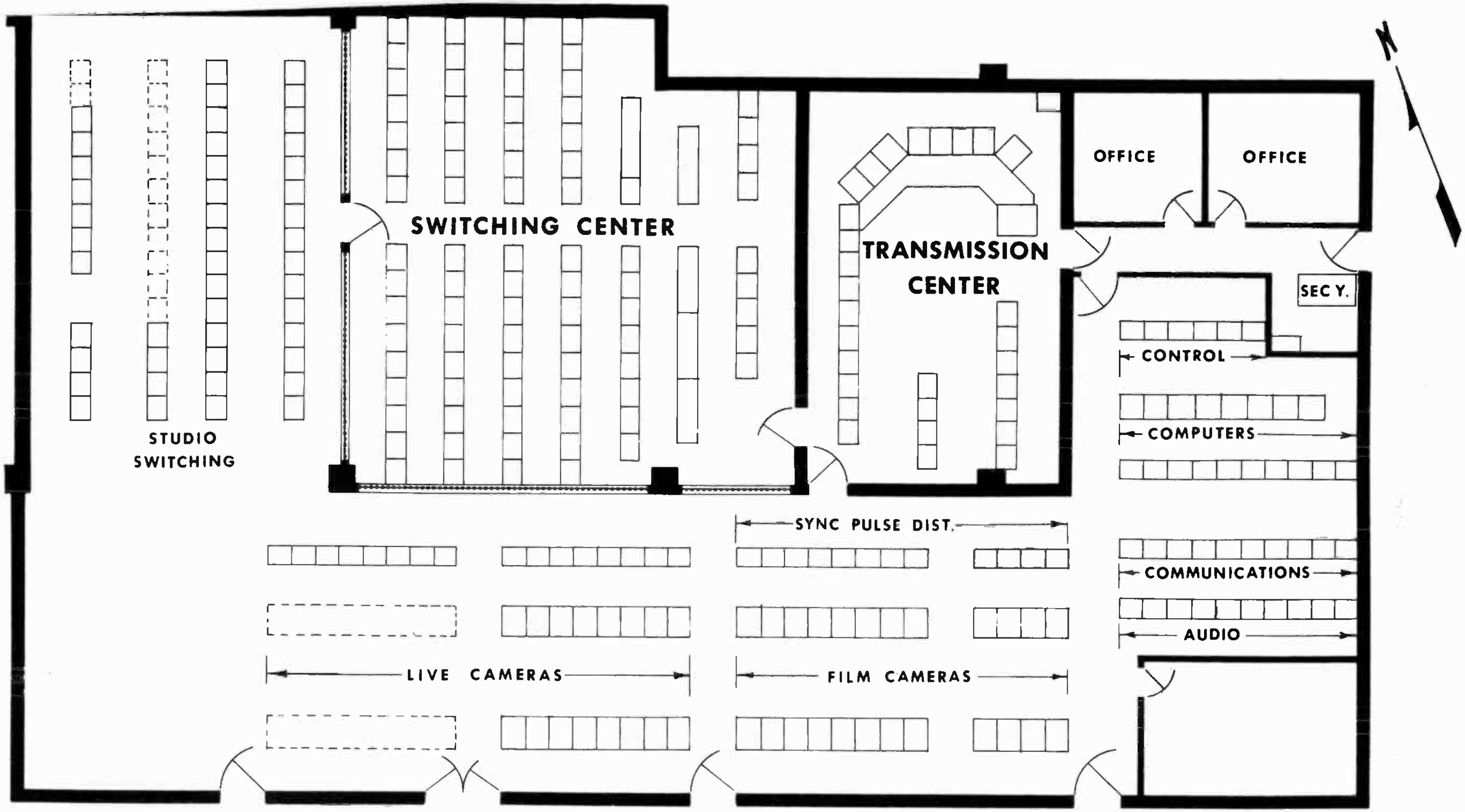


FIGURE 14

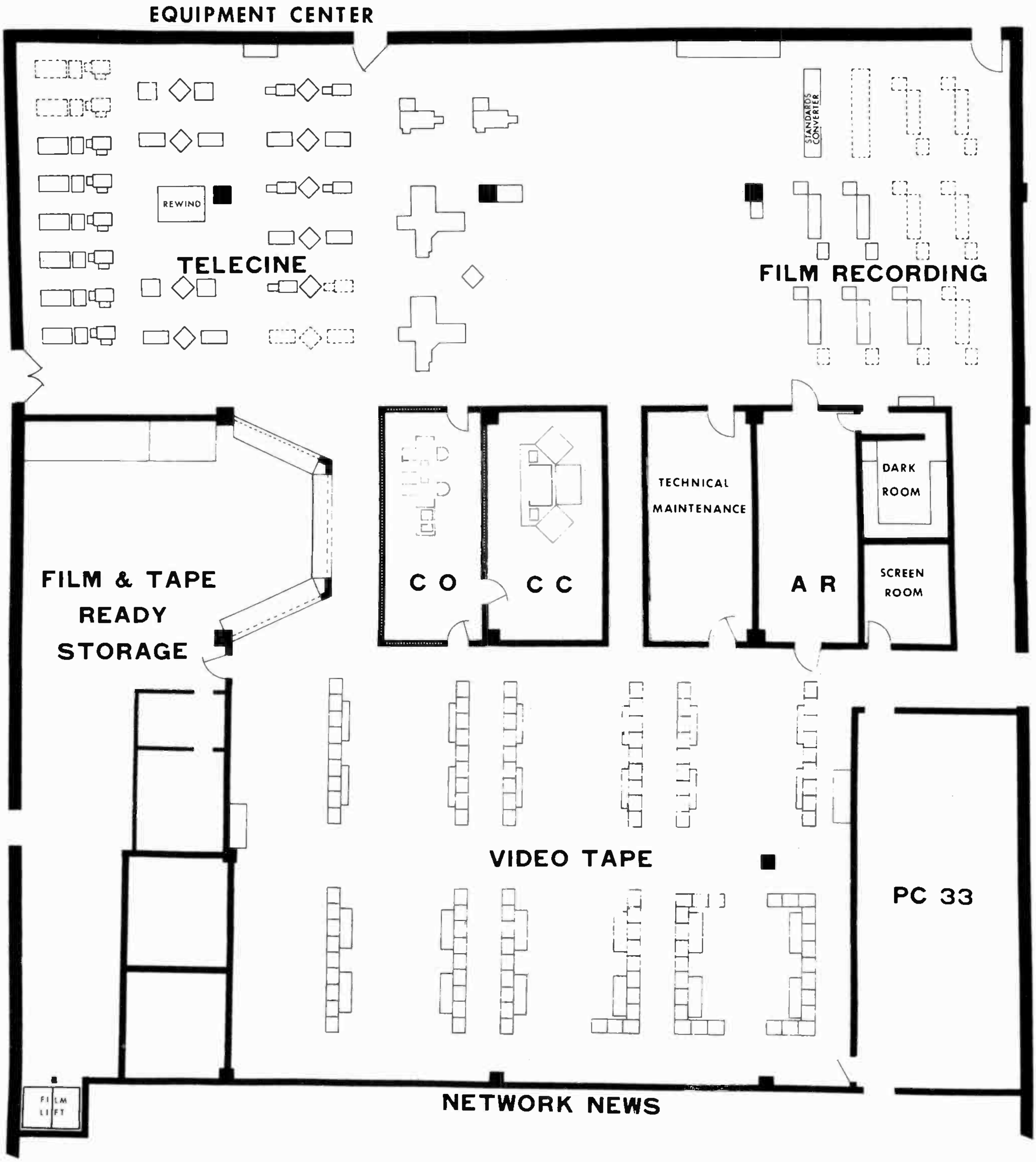
This view shows the technical operator, left, and program man positions, in a continuity-type Program Control room. In normal operation, the technical operator sits to the left, monitoring and controlling audio and video quality of the twelve sources which can be controlled from the control room at the same time. Switching is controlled by a digital computer, located elsewhere, the switching panel at the right of the control section being used only for emergency. Duplicate program monitors and computer read-outs are provided [illegible] of twelve smaller input channel monitors.



EQUIPMENT CENTER

FIGURE 15

The location of rack equipment centralized within the Equipment Center is indicated. Transmission Center houses all necessary equipment and controls for supervision and test of incoming and outgoing circuit performance, and serves as a principal technical communications center. Switching Center houses the relay and amplifier equipment required to handle the routing and interconnection among sources and control points.



OPERATING CENTER

FIGURE 16

A factory-like flow of bulk film and tape from the Ready storage area to the appropriate section of the Operating Center is provided. The Ready area is tied into shipping and editing areas by a film lift (dumbwaiter) system. The "CO" (Central Operating) room is the supervisory center for this entire area and has facilities for overriding computer assignments of tape and film channels in an emergency. The "CC" (Closed Circuit) control provides a quality control point for auditions or other transmissions which do not require full control room facilities. The "AR" (Audio Recording) room contains auxiliary audio record and playback equipment to serve both film recording and video tape.

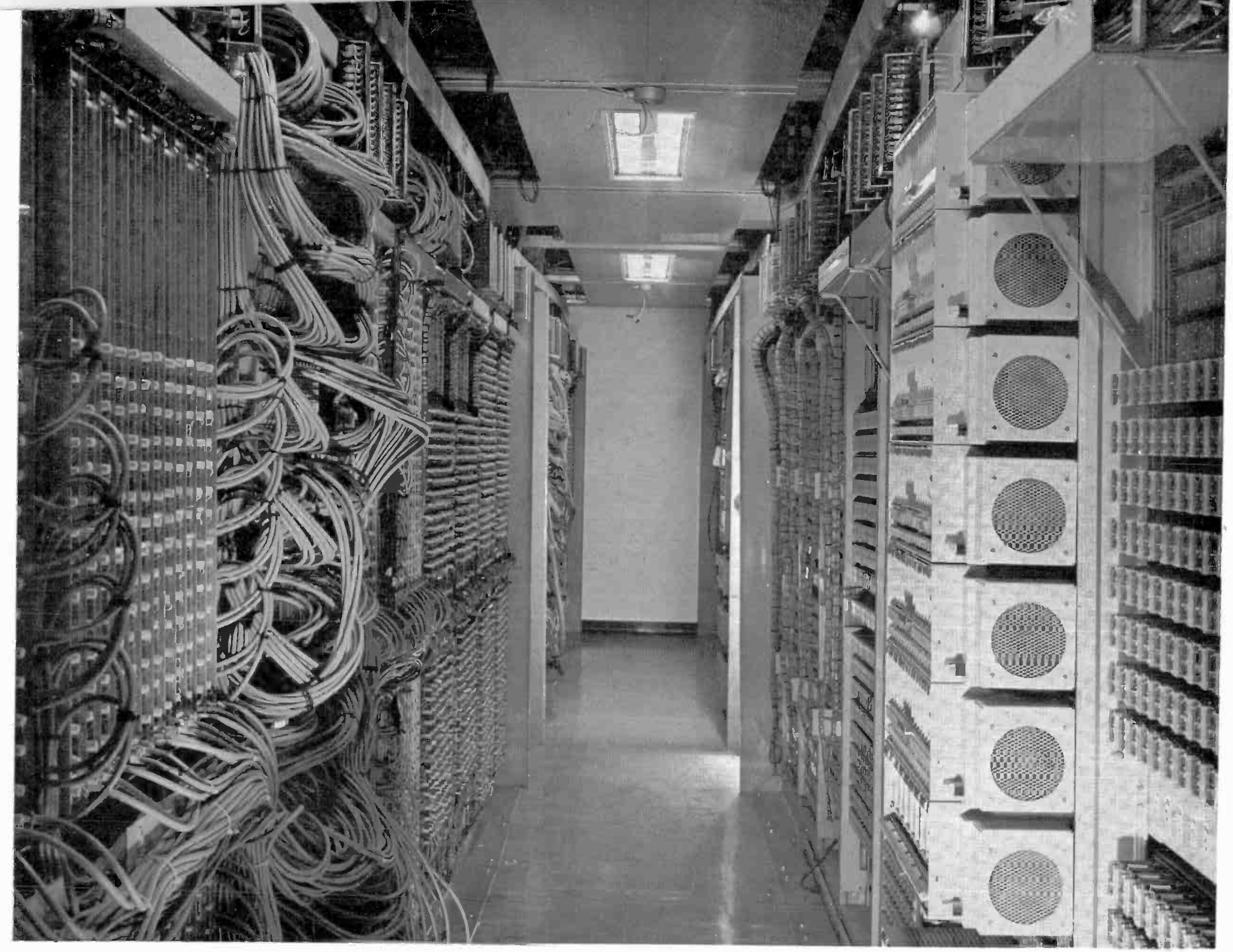


FIGURE 17

This view shows two of the five rows of wire-spring relay selector equipment which makes up the signal selection portion of the Master Exchange switching system. A total of 35,000 wire-spring relays are used to handle audio, video, and communications circuits.

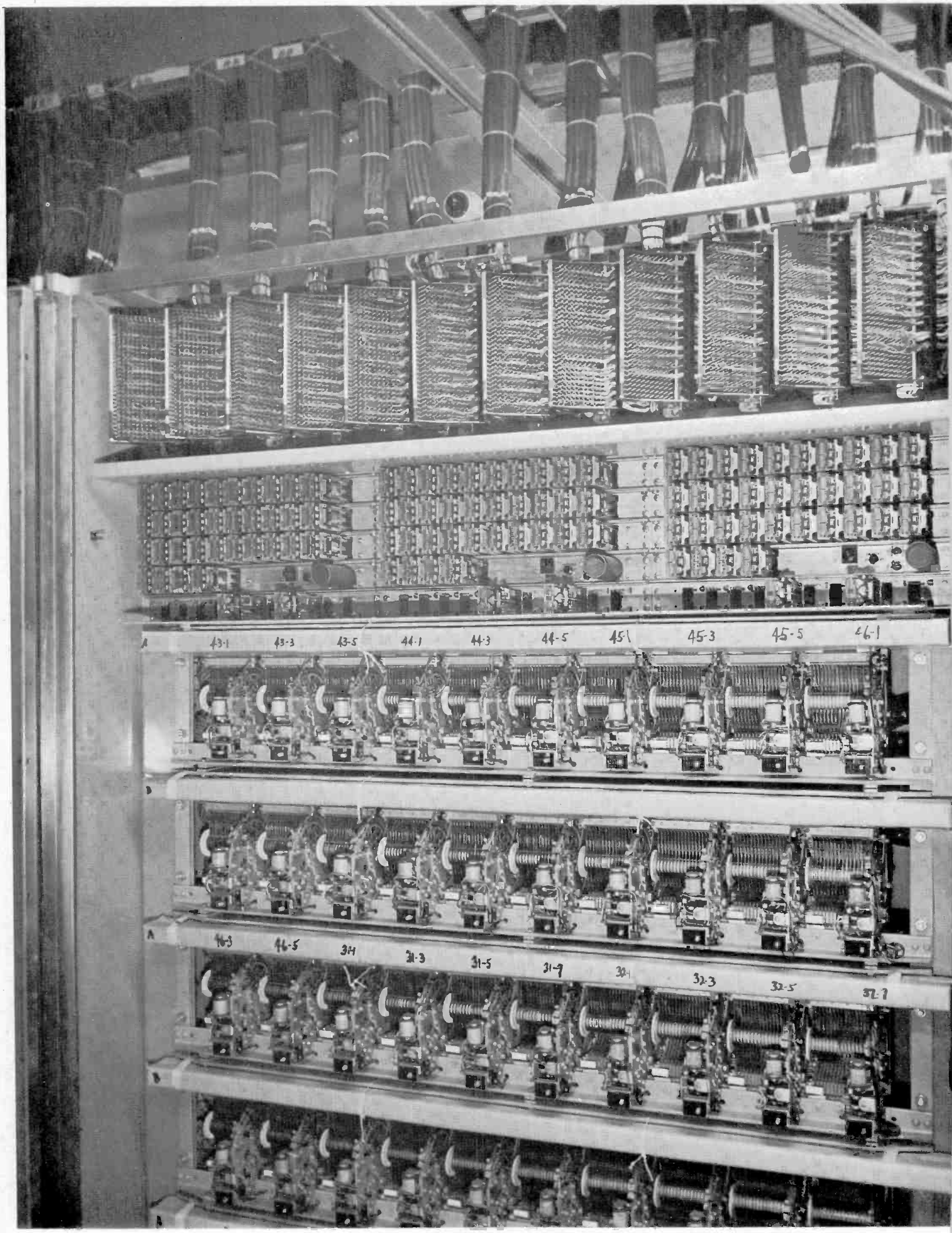


FIGURE 18

In the Master Exchange switching system, control circuits accompanying the signal sourc
are routed to the assigned control point by means of motor-driven rotary selectors. Th

FIGURE 19

The studio control room, as viewed from the lighting director's position, shows in the foreground the auxiliary video switcher and special effects panel. When required by the nature of the program, certain special effects functions may be delegated to this position from the regular video switcher panel.

The next large panel is the video operator's control position. The video switcher position, the production area and, through a sliding glass window, the audio control area, may be seen.

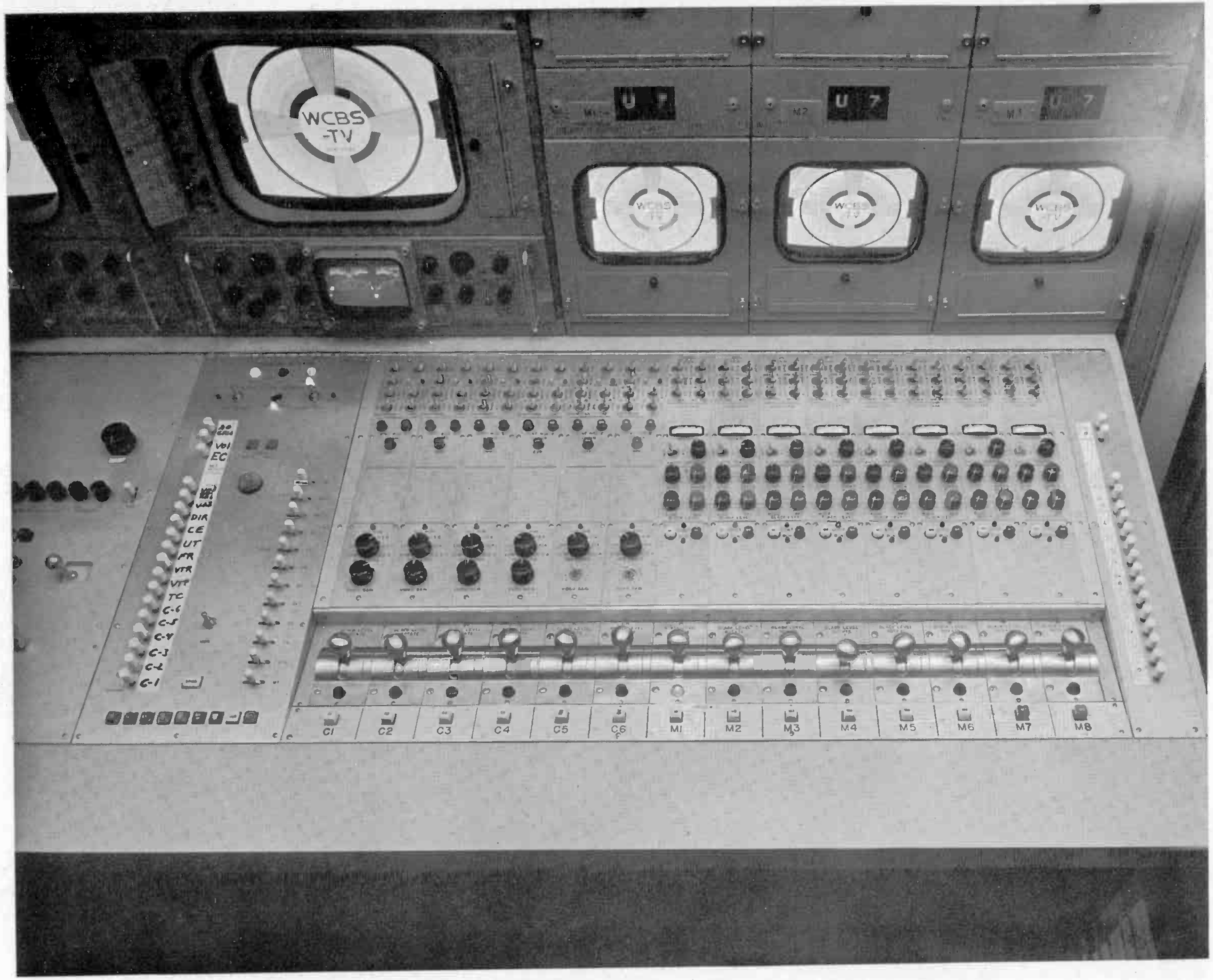


FIGURE 20

A close view of the studio video operator's control position shows six camera control channels, C1 through C6, and eight channels, M1 through M8, equipped to handle tape, film, or remote inputs assigned to the studio through the Master Exchange switching system. Primary control of gain (or exposure) is provided by lever movement, and black level setting by lever-knob rotation. Supplementary gain control, color "black" level controls, tape-capstan [illegible]olarity reversal, as appropriate to the source

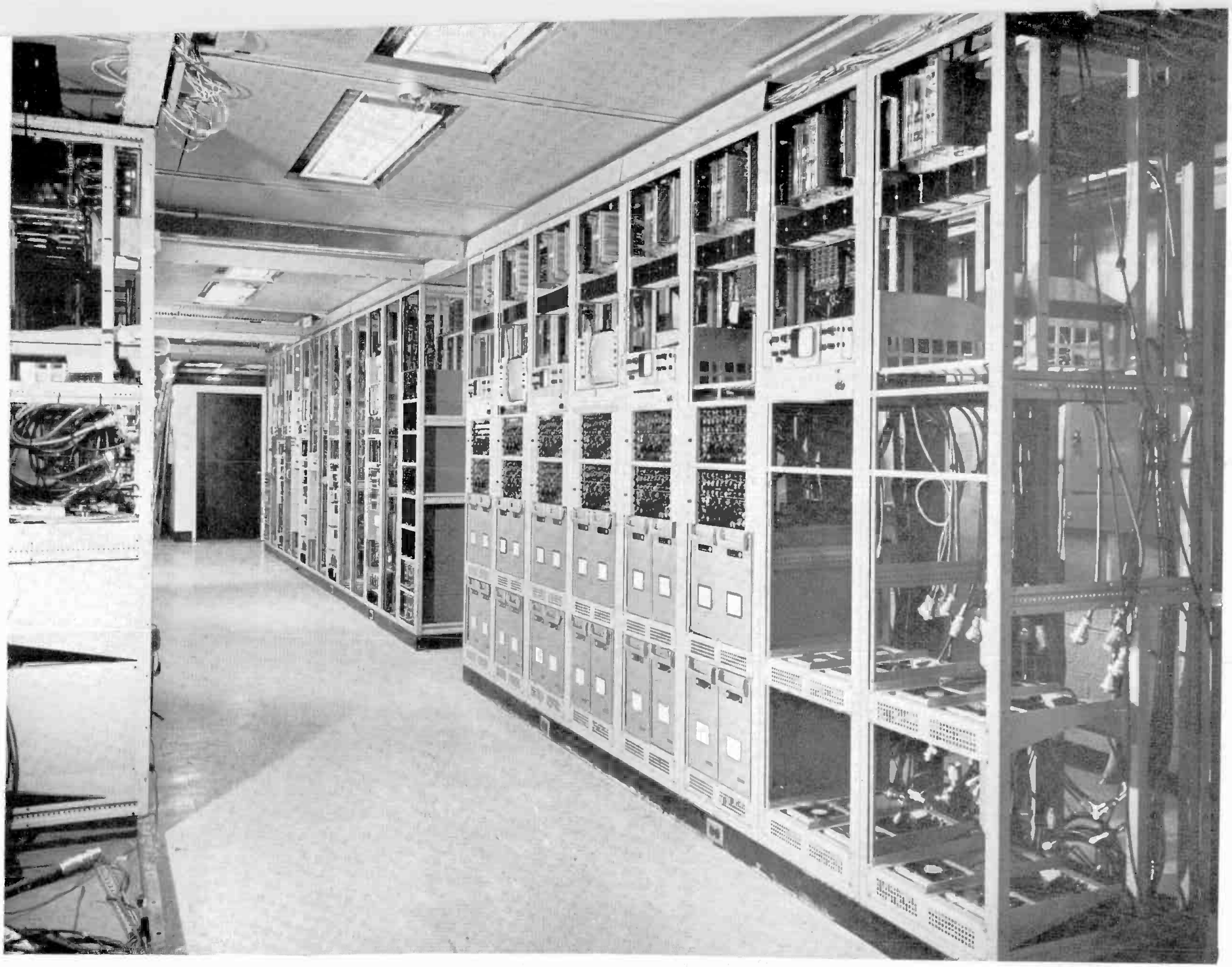


FIGURE 21

Camera channel equipment and pre-operational adjustment controls are centralized in the Equipment Center. Live camera controls are in the near group of racks; monochrome and color film channels in the farther group.

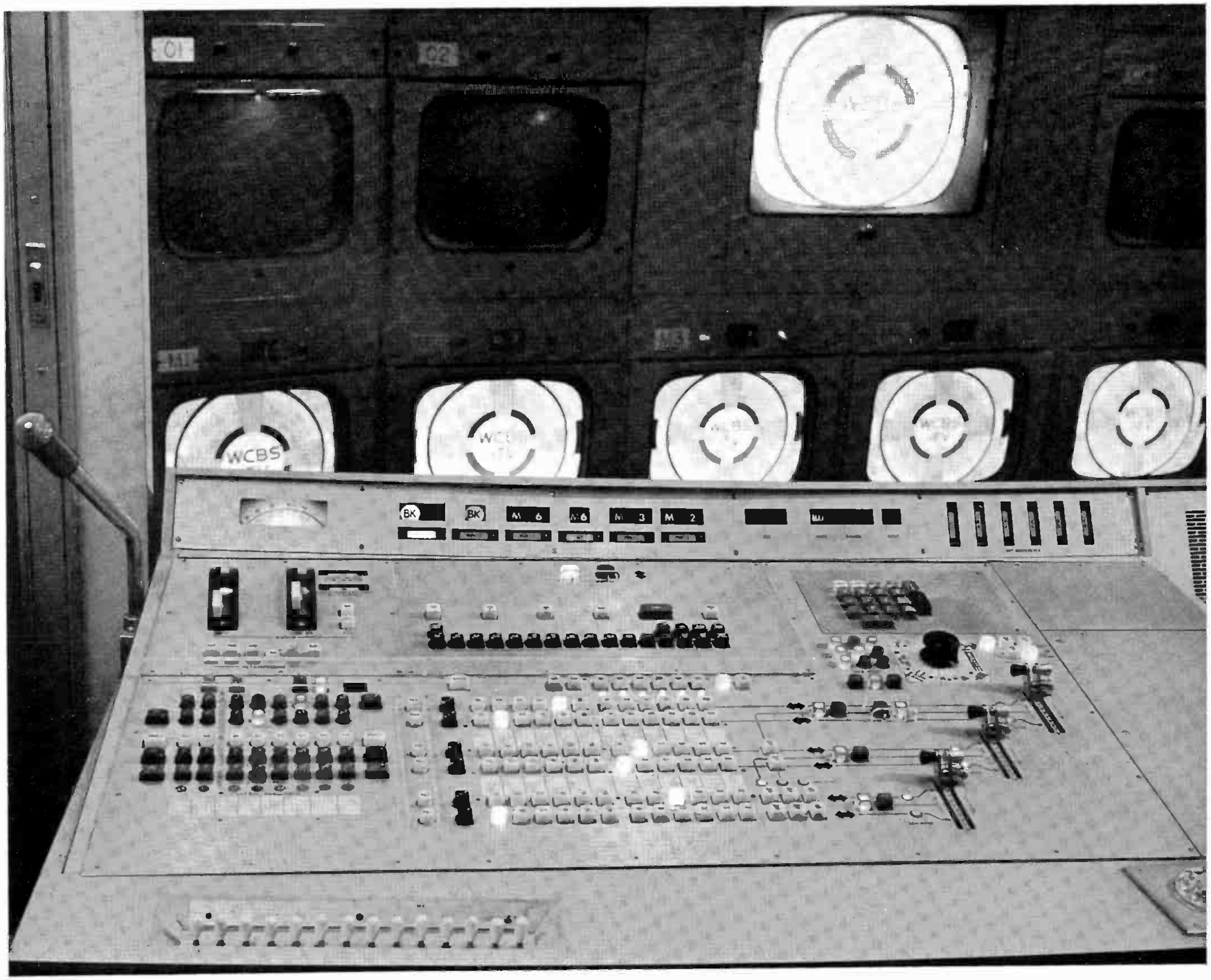


FIGURE 22

The studio switcher panel has been kept simple in appearance and operation. Two fader/effect rows feed into a master fader/effect output. In addition to studio cameras, the twelve inputs accommodate up to eight of 80 or more central film, tape, or remote sources which may be assigned to the studio. These may be placed on any desired position by use of the "adding machine" keyboard in the upper right portion.

The centrally-located preview selector row, by appropriate mode-selection, may be used to operate several different preview selectors or as an emergency output selector. Combined audio/video switching and control of audio output level may be delegated to the video switcher when full audio facilities are not required. Individual and grouped stop and start for ... film, and slide playback equipment are provided in the lower left portion. ... start and stop. Inter-

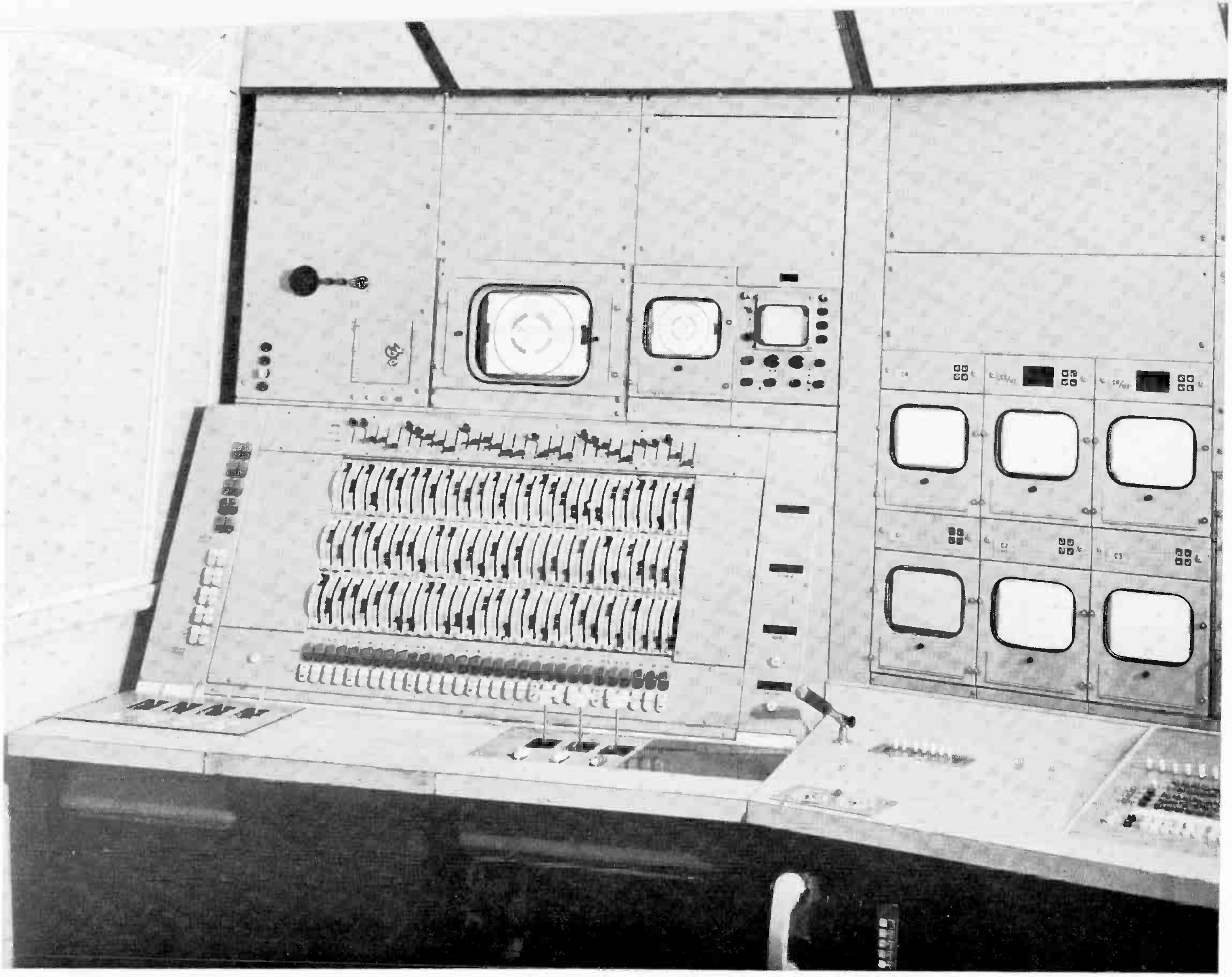


FIGURE 23

The lighting console shown here is for the smallest studio and has 30, 12-kw dimmer circuits with another 30 non-dim circuits. The console may be used manually as a three-scene preset console with provision for cross-fades or ganged fades among any combinations of the three scenes. Alternately, the control settings for a scene may be stored in the central computer memory. The quadrant controls are set as desired, a scene number assigned, and the information read directly into computer memory by merely pressing a button. Recall, by keying in the assigned scene code number, causes the next-scene quadrant control levers to be reset by motor drive to the positions which they had been set on read-in. Magnetic amplifier dimmers are controlled by the settings of the quadrant levers.

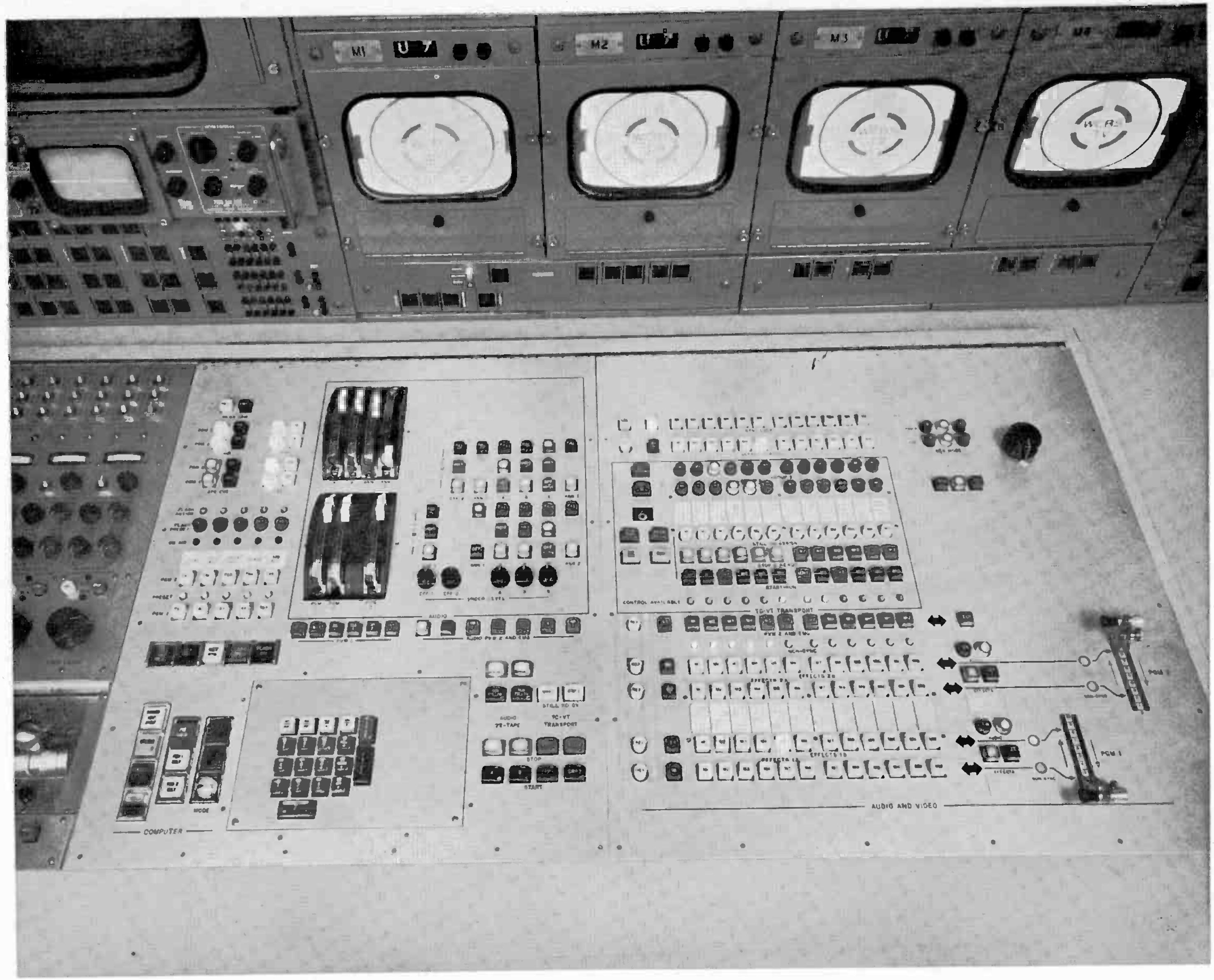


FIGURE 24

In normal Program Control operation, the combined audio/video switching is completely controlled from computer memory. Fader/effects levers are motor driven, separate audio selection and control are introduced, sync lock is activated, sources are preselected and continuity switching for two different output feeds controlled in accordance with instructions previously stored in the central computer system. The panel shown here provides a complete backup facility which affords manual control in an emergency. Changes in instructions stored in the computer, as well as the call-up and positioning of assigned signal sources, are accomplished by means of [illegible] This is located where it can be reached from the normal

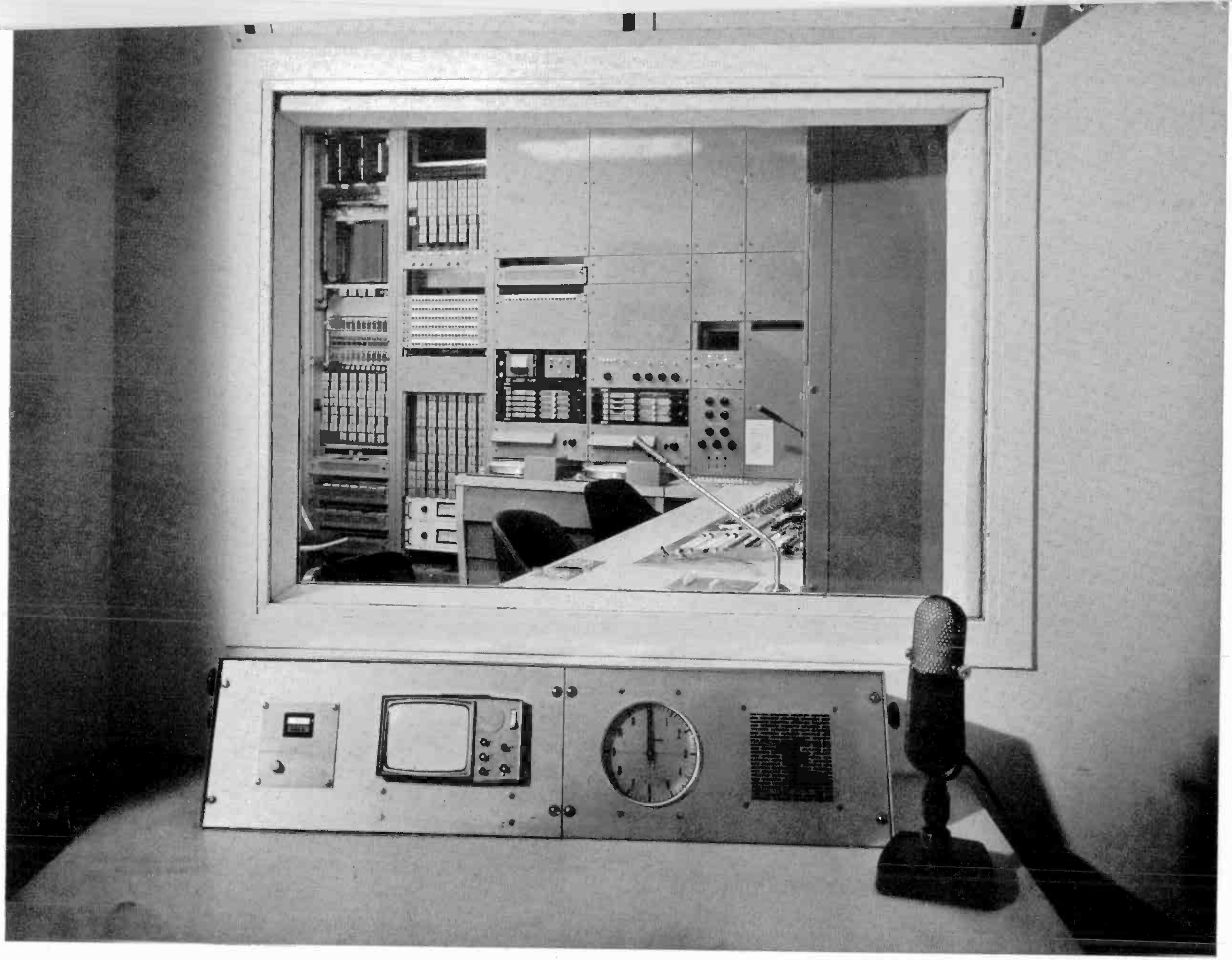


FIGURE 25

Program Control audio turntables and cartridge tape equipment and the audio switcher, all located to the left of the technical operator's position, are seen from the announcer's position.

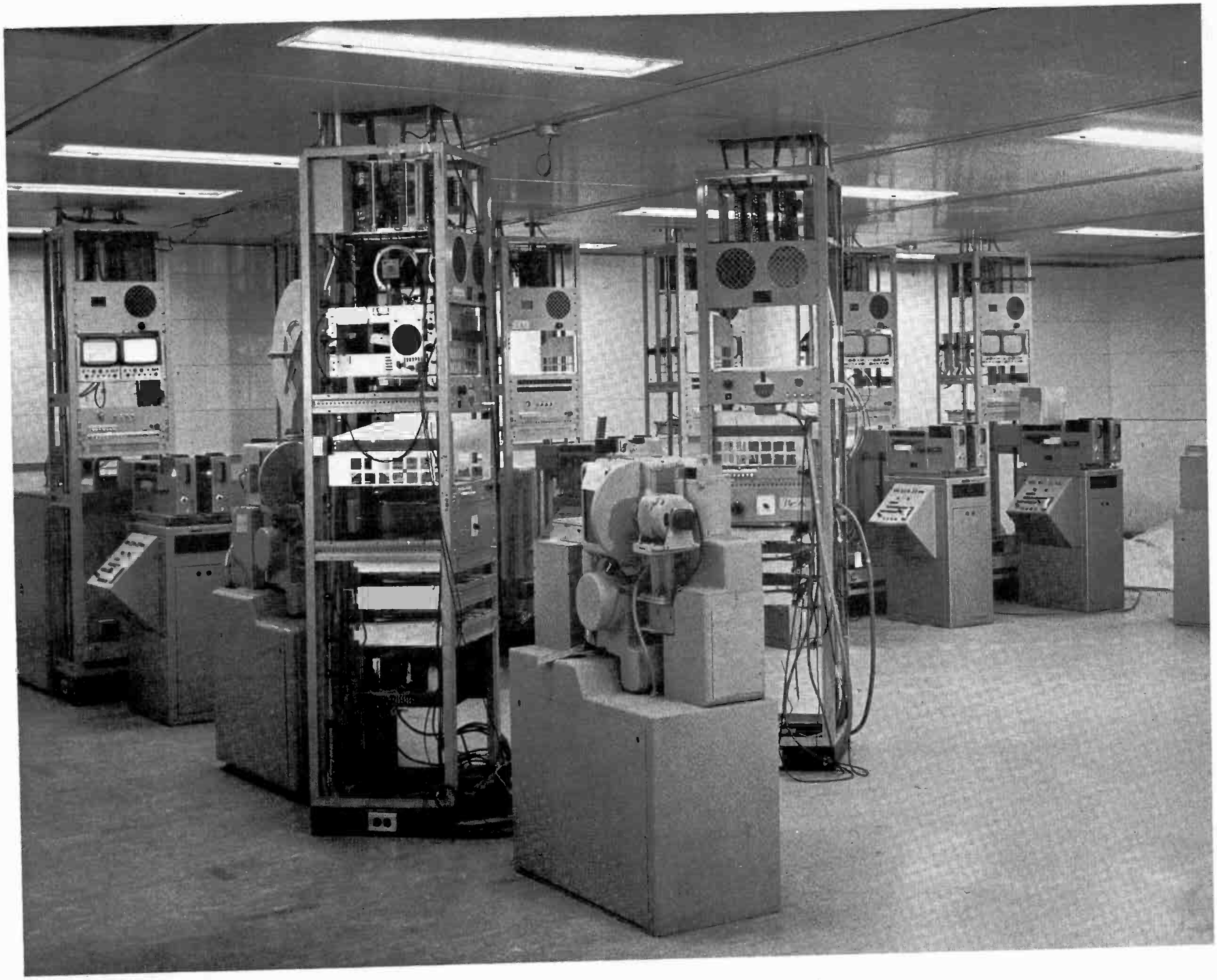


FIGURE 26

...installation shows two 35mm projectors and a row of six dual-

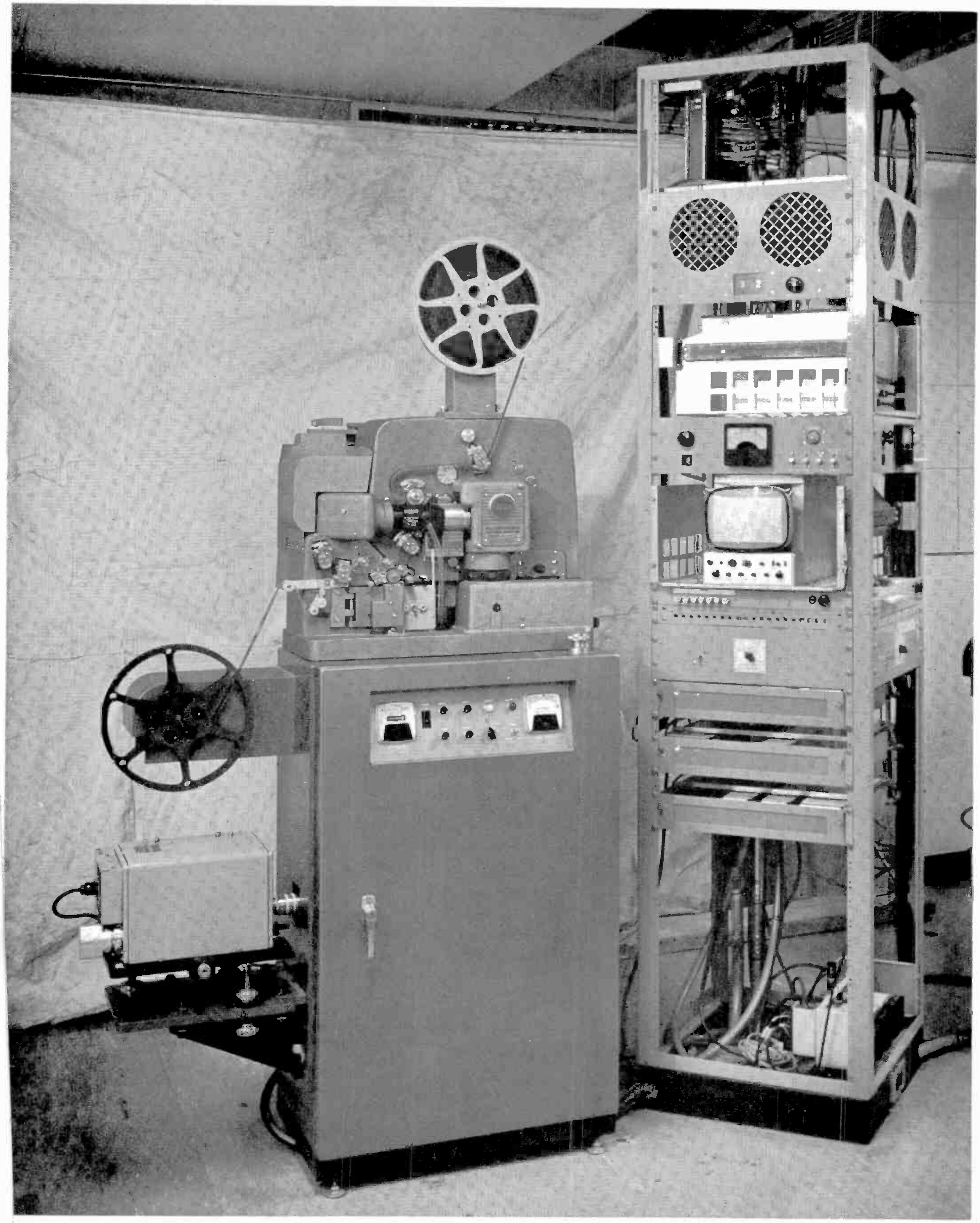


FIGURE 27

6mm projector with its own vidicon film camera and rack is shown during installation test. of a separate camera for each monochrome projector is dictated by the long periods dur- which a projector must be assigned to a control point in network production work.

ingle equipment rack, with monitors facing outward on two adjacent sides, is placed at an le in a position which provides convenient access and good visibility from the loading

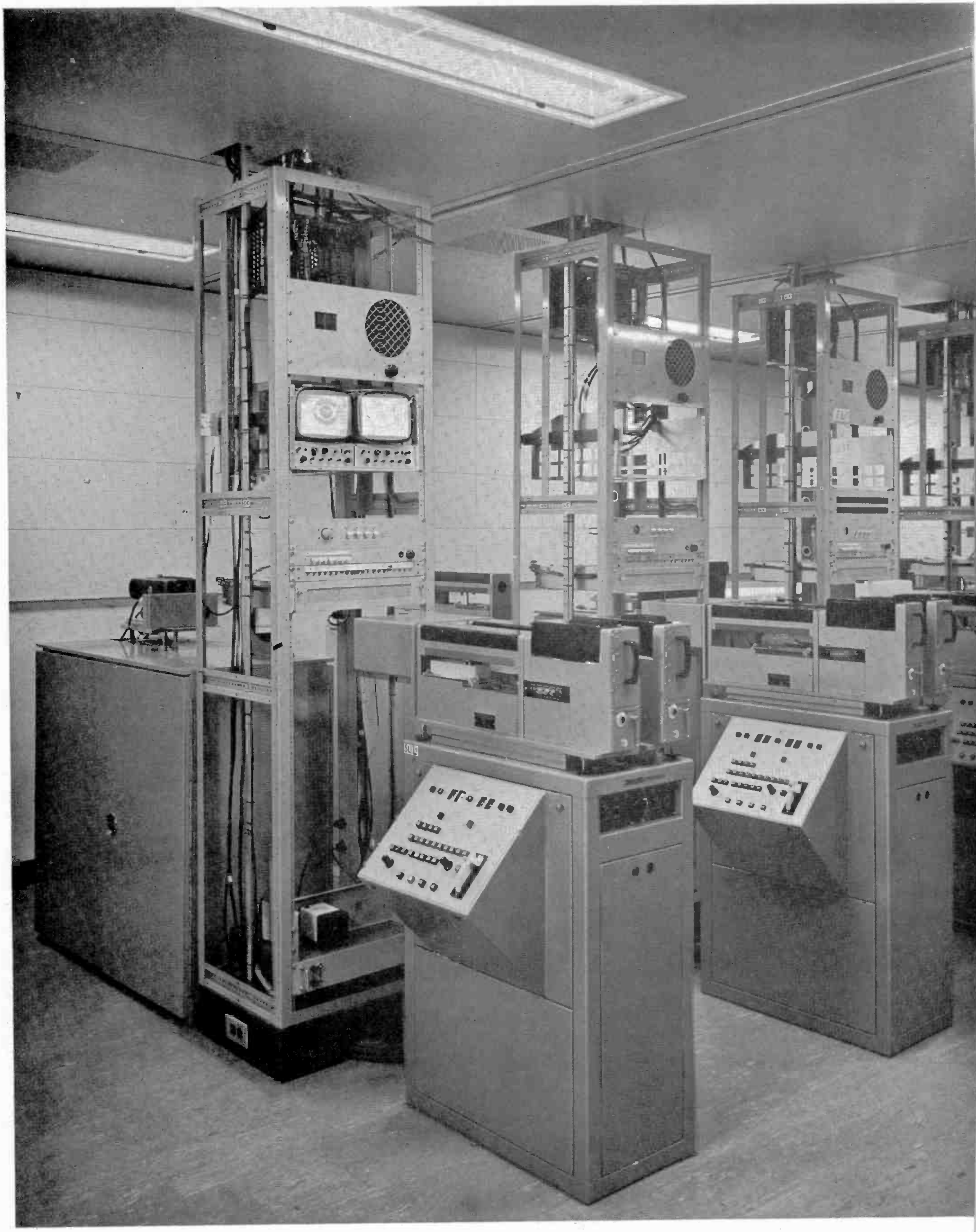
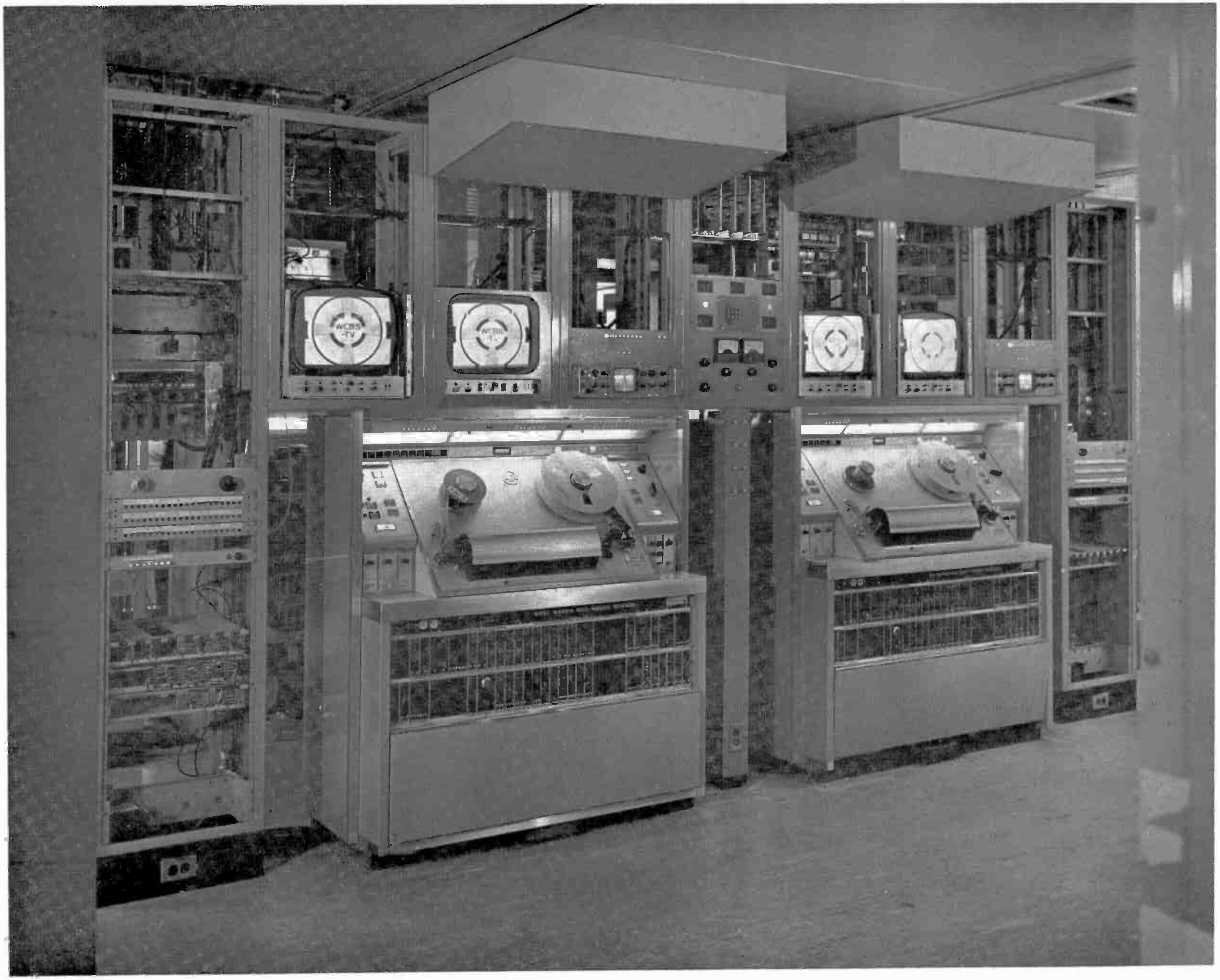


FIGURE 28

Two of the six dual-channel slide projector channels are shown. The slide projectors provide random access, lap dissolves, and superimpositions, under complete remote control. Computer control of these functions is provided when they are assigned to one of the Program Control rooms.

FIGURE 29

Video tape machines are grouped in pairs and placed in facing pairs. Thus, four machines are grouped together in a space easily covered by an operator and yet spacious enough to accommodate several non-related recording or editing operations without undue interference.



<u>FIGURE 30</u>

Two video machines are shown during installation in a typical paired group. The associated [illegible] assemblies are identical for the Ampex and RCA video tape machines

"Some Recent Improvements in Vidicon Tubes and Associated Camera Circuitry"

R. E. Putman

I. T. Saldi

General Electric Company

Syracuse, New York

Given at the Engineering

Session of the 42nd Annual

Convention of the National

Association of Broadcasters

Chicago, Illinois

April 6, 1964

The vidicon has had a remarkable growth in stature since its introduction in 1952. The first users tolerated many deficiencies in the early tubes because the vidicons were less of a problem than the iconoscopes they were replacing.

The first vidicon introduced was the 6198. The sensitivity of this tube was low, the lag high, the shading atrocious, center-to-edge resolution poor, and the tube displayed a large number of blemishes. Yet, in spite of all these disadvantages, stations began to use vidicons because they filled a need and their operating cost was low.

However, as vidicon usage became more widespread, complaints started to accumulate and the tube companies accelerated their improvement programs. The first change introduced was dynamic focussing. This tube, the 6326, did produce a flatter picture and better center-to-edge resolution, but it did not solve the sensitivity, lag or blemish problem.

The next change was to eliminate the side appendage. (See Figure 1.) This tube, the 6198A, minimized the handling and blemish problem, but it did very little to improve shading, sensitivity, lag, or center-to-edge resolution.

The next change was the introduction of an indium target seal. This development opened the doors to the vidicon quality enjoyed today. The indium cold seal allows the target to be prepared separately from the tube envelope. Consequently, the target thickness is uniform and the targets can be inspected prior to assembly.

The first tube fabricated with an indium seal was the 7038. This tube had higher sensitivity and improved center-to-edge resolution. The most striking improvement was the flatness and cleanliness of the images produced. This tube then became the standard of the industry.

The next improvement was one of sensitivity. This tube, the 7325, was about twice as sensitive as the 7038.

In 1958 the 7735A was introduced. This tube had an improved sensitivity-lag characteristic. The most striking feature of this new tube was the "crispness" of the images produced. In general, other vidicons suffered from a grain problem. The 7735A is devoid of grain. This tube then became a new standard of the industry and presently is the most popular vidicon on the market.

As the vidicons have improved in performance, improvements in the external circuitry have been necessary in order to realize the full capability of the system. Careful attention to details, plus the use of transistors, has improved system circuitry. Some of the areas that have required careful attention in order to achieve the ultimate in resolution and stability of the system have been in the area of focus current regulation. Small drifts in this current makes a most noticeable effect on picture quality. Regulation of all voltages is extremely important, as well as the need for careful attention to the stability of the focus voltage of the tube, regulation of the supply voltages, and even DC on the filaments. Transistorization of equipment has reduced the amount of heat generated, as well as preventing local hot spots of temperature that, in the past, contributed to changes in equipment performance.

From 1958-1962 there have been a few minor changes in vidicons such as low power filaments, particle shields, etc. Today there are about 35 magnetic vidicons registered with the EIA. However, all these tubes revolve around three basic types - the 7038, the 7325, and the 7735A. These are the tubes most commonly used today. Figure 2 shows the improvement in vidicon sensitivity since their introduction in 1952.

During the past year several major advancements have been made in vidicon technology. The two most exciting developments to be introduced during the past year were:

1. The separate field mesh vidicon.
2. The lead oxide vidicon.

The separate field mesh vidicon, the 8541, has proven thus far to be by far the best vidicon that is commercially available. This tube contains a 7735A target and a low power filament. It differs from standard vidicons in that the mesh is electrically separated from the focus electrode.

The advantages of the 8541 over standard vidicons are:

1. Excellent signal uniformity over a wide range of target voltages.
2. The tube can be overbeamed without loss of resolution. This is a very desirable feature for automatic target control cameras.
3. Can be operated at low target voltage without loss of picture quality.
4. The most striking advantage is the improved amplitude response. The amplitude response of the 8541 at 400 TV lines is twice that of the standard vidicon.

Figure 3 shows the amplitude response of the standard 7735A vidicon operated in a 40 gauss focus field. The amplitude response of this tube at 400 lines in a 40 gauss field is about 30%.

The amplitude response of the 7735A can be improved by increasing the focus field and focus voltage. Today it is not uncommon to find equipment operating from 30 to 80 gauss focus field, with the tendency being toward the higher

VIDICON TARGET CONFIGURATION

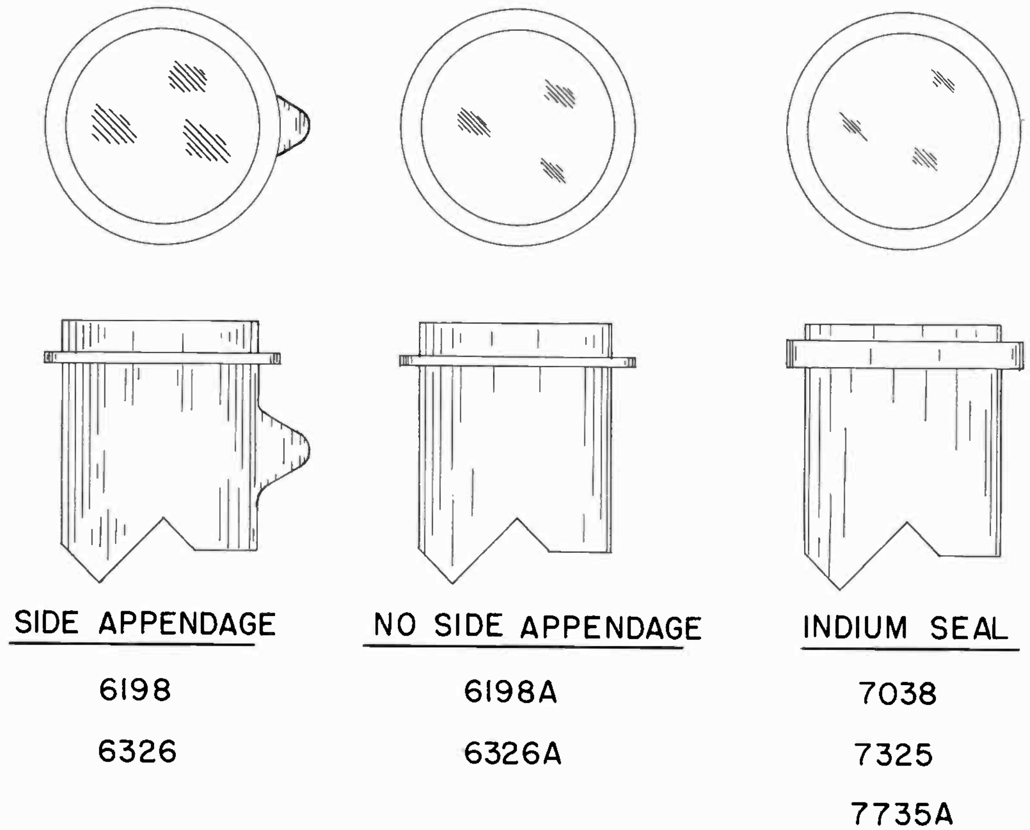


Figure 1

IMPROVEMENT IN VIDICON SENSITIVITY SINCE THEIR INTRODUCTION

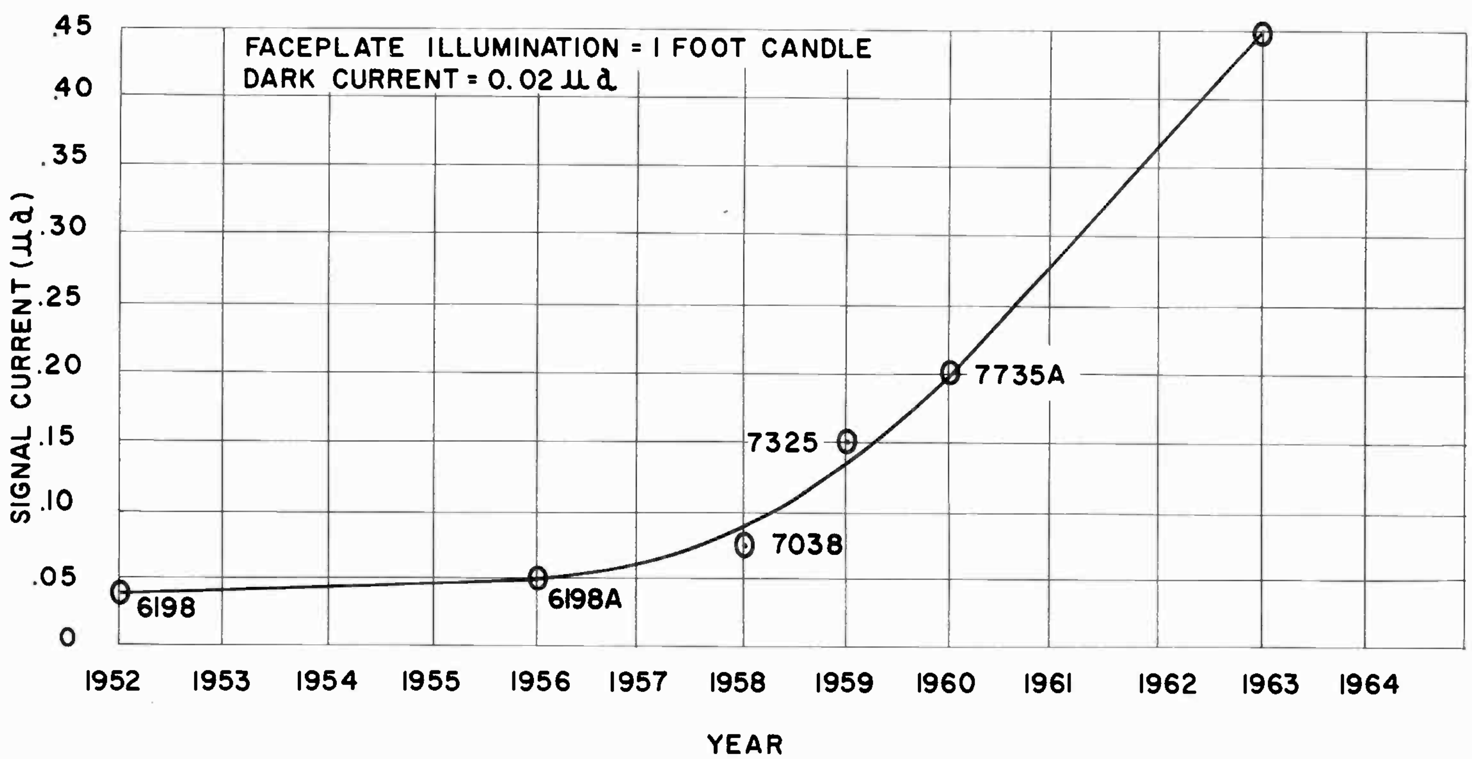


Figure 2

AMPLITUDE RESPONSE
STANDARD VIDICON GL7735A
FOR UNCOMPENSATED HORIZONTAL SQUARE WAVE

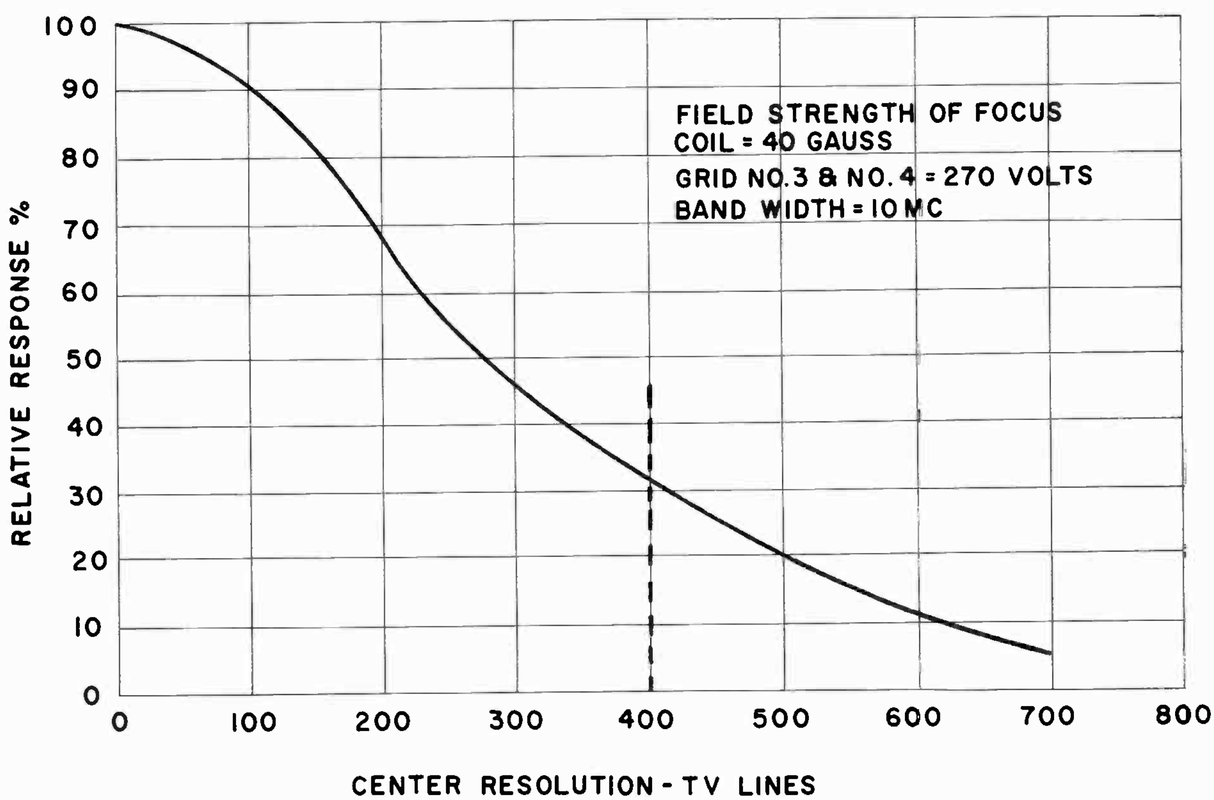


Figure 3

AMPLITUDE RESPONSE
STANDARD VIDICON GL7735A
FOR UNCOMPENSATED HORIZONTAL SQUARE WAVE

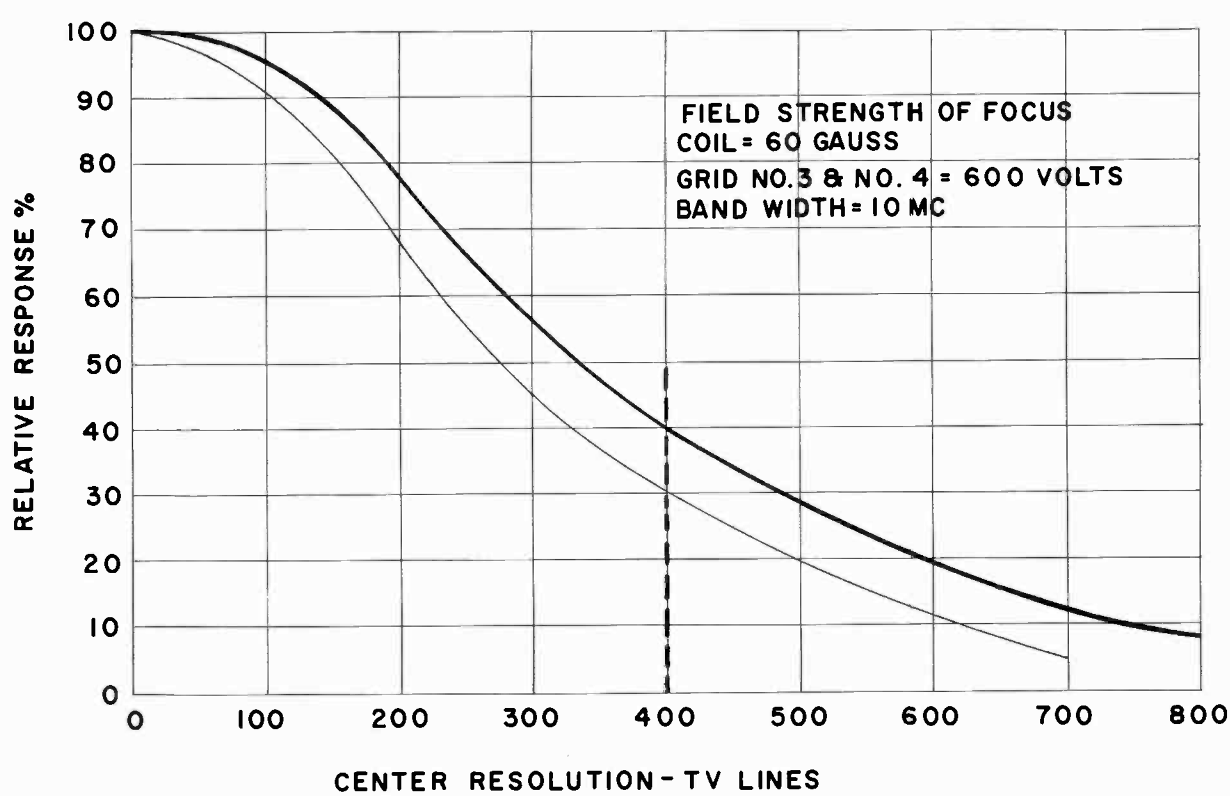


Figure 4

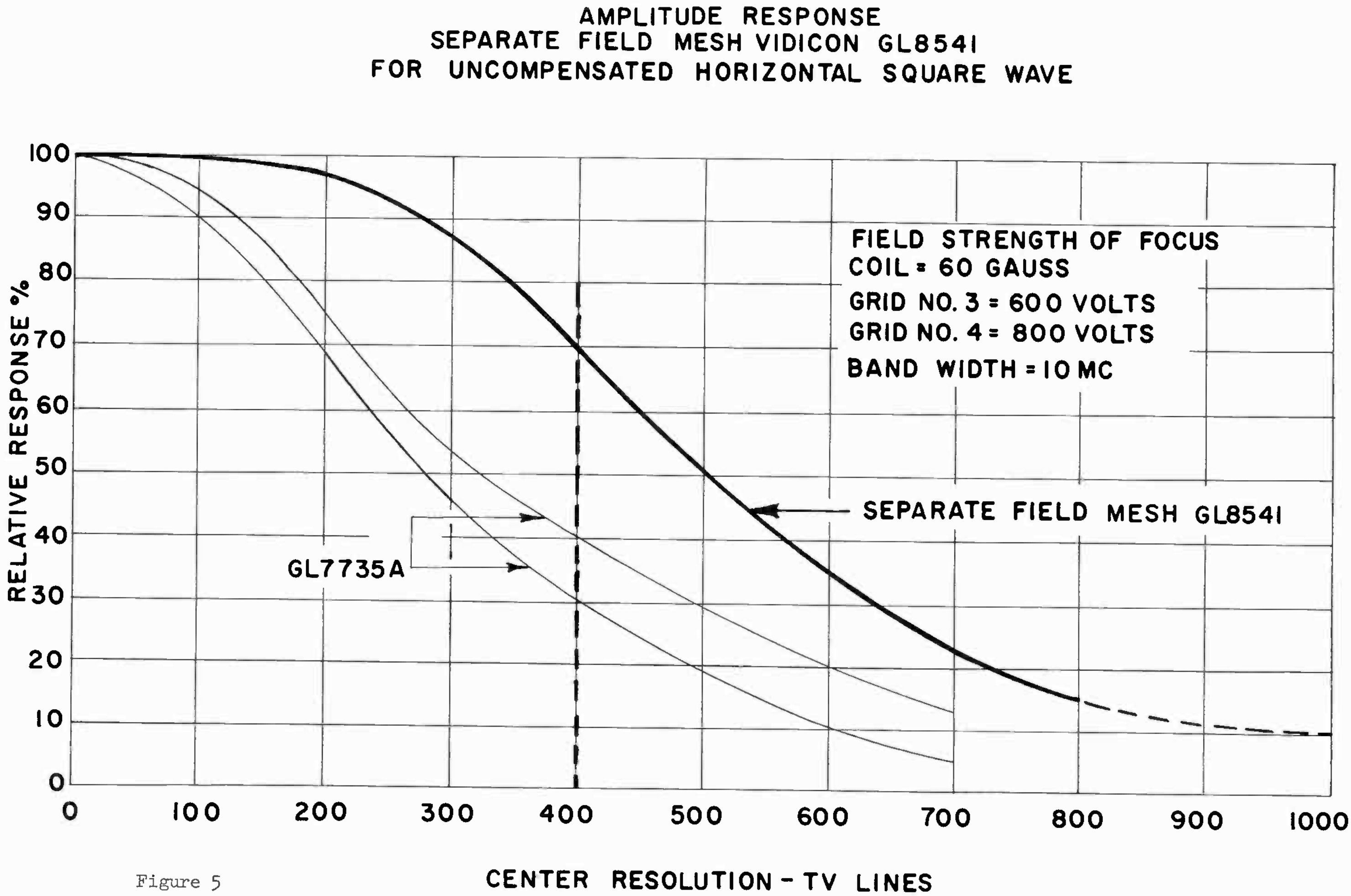


Figure 5

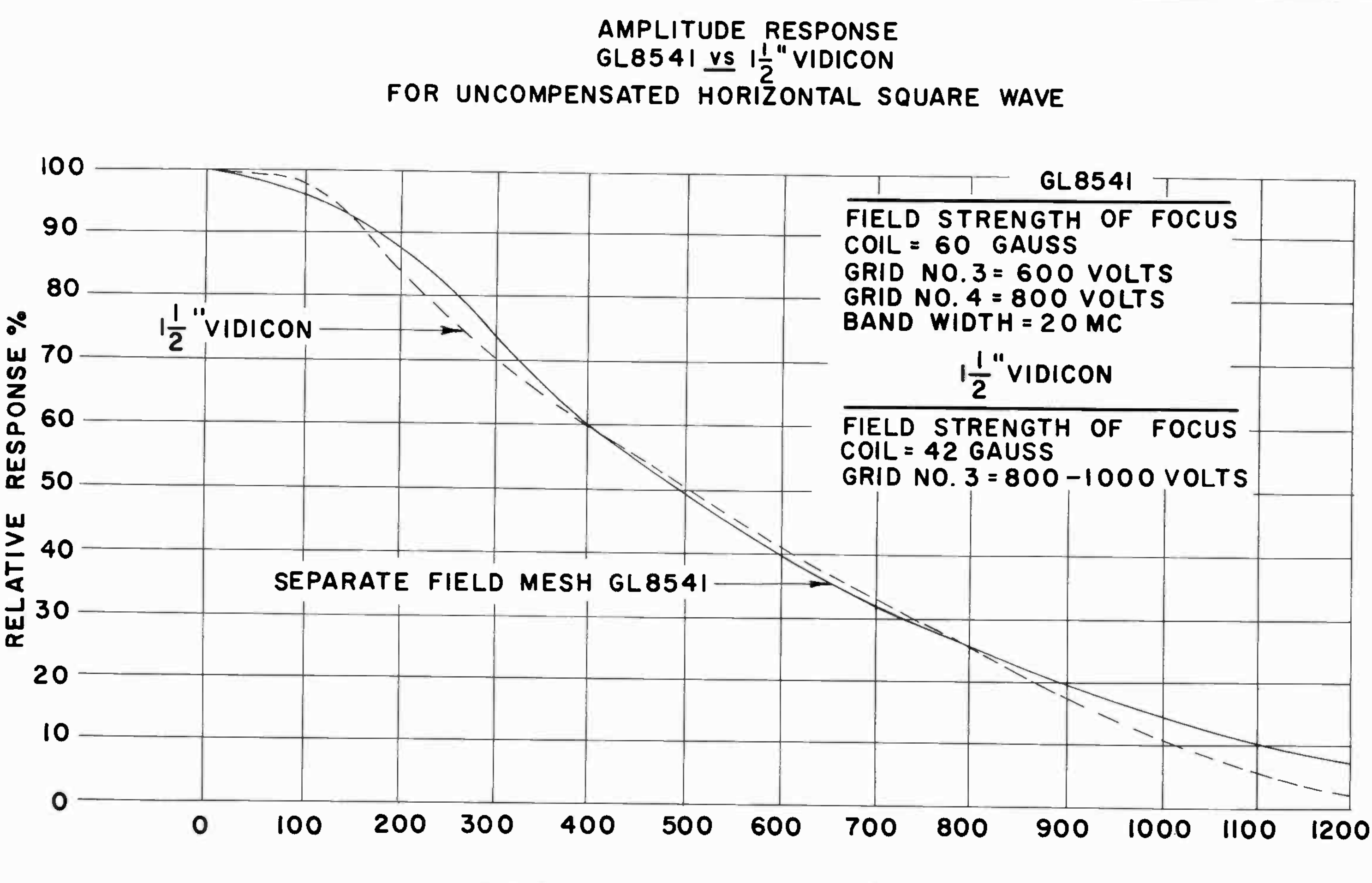


Figure 6

IMPROVEMENT IN VIDICON SENSITIVITY SINCE THEIR INTRODUCTION

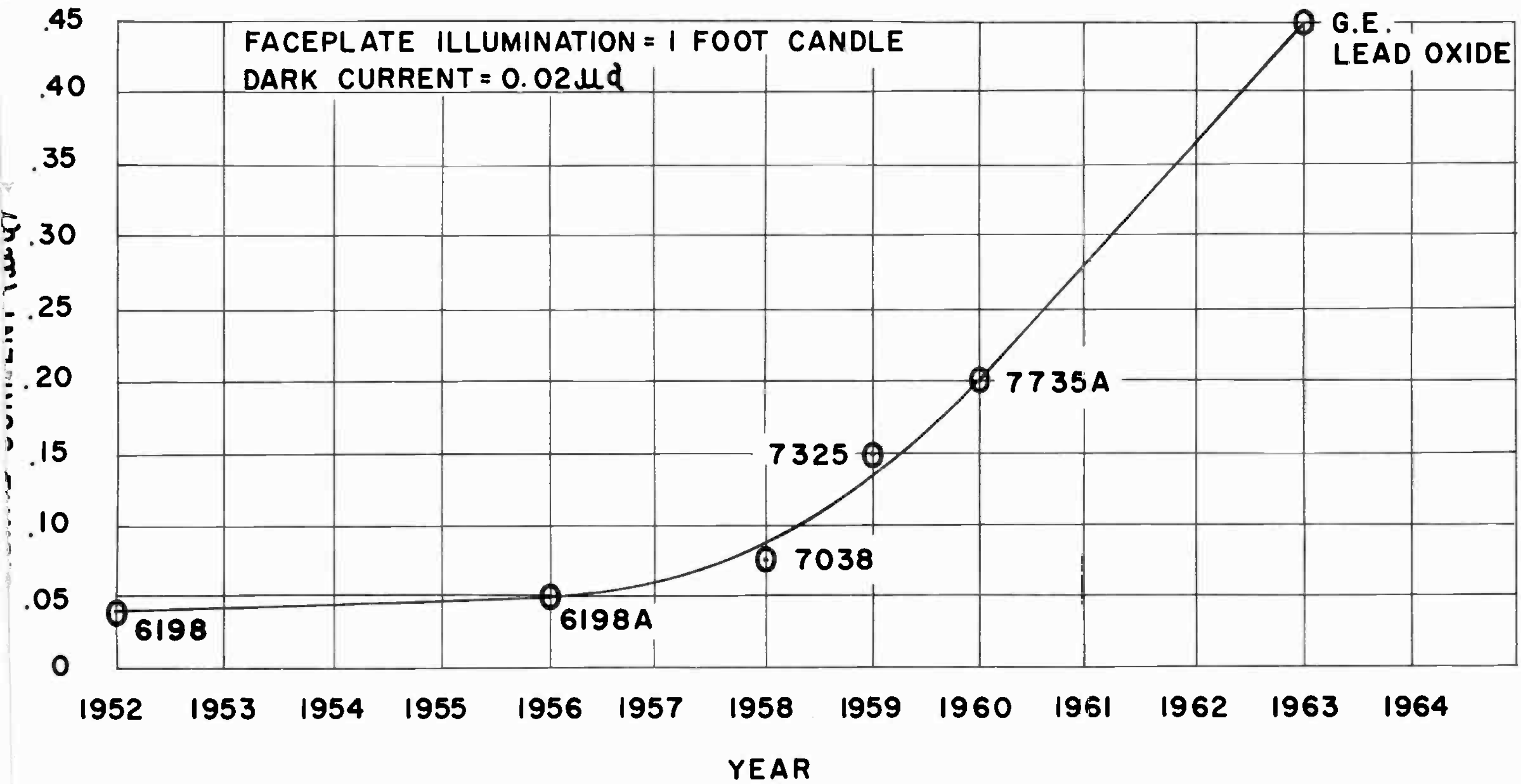


Figure 7

Visual Communication Products

GENERAL ELECTRIC

212 West Division Street, Syracuse, N.Y. 13204

AUDLOK

J L Hathaway
Senior Project Engineer
National Broadcasting Company

Paper Presented at National Association of Broadcasters
Engineering Conference, Chicago, Illinois April 6 1964

AUDLOK

J L Hathaway
National Broadcasting Company

Summary

Television broadcasters have utilized the well known system of Genlocking when programs have originated from remote locations. This has entailed certain deficiencies as well as added expenses which are avoided with the Audlok system. In this new system, synchronizing information is sent over audio telephone circuits for slaving as many remote generators as desired. These can be precisely coordinated in time relationship at the master generator location and so permit the use of such effects as dissolves and wipes.

PHILOSOPHY behind the Audlok system is best understood after consideration of certain aspects of the well known "genlock" - especially what it will and will not do. Most broadcasters are familiar with systems such as "genlock," whereby synchronizing generators are locked together so that their pulses are in substantially the same time relationship. This is accomplished by transmitting sync pulses from the master sync generator over a video circuit to a second generator, usually termed the slave. When the pulses are first applied to the genlock elements a momentary shift of frequency and timing is produced so that the slave's sync pulses become aligned with those from the master. Thereafter, they remain in locked alignment. This requires between a fraction of a second and about four seconds, depending on the relationship of the two sets of pulses at the time of application. Most modern sync generators are equipped with genlock or equivalent circuitry.

Sync pulses from the master generator are frequently conveyed over the video circuit in conjunction with picture signals. Such composite transmission requires a means of stripping off the sync pulses for application to the genlock. In other instances, however, video circuits transmit only the sync pulses to the slave. The genlock system is automatic and has usually been found quite reliable - but there are requirements which it sometimes cannot meet primarily because the sync pulses fall in time coincidence at the slave sync generator, not at the master. Furthermore, when an extra video circuit is needed for transmission of pulses there is an extra element of expense. As an illustration, consider a camera to be used with such video effects as wipes and dissolves, located a few miles from the main control position. If video circuits are available both to and from the remote apparatus, this can be slaved in a time relationship which permits adding video effects at the remote location. However, such effects should usually be applied at the main control position for most types of field presentation so this arrangement not only involves the cost of an extra video circuit but is operationally unsatisfactory. As an alternative, the remote sync generator could be used as the master and the composite video signal transmitted to the central control position to lock and slave the central sync generator. This arrangement would generally be less expensive and more satisfactory than the reverse slaving - in fact, if only the single remote camera location were involved it would be hard to beat. Unfortunately, if more than one remote were required it would not work, since the central sync generator could ordinarily be slaved to only one remote.

AUDLOK in its present form is inferior to genlock in that it is not completely automatic. On the other hand it does things not possible with genlock. Audlok permits the ready alignment and locking of a remote sync generator so that pulses are properly timed at the central control location. Several remotes can be slaved so that each is in time coincidence. This requires no extra expensive video circuits to the remote locations, merely ordinary telephone audio wire circuits from which the name Audlok has been derived. The basic Audlok system is shown in block form in Figure 1. Two remotes are indicated audloked to the master sync generator. More could be added if desired. A remote is adjusted so that the pulses arriving with picture signals at the central location are in time coincidence with the master sync generator. This may be accomplished by watching the pulse-cross monitor while adjusting the phase shifter. When a remote has been properly aligned it remains so without readjustment unless a break or other discontinuity should occur on the audio sync feed line. After the first remote has been adjusted, the pulse cross monitor may be switched to the second and alignment achieved by the second phase shifter. There is no limit to the number of remotes that can be handled this way.

EQUIPMENT necessary for audloking a single remote includes a transmitting unit at the central location and a receiving unit at the remote. Fortunately, the receiver is quite small and normally requires little or no attention. The transmitter, slightly larger and more complex, includes three main components: a phase shifter, a frequency divider, and an alarm circuit. These are shown in block form in Figure 2, and will be described in broad detail. The purpose of the phase shifter is to permit phase advance or retardation of sine wave signals derived from the master sync generator's horizontal drive pulses. A front panel dial when turned one direction, say clockwise, produces a smooth phase advance without limit, whereas the reverse rotation causes phase retardation. The frequency of the sine waves is double that of the input drive pulses and thus two complete rotations of the front panel dial produce a single line of phase adjustment. This permits excellent resolution in aligning a remote sync generator. To phase remote pulses in a relatively short period of time, which could require several hundred revolutions of the phasing dial, a motor drive is provided. The motor rotates in either direction by way of a normally off, 3 position toggle switch. The usual procedure is to first bring the vertical pulses into approximate alignment by motor drive and then ease in to precise line adjustment manually. The complete process generally takes about 45 seconds. Following the phase shifter in the circuit is a highly stable 8 to 1 frequency divider. This is followed by an amplifier tuned to pass 3.94 KC and a balanced audio output transformer. Also the output system includes a meter and control for adjustment of level.

THE PHASE SHIFTING SYSTEM is the heart of the transmitting unit, so this will be considered in finer detail. The schematic of Figure 3 includes the pulse amplifier at the left driven from horizontal pulses from the master sync generator. These are amplified and converted to double frequency sine waves through the double tuned toroid transformer T1. Coupling of this transformer is just beyond the critical point so as to achieve an almost flat bandpass 30 to 33 KC. This is desirable in making the system less critical to slightly differing sync generator frequencies as well as initial manufacturing alignments. The center tapped secondary has a peak to peak voltage of approximately 110 across the entire winding. Such a high voltage is desirable to insure sufficient level beyond the phase shifting condenser with minimum amplification ahead of the 8 to 1 divider. The phase shift capacitor entails a severe voltage attenuation, as it has very low capacitance.

The phase shifter itself is a capacity commutator. It amounts to a rotatable condenser which functions like a single rotor plate with four stator plates, each being mechanically displaced by 90°. Four voltages are derived from the transformer secondary which are electrically displaced 90° from each other. The voltages to ground of each secondary terminal are obviously in 180° displacement. The two remaining 90° displacements are obtained by simple R-C networks wherein capacitive reactance at 31.5 KC is numerically equal to R. Such combinations of R and C, operating into very high impedance loads develop voltages of the same magnitude to ground as each of the transformer terminal voltages, but retarded by 90°. With connections as shown, when the rotor is adjacent to plate 1 it receives what might be termed the first phase. If it is adjacent to plate 2, it receives the second phase, and so on for phases 3, 4 and again to 1 where it has gone through a full 360° of phase shift. At positions mid-way between two plates the capacitive coupling is from both stators and consequently the phase is mid-way. Continuous rotation in one direction produces continuous phase advance of 360° per rotation, while reverse rotation produces similar phase retardation.

A NOVEL ALARM SYSTEM is also incorporated in the transmitter. This is used to replace the pulse-cross monitor after the preliminary pulse check. During programming it would be confining and difficult to continually watch the pulse-cross for possible trouble. If several remotes were needed it would be quite expensive in manpower requirements. Therefore the built-in audio alarm was developed to replace visual monitoring. In the event of a loss of time coincidence of the sync pulses from two generators a loud intermittent beeping is produced and also a flashing red light indicates which of the various remotes is in trouble. The coincidence alarm circuit is shown in simplified form on Figure 4. Sync pulses are fed into the alarm from the master and also from the slave generator, in the same manner as the feeds to a pulse-cross monitor. The principle involved is that if two composite sync signals are similar in all details, such as pulse widths, amplitudes, number of equalizing pulses, etc, it is possible to balance one against the other for zero output, providing they are in time coincidence. In practice this has been found to be very effective and easily accomplished. As shown schematically, the two sets of pulses are applied to a transformer primary so as to produce opposite polarities in the secondary. When the input balance control is adjusted to equalize levels, if the pulses are in time coincidence the transformer delivers substantially no output. If the timing of one set of sync pulses changes by a small fraction of a microsecond, high level pulses are delivered to the balanced modulator. These cause the oscillator tone to be transmitted and amplified to the loudspeaker and indicating light. In order to give a loud distinguishable alarm, the oscillator is of the squedging type and produces approximately 1 KC beeps at the rate of 3 per second. The red light flicks on brightly during each beep.

The complete transmitter is pictured in Figure 5, showing the phase and motor controls, the outputlevel meter and control, the alarm balance, light and loudspeaker, and a pilot light.

Figure 6 pictures the plug-in circuit board assembly of the transmitter.

THE AUDLOK RECEIVER was developed for use at either temporary field pickup locations or at the more permanent studio setups away from the master control location. Basically, the receiver merely amplifies and multiplies frequency of the 3.94 KC signal from the audio telephone line. Transmission distance may be anything from a few yards to a few hundred miles. When a long telephone circuit is employed there are two main requirements: it must pass the signal frequency and it must not be of the carrier type circuit wherein the carrier may be reinserted slightly off frequency,

The receiver is best explained by referring to the schematic of Figure 7. Here, the upper line of transistors is for amplifying and multiplying frequency. The circuits below include the power supply and an audio alarm. As indicated, the 3.94 KC sine wave signal feeds in from the telephone line through a balanced transformer. Next, following a level control, is a reasonably high Q circuit tuned to the input frequency. This circuit eliminates most of the noise components sometimes present on the received tone signal, and does so prior to the introduction of non-linearities which might otherwise introduce cross modulation products. Next, following a transistor amplifier, is a double frequency tuned circuit. A meter connected at this point permits adjusting to optimum level as will be described later. Also from this point, signal is fed to precisely control phase of a locked oscillator. The latter is adjusted for future equipment if a 31.5 KC crystal oscillator were employed in place of the locked L-C oscillator. If the crystal worked into an 8 to 1 frequency divider, its output phase could be compared to that of the incoming 3.94 KC tone. An error signal could then be applied to a reactance element for correction of the crystal oscillator phase.

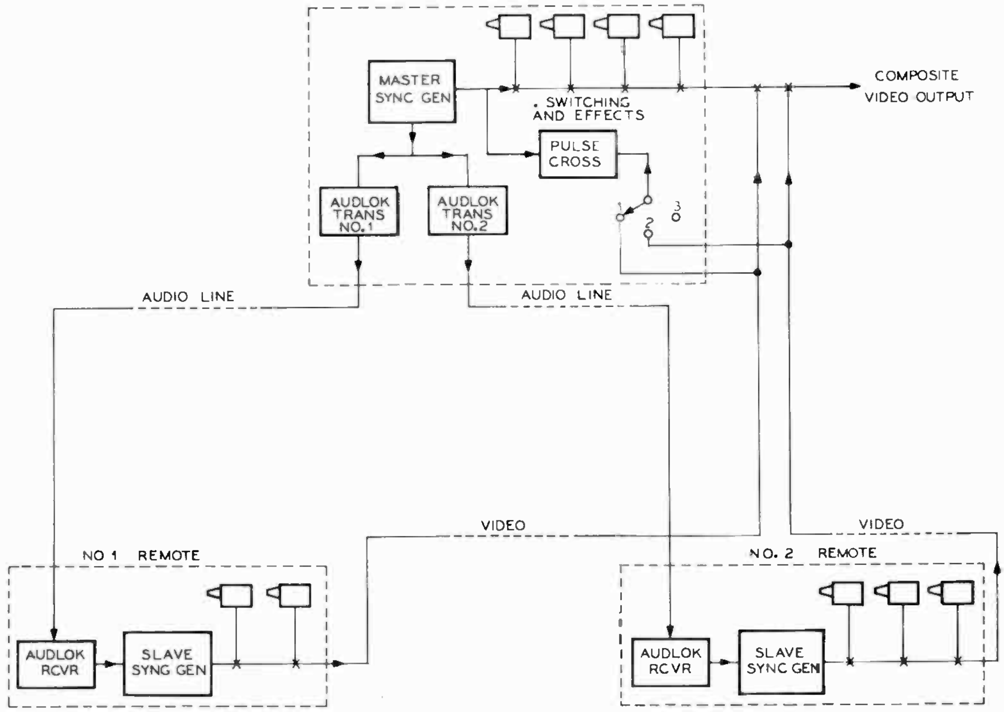
The Audlok receiver requires an input tone level of at least -24 DBM. In operation the input level control is adjusted so that the meter reads anywhere from 100 to 150 on the 200 microampere scale. If less than a reading of 100 is employed the oscillator may lock satisfactorily on constant signal but may not follow the transmitter when motor drive is used for rapid pulse alignment. On the other hand, if the reading is greater than 150 the pulse timing error becomes greater than desired. Measurement of a complete Audlok system, including two sync generators and 40 miles of audio line gave a timing error below .03 microseconds when the receiver meter indicated 150 or lower.

Output from the receiver approximates 45 volts peak to peak. This may be used to control the slave sync generator in either of two connections:

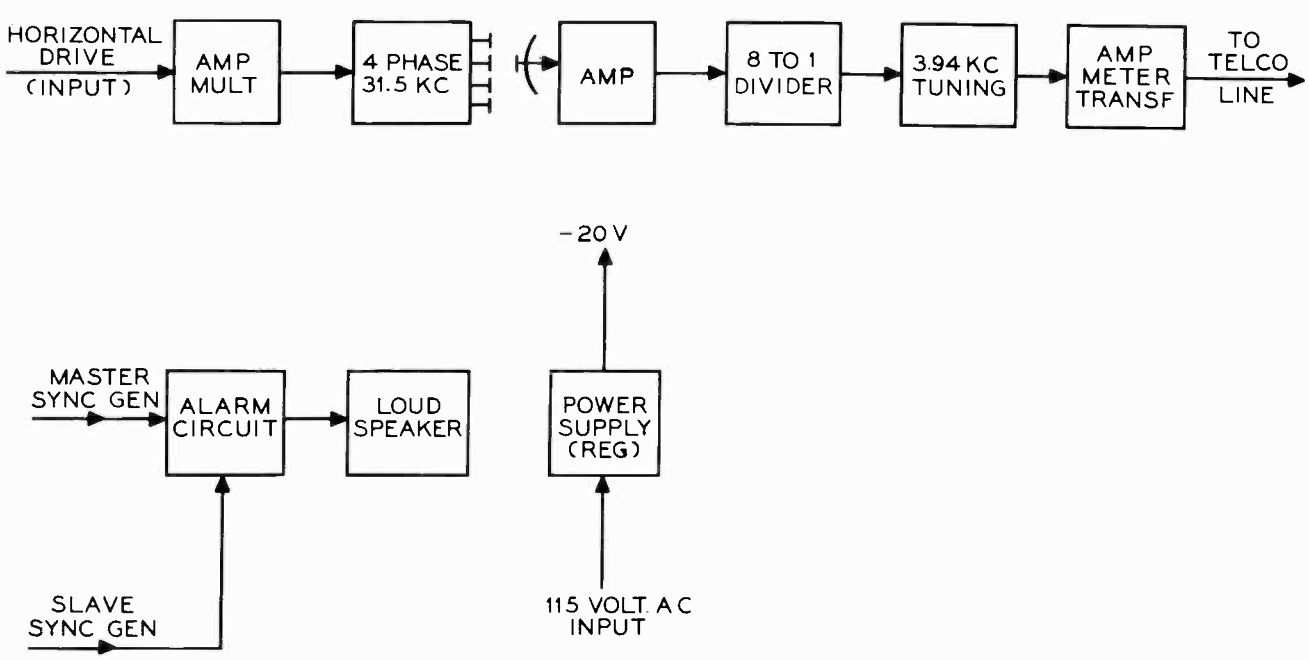
1. The 31.5 KC plugged in at "External" in the manner of a color crystal divider unit. With this connection the mode switch should be at "External."
2. The 31.5 KC plugged in so as to replace the internal crystal, with the mode switch at "Crystal."

EXPERIENCE with the Audlok system has shown that it is easy to use and reliable. It has also shown the tremendous advantages of being able to properly coordinate at a central location any number of remotely located sync generators. Program-wise Audlok has become a "must" in our planning - especially for such events as conventions, elections, inaugurations and news.

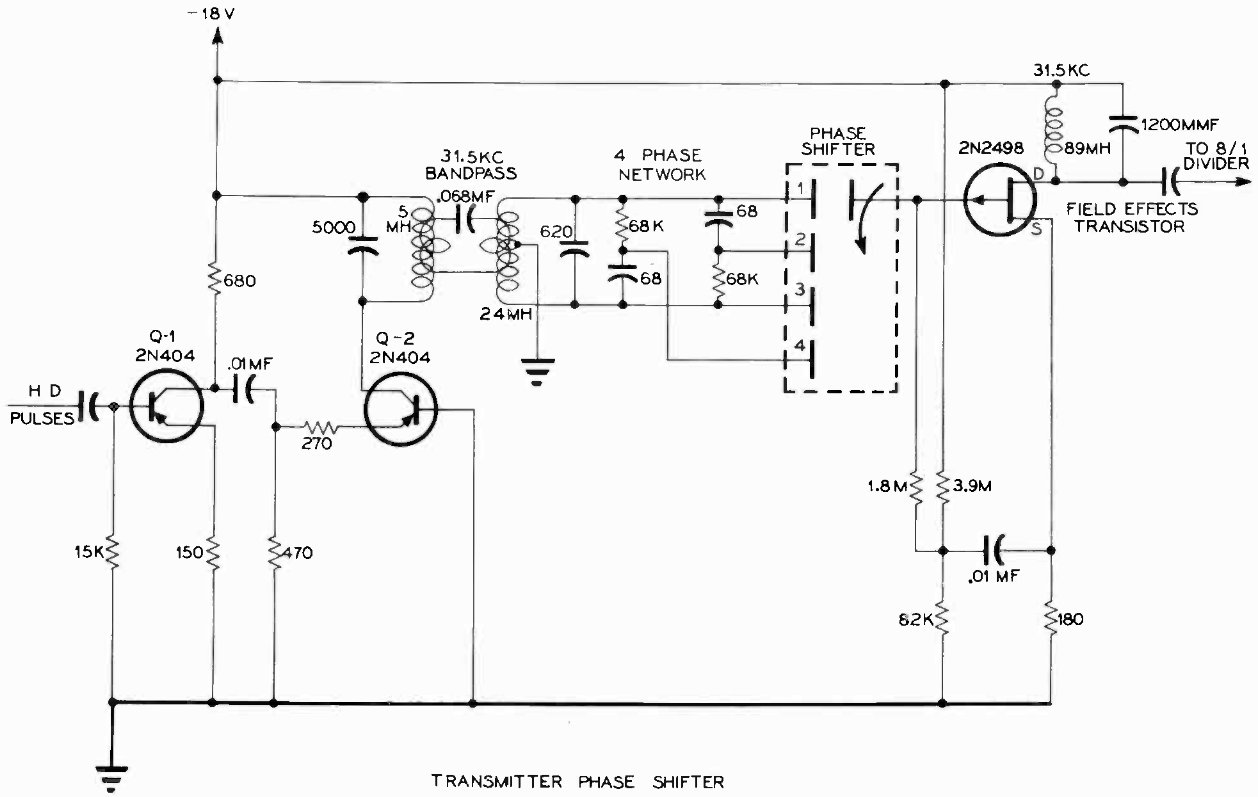
The author wishes to thank A C McClellan for his development work on the final model Audlok system. Also, William Trevarthen and James Wilson for their enthusiastic support and contributions to this project.



BASIC AUDLOK SYSTEM
MASTER WITH TWO SLAVE SYNC GENERATORS
FIGURE 1

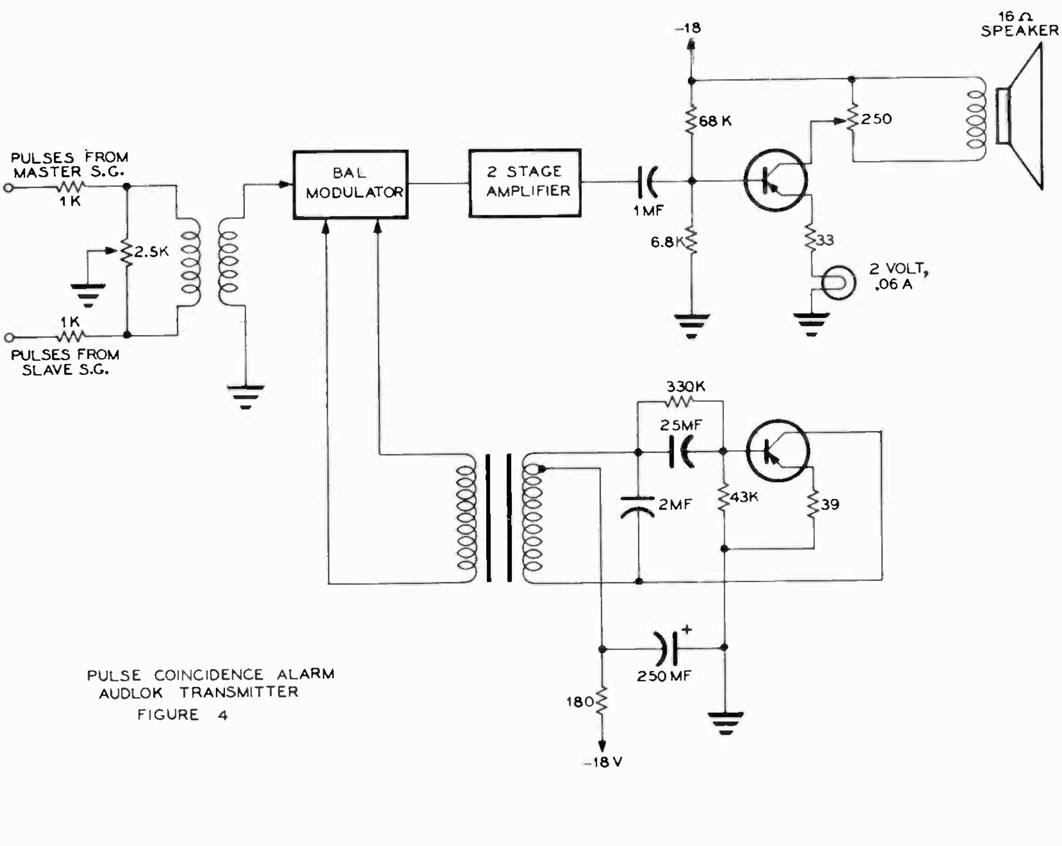


AUDLOCK TRANSMITTER
FIGURE 2



TRANSMITTER PHASE SHIFTER

FIGURE 3



PULSE COINCIDENCE ALARM
AUDLOK TRANSMITTER
FIGURE 4

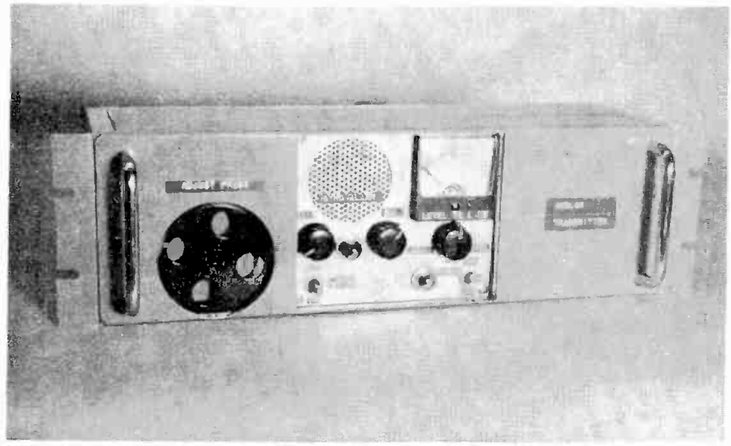


FIGURE 5 AUDLOK TRANSMITTER

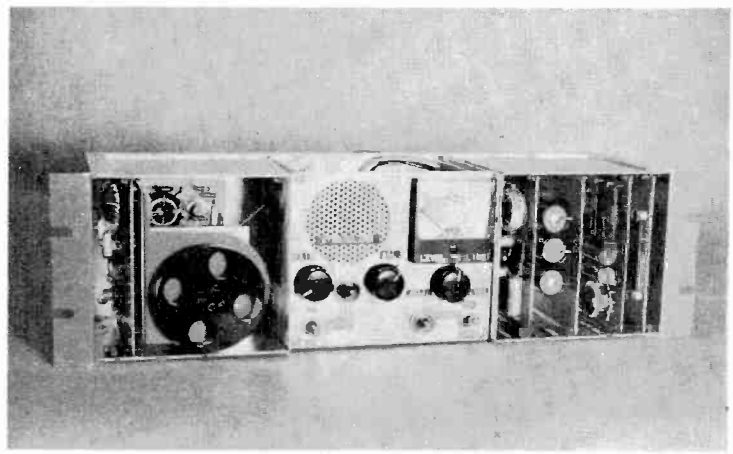


FIGURE 6 COVER REMOVED

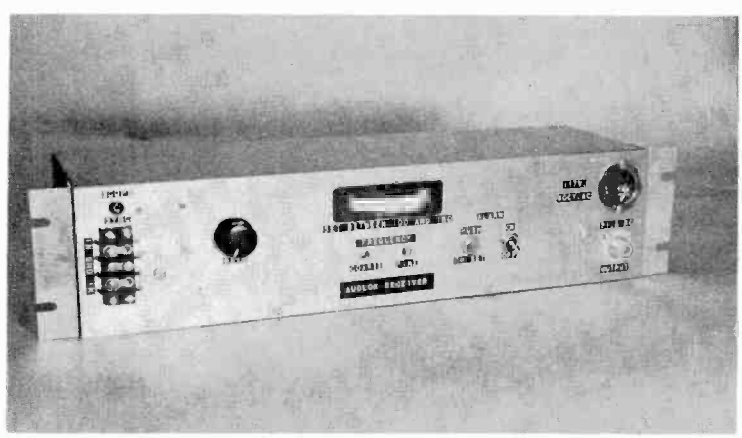
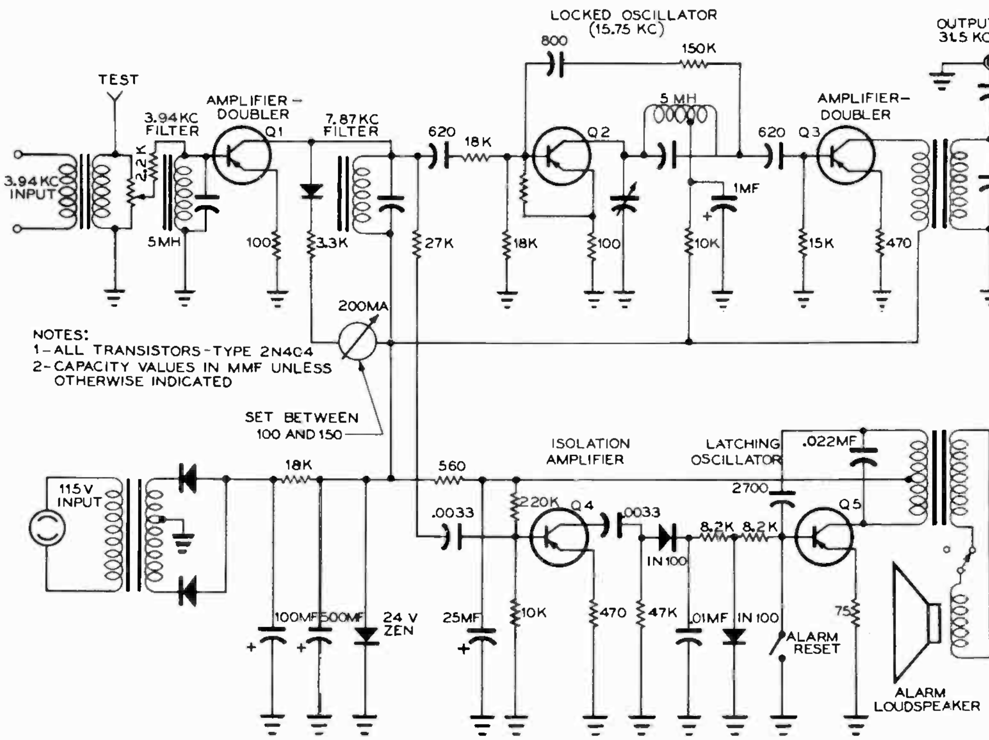


FIGURE 8 AUDLOK RECEIVER



AUDLOK RECEIVER
FIGURE 7

CONDENSER MICROPHONES AND REVERBERATION: TWO ANSWERS TO COMPETITION FOR LISTENER APPROVAL

Delivered at the 18th annual Broadcast Engineering Conference

National Association of Broadcasters

by

Stephen F. Temmer, President
Gotham Audio Corporation
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Chicago, Illinois
April 6, 1964

CONDENSER MICROPHONES AND REVERBERATION: TWO ANSWERS TO COMPETITION FOR LISTENER APPROVAL

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INTRODUCTION

Broadcasters are saddled with engineering problems even though most of their life is actually spent in programming, selling, public relations and such other very non-engineering subjects. Many broadcasters ignore this phase of their operation as merely a necessary evil and relegate these duties to a person or persons not even considered on the management team. They interpret FCC and NAB standards to be in the nature of "operating instructions" for an engineering department which, if closely followed, carry within them the key to all that is required of a broadcaster. There are many who realize that this is not so at all but that these two organizations try to put a floor under engineering; a minimum quality that can just be tolerated before it becomes obviously bad to every listener. They walk around the basement of this hotel looking at the myriad types of equipment being offered to them to "improve their quality" and the more they walk the more confused they get. Uppermost in every station manager's mind when it comes to engineering is one single question: "How can I invest my funds most wisely so as to derive maximum engineering effectiveness?" Let's look into that phrase in greater detail:

WHAT IS ENGINEERING EFFECTIVENESS?

Many questions and indeed many answers suffer from semantics and this question is no different. "Quality" can be many things to many people. QUALITY may mean good looking equipment: equipment you will be proud to show off to clients, listeners, and competitors. Some of you may even engage a page staff to make sure that as many people as possible see your equipment and perhaps draw the desired conclusion from its colorful, clean, modern exterior. This is undoubtedly a big plus to some operations. Another thing which QUALITY may bring to mind is equipment which runs day in and day out without letting you and your listeners down; without failing even though properly maintained. The absence of this sort of "quality" starts getting into real money out of your pocket and this money must be added to the initial cost of the equipment. The resulting price tag (direct plus hidden cost) may astound you and may exceed the price of the top cost equipment on the market! QUALITY may furthermore be the resale value of the equipment; what it will cost you to step up to the next higher equipment quality level which is largely dependent on what you can get for your used equipment.

But above and beyond all that is the QUALITY which is audible to your listeners, your clients, and last but not least to you. This sort of quality I call "effectiveness." Much of this judgment is difficult to make on the spur of the moment. Many people, I dare say most people, are unable to "put their finger on it." It is something which makes your place on the dial a more pleasant and relaxing spot to spend long periods of listening time.

ENGINEERING INVESTMENT ADVICE:

No question there is much that you must buy for your station simply because it is needed in its operation. But there comes a time in every station's life when you are out to "buy something new" for the place, and you have to ask yourself how best to invest your money. You could buy a new studio console, a new transmitter, a new microphone, turntable, loudspeaker, or any number of items. The question is which will bring the most effective results per dollar invested. Where in the chain of equipment is that special "pressure point" which will make your listeners "sit up and take notice?" As an individual equally interested in all audio equipment for such operations, I can let you in on the information that will help you decide which delivers the most results for the money.

MICROPHONES:

If engineers in a broadcast station had the opportunity to apply the same objective engineering tests to microphones which they perform on all their other equipment, there would be a revolution in the microphone field. There is no doubt in my mind that you would instantly discard any audio amplifier on your premises which has the frequency response characteristics of your present microphone or for that matter your turntable pickup or loudspeaker. With amplifiers, we speak of ±3 dB in response with a wrinkled nose and 50-15,000 cps range with an air of "could-be-better" acceptance. We re-equalize a tape machine if it is down 3 dB at 15KC and replace the heads if it shows a slight peak or dip within its range. Well, many microphone test curves throw decibels around only in dozen quantities and speak of response curves that have nothing measurable above 10KC. It's a good thing that the FCC requires no proof of performance checks on mikes or you'd never get a license, for the testing of microphones even at best produces only controversies among acoustical engineers. But believe me, gentlemen, here is one of those "pressure points" in your station's nerve system. You simply have no idea what a change of nothing other than your microphone will do even for a 20-year old console or transmitter.

Without a doubt the pinnacle of quality in microphones is the Condenser Microphones. It is this type of microphone which is used exclusively by acoustical test engineers, by space scientists and all those people who value objective quality coupled with unwavering continuity of service and constancy of specifications. If all this is true, why then doesn't everybody use them in broadcasting? Well, there's a hook in this as in anything else. The impedance of condenser microphone elements run into the hundreds of megohms and require a one tube preamp close to the element to convert to low impedance line output. Contrary to common belief, this preamp is NOT needed to raise the low level of such condenser elements. On the contrary, condenser microphones deliver the highest output of any microphone outside the carbon mike element. The preamp in turn requires a power supply and all this takes up room and above all costs money. For those of you who last had contact with condenser microphones in the thirties, let me assure you that we have come a long way from then. Such microphones are no longer temperature or humidity sensitive, require no "baking" in an oven before use, and indeed have the longest service-free life span without deterioration of its specifications of any microphone made.

Because of the fact that the capsule uses either solid nickel or a gold sputtered Mylar diaphragm weighing fractions of a microgram, you have the ideal transducer in which the moving mass has been reduced to the vanishing point. The result is incredible smoothness of response, low distortion, and longevity. Condenser microphones used in acoustical work can be bought today with response flat to 100KC or more and down to DC at the low end.

One of the delightful features of such microphones is their purity of directional characteristic, small size, and thanks to recent patents in the field, ability to change their directional pattern electrically and even from a remote point. Many radio and TV stations have switched to this type of microphone for their announce positions as well as for what is sometimes referred to "the critical applications." The directionality which can be achieved by such microphones is truly astounding. The usefulness of any directionality is always coupled with the resulting frequency response of the microphone. Cardioid and hyper cardioid patterns as well as the now seldom used, but so very valuable, figure-8 pattern and omni-directional patterns can be chosen by the mere flick of an electrical switch. Changing pickup pattern doesn't change the frequency response of the microphone one bit. The crispness of the sibilants makes speech so much more intelligible that you don't need much gain on your P.A. speakers for the studio audience and the result is less or no problem with feedback howls.

Many of you might ask the question (especially AM broadcasters) what's the sense in doing anything above 6KC, if the little table model radios don't reproduce it? First of all, response curves don't just take a nose dive; they drop more or less gradually and there is no dividend having the mike down X dB when the receiver is down Y dB. The result to the listener will be down X+Y DB when it could have been just Y dB alone. Secondly, the quality we are after is for a response free from spurious resonances; free from valleys and peaks and that is the case when you have a moving system of such vanishingly small mass. You can truly plot a condenser microphone's response curve using a straight edge! The third argument concerns the records you play on your station. More than 90% of the studios turning out such records are equipped partially, if not entirely, with condenser microphones, and it sometimes is strange to hear a station on which the disks sound "liver" than the live announcer. Without a doubt a change of microphone to a better type of unit produces instant audible improvement; more so than the change of any other piece of audio equipment in your station.

WHAT ABOUT REVERBERATION?

So far we have spoken about a device which improves the REPRODUCTION of sound or the truer mirroring of the original sound image. Now we are heading into the area of additives, as the battery manufacturers like to refer to them. There are methods by which sound can be enhanced and its effect heightened. After all, a radio listener is using clinically only about 3.5% of his senses as compared to 96.5% for the other 4 senses combined, to gain a 100% impression of what you are telling him. These 3.5% of him are working overtime and the imagination can be quickly influenced by even the slightest changes in sound characteristic. A speaking voice which sounds dry acoustically gives the impression of being in a padded cell even though the announcer may be saying that he's speaking from the "Crystal Studio." I've often wondered whether the crystal is in the microphone or the chandelier. No amount of words can be as effective as a characteristic sound which reminds the listener of something he has heard before. One of these additives is a reverberation producing device or, as it is sometimes referred to, an echo unit or echo chamber.

It can put back into the voice at the mike what successive layers of rock wool wheat and fiber glass on the walls have taken out of it: its natural reverberant quality. It can take a remote dance band pickup from some dingy padded cellar and give it the airiness of a Viennese ballroom. It can even turn the listeners' own room into such a ballroom and that is the magic of painting with sound. But aside from all of the audible qualities of such a unit, there is an even more fascinating aspect for AM broadcasters and that is the actual "fill factor" of the transmission. The slower decay of reverb can successfully pack more modulation density into your signal and with it can get a more redundant signal to your listeners' receivers, more intelligibility in the fringe areas. A compressor fills those valleys between modulation peaks with noise, reverberation fills them with bona fide program material.

A TRUE REVERBERATION GENERATOR:

There are numerous ways of generating echo. There is, first of all, the actual room containing a loudspeaker and microphone; but in order to be really effective, such a room must be fairly large, and since it also must be quiet, becomes a matter of major acoustical construction. It also costs rent each and every month and can't even be used for storage. There are methods of generating reverb using tape loop echo devices but these all fall short because of a single fact; they all produce a finite number of reflections which invariably sound like chatter. The only other method invented thus far for producing echo without constructing a chamber is the steel plate reverb unit. A sheet of steel 4 x 6 ft. and extremely uniform in its 1/64" thickness is tightly stretched in a tubular frame. A loudspeaker coil attached to it at some point near its center is free to move in a magnet structure and the steel plate is thus excited by the input signal. The waves set up in the plate now travel in all directions, get reflected from each edge of the plate, and re-reflected again and again much like a thunder sheet would act. These myriad reflections are then sensed by an acceleration sensitive element attached to the plate at some other point which are then amplified. The resulting sound is in every way similar to that of a real chamber. Since the device does not use any moving parts, head, tape, or springs, failure is as unlikely as it would be for any amplifier in your system. And now comes the extra added dividends.

STEREO REVERBERATION FROM A MONO SIGNAL:

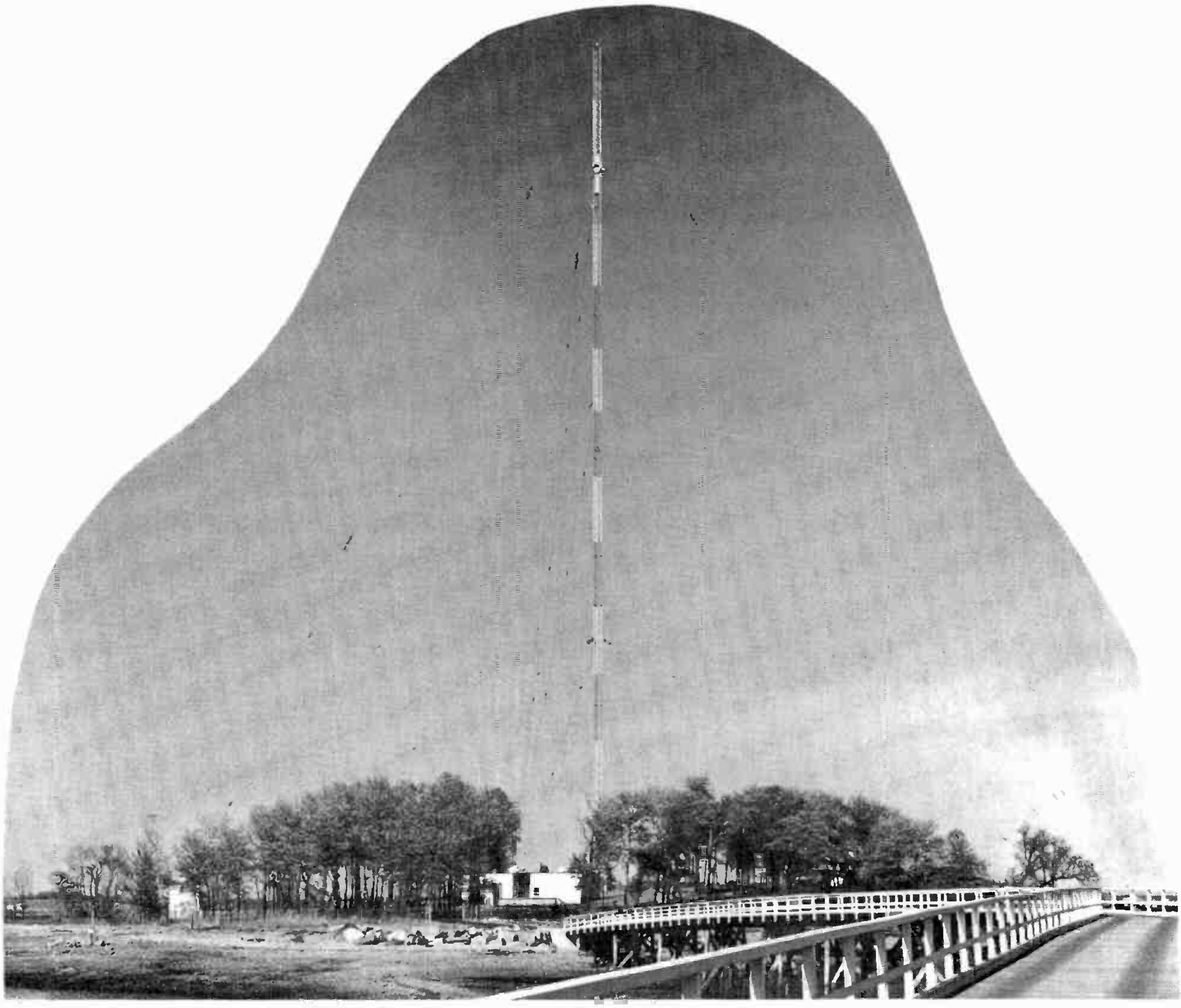
For FM-stereo broadcasters, here is an amazing plus. By placing another such pickup on the plate at considerable distance from the first, a second output is obtained which has a random phase relationship to the output of the first pickup. If you feed one output to the vertical and the other to the horizontal input of an oscilloscope, you can see that the resulting pattern is a dense modulation in the form of a circle. This indicates that when these

produced over two stereo arranged loudspeakers, an infinite
se relationships will give a sound which appears to spread
to the other. Since the reverberant part of any sound in
y itself without the initial sound causing it is always
ent to drive the reverberation plate from a mono or A+B
is the ability to produce a usable stereo signal for FM
ose mono records which contain much of the great music
pre-stereo days. You can also use this effect to add
our announcer's voice from a single microphone. And above
ompatible. That means that your mono only listeners will
ono signal with just a little less reverb added than the

two output combi...

The two fields, microphones and reverberation, which I have ...e, to my mind represent those phases of broadcast engineering which ... significantly upgrade your station quality in relationship to dollars ...sted. Since most manufacturers will allow you to try such devices without any obligation, you will have an opportunity to hear the results for yourself. We will now play for you some examples of the before and after sounds using these devices to their best advantage.

WNBC-WCBS SHARED ANTENNA SYSTEM



Presented at The 18th Annual NAB Engineering Conference April 7, 1964

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CBS RADIO DIVISION

WNBC-WCBS SHARED ANTENNA SYSTEM

In order to improve the service from WNBC, the National Broadcasting Company station in New York, a change in transmitter location was desired. After some search an island of about six acres known as High Island in Long Island Sound was obtained. The island is close to shore and accessible by bridge in the Borough of the Bronx in New York City. This location, being near sea level, had the advantage of permitting a higher antenna as well as a ground system extending into salt water.

The transmitter of WCBS, the Columbia Broadcasting System station in New York, was located on Columbia Island about one and one half miles from High Island. This Island was reached only by boat, and as remote control was anticipated, it was desirable to provide easier access to the transmitter. There had been occasions during winter ice conditions and storms when Columbia Island was isolated for a day or more. As good transmitter locations are not plentiful in the vicinity of New York City, it was natural to consider a joint project on High Island. After some study it was agreed that NBC and CBS together would plan, design, and construct, complete new transmitting stations using a common antenna. The two stations are both Class 1A with powers of 50 KW. WNBC operates on 660 kc/s and WCBS on 880 kc/s. The frequency separation, one being three fourths of the other, seemed sufficient to insure successful operation into a single antenna.

FCC construction permits when obtained, contained specifications for both stations that the antenna height must not exceed 549 feet above mean sea level, that the unattenuated field intensity at one mile, based on 1 KW antenna input, must be at least 225 millivolts per meter, and that any spurious radiations resulting from cross modulation be held to non-interfering levels.

Considering the ground elevation, the antenna height became about 528 feet above ground. The theoretical no-loss performance of a plain vertical antenna of this height is only 206 mv/m at 660 kc/s and 228 mv/m at 880 kc/s. It was then obvious that some increase in efficiency would be necessary at 880 kc/s to compensate for losses and that an appreciable increase would be necessary for 660 kc/s. To obtain the increase, a top loaded and reactance sectionalized antenna tower was indicated. To determine the optimum degree of top loading, position of tower sectionalizing and reactance insertion, the RCA Laboratories were engaged to model the antenna.

With the physical data arrived at, the antenna was specified as shown in Figure 1. The tower has a triangular constant cross-section, 4½ feet on a face, is sectionalized with a single pedestal type insulator about 85 feet from the top and guyed at four levels. The set of guys attached to the top of the tower (unlike the others) have no insulators at the tower, and are electrically bonded to the tower. The upper sections of these guys are therefore used for top loading to increase the electrical height of the tower. A suitable reactance is connected between the upper and lower sections of the tower to control the effective electrical height.

Vertical plane radiation patterns obtained from the model, indicated that a field of about 246 mv/m at one mile might be realized for one KW radiated power. The value was approximately the same for both frequencies. This meant that on the basis of 50 KW input to the antenna, the required field would be obtainable with about 42 KW radiated power, leaving 8 KW available to supply the system losses and any tolerance in the modeling data.

To provide additional information, a mathematical model was prepared for each frequency and arranged to program a computer, with variables of top loading, current distribution, (which would be obtained by variation of the sectionalizing reactance) and estimated values of tower ohmic resistance. These computations indicated a trend of increased field with reduced length of guy top loading, other variables being held constant. This results from using guys for top loading instead of the so called "HAT" of structural steel. The guy loading, while quite desirable from a structural viewpoint, has a vertical component which modifies the effective current distribution of the very top portion of the antenna. It was obvious, however, that appreciable reduction in top loading would result in excessive values of sectionalizing reactance necessary to maintain a suitable current distribution on the tower. This would cause high sectionalizing voltages and losses in the reactance network. The guy top loading was finally set at a length of about 120 feet. There would be some effective extension of this value due to the capacity of extra large insulators at the ends of the loading sections.

The antenna system was constructed in accordance with the above values. The design was based on 50 lbs./sq.ft. on flats for wind loading and the tower is constructed from 30 foot welded sections. In view of the voltages anticipated from the operation of two 50 KW transmitters (the peak voltages add arithmetically) three exceptionally large guy insulators were used at the ends of the guy sections used for top loading. The remaining insulators were spaced in an attempt to minimize guy currents and equalize insulator voltages. Considering that the antenna was to be used for two separate transmitters with the increased complexity in the networks for matching, isolation, and sectionalizing, it was felt advisable to have an auxiliary antenna with its own networks. For this use, a bottom segment of one of the top guys cables was made 200 feet in length with the top end terminated in large insulators and a corona ring. Although only the lower power auxiliary transmitters would be used on this antenna, the peak voltage at the upper end calculated to be well over 100 KV. All guys were fabricated from one inch diameter Alumoweld cables. Each strand in the cable is of steel with a thick aluminum covering providing good conductivity for the current carrying portions.

The tower being sectionalized and top loaded has a higher loop current than would be found in an equivalent unloaded antenna. Because of this higher loop current, conduction losses in the steel tower might have become significant. As a precaution, we obtained the cooperation of the tower fabricator in the control of the galvanizing process and obtained a galvanized coat thicker than normal.

An efficient ground system was designed and installed, starting with a conventional expanded copper mesh ground screen about 40 feet square around the tower base. From this screen 120 radials of one inch wide buried copper ribbon were extended approximately one fourth wave length to the island shore line. Further extension of the radials was by #2-0 stranded copper cable to a point where at least 50 feet was immersed in salt water. The ends were anchored by securing to concrete blocks.

At this stage, base impedance and tower current distribution measurements were made, on one frequency at a time, using various amounts of a temporary simple coil for the 660 kc/s reactance at the sectionalizing point, and a short circuit or capacitor for 880 kc/s. Field intensity measurements were next made to determine the antenna performance as well as to exactly confirm the optimum value of sectionalizing reactance for each frequency. This work was performed with the advantage of daylight while the two stations were still in operation at the old locations, by permission from the FCC to use a test power of 50 watts on the frequencies of 640, 680, 860 and 900 kc/s. Advantage was taken of the water of Long Island Sound bordering on the station to use a boat in making radial measurements in several directions. This method was faster and produced more consistent data than could be obtained on land with short radials in the built up city area. The boat was run on a radial starting from and ending with a fix. Speed was maintained as near constant as possible, with the start, finish, and measurement times recorded. An example of these measurements is shown on Figure 2. From these, as well as measurements on land, it was confirmed that the antenna would meet the required radiation efficiency. The sectionalizing reactances required, were determined at 180 ohms inductive for 660 kc/s and 50 ohms capacitive for 880 kc/s. The tower current distribution placed the minimum at about 23 degrees above the ground. The widely differing reactances were due to insufficient height for the low frequency, while at the high frequency the antenna with the top loading, was somewhat too high.

It was now necessary to consider a design for the permanent sectionalizing reactance. This component is of particular interest because of the two-frequency requirements and the necessity to avoid large losses. Several networks had been considered which would supply the separately required reactances. With the precise values now in hand the networks shown in Figure 3 were re-examined. #1 is the simplest, however, calculations indicated that the coil current would exceed 400 amperes and the loss at 660 kc/s would be about 6 KW. The reactance slope, or variation against frequency in the band ± 10 KC would also be excessive. The base impedance of a loaded antenna varies more rapidly with frequency than that of a simple antenna. Using a sectionalizing reactance such as is necessary for two frequencies causes a still steeper base impedance variation and results in concern for the proper loading and low distortion operation of the transmitter. These characteristics were sufficient to reject #1 network. The other three networks, by proper choice of values can all be made to exhibit nearly equal and acceptable amounts of loss and reactance slopes. #2 however, develops a peak voltage well over 100 KV across the capacitor, and #3 an effective current of 200 amperes in L_1. Voltages were computed for full modulation and the current for no modulation condition. These characteristics do not make for easy design, and in addition these two circuits would be critical to adjust, especially if it became necessary to do so after installation high up in the tower. #4 network provided a very happy compromise. The voltages and currents are not uncomfortable for design purposes and the adjustments, even after installation, can be made straight forward. At this point it should be explained that the provision for getting a power circuit past the tower sectionalizing to supply the top beacon had already been made. Previous measurements had shown that running power circuits up through the tubing of a sectionalizing coil and the consequent short circuiting of unused turns for adjustment, would reduce appreciably the effective Q of the coil. Therefore an insulating transformer such as is commonly used at the tower base was installed at the sectionalizing level to supply the top beacon. The operation of #4 network can best be seen in Figure 4. L_1 C_1 is made anti-resonant at 660 kc/s so that for practical purposes, all the sectionalizing current at that frequency flows in L_3. Thus with L_3 alone connected, it may be adjusted to the proper value by reference to the antenna base impedance determined during the tests. With the other leg of the network added, and an approximate value of L_2 in use, L_1 C_1 may then be adjusted for the same base impedance as obtained before. The frequency may then be changed to 880 kc/s and L_2 adjusted for the base impedance determined for that frequency.

Figure 5 shows the way in which the network was installed in the tower. A 5 foot open face section above the sectionalizing insulator made room for a shield cabinet containing L_3 and a 10 foot space below the insulator was provided for a double compartment cabinet for L_1 C_1 and L_2. As there is very little circulating current between the two legs of the network they are individually connected between the tower sections. The shield cabinets are constructed of one eighth inch thick aluminum with welded seams and ventillating louvres with baffles to minimize rain entrance. The doors have special RF bonding and weather strips. The coils for the network were specified so that there would be a minimum of unused turns and as good a Q factor as feasible. Before installing the coils in the cabinets the Q's were carefully measured by plotting resonance curves for each frequency. Q's between 900 and 1000 were found. When the coils were installed in the shield cabinets the Q's dropped to about 600. On the basis of a 600 Q the network loss computed at about 1500 watts for each frequency. The capacitors for C_1 are multiple vacuum units, three of which are variable. They are rated at 60 KV. The network provides a DC path for static drain and a ball gap across the sectionalizing insulator supplies protection to the network from lightning. The single sectionalizing insulator minimizes stray capacity between tower sections. It is equipped with a rain shield and was especially designed to tolerate a small amount of rocking, which can occur during high winds.

The pictures Figures 6 and 7, show L_3 mounted in the upper cabinet, and L_1, C_1, L_2 mounted in the lower cabinet. The cabinets were painted with Day Glo, the same as the two top orange sections of the tower. This paint, having florescent characteristics, provides increased visibility during daylight.

Figure 8 illustrates the effect on the antenna base resistance of using a two frequency sectionalizing reactance network instead of a simple coil as would be used in the case of the antenna being built for one station. The base resistance around 660 kc/s was measured using only the coil L_3 at the section and again when the entire network was connected. There is an increase in slope of about 1.3 over a 20 KC band when the complete network is connected. It may be noticed that the two plots cross at the carrier frequency.

Figure 9 illustrates the measured current distribution on the tower at 640 kc/s. The complete curve was obtained with a sectionalizing reactance of zero and indicates only the tower current. That is, the current in the guy loading and the effect of it is not shown. The partial curves show the locations of the current minimum for sectionalizing reactance values of j140 and j190 ohms.

Although some trouble was experienced initially with inadequate electrical bonding at the cabinet door edges, there has been no difficulty to date with the sectionalizing network proper. The antenna system as a whole is performing satisfactorily.

During the early stages of the project, we became aware of many serious problems relating to the design of the isolating and coupling networks. The general performance criteria we originally had in mind were not reducible to specific performance standards until several network designs had been studied in detail.

General problems relating to network losses were of particular concern in this instance because the circuitry required to provide the unusually high isolation necessary between these transmitters could very easily result in excessive losses. A second important factor relating to circuit performance dealt with the problem of maintaining reasonably constant load impedance over the bandwidth being transmitted. In normal installations, this requirement does not impose any special design requirements, but under some circumstances, the impedance bandwidth problem may become controlling in network design. A further requirement was that the coupling and isolating network for each station be capable of being disconnected from the antenna system in the event of failure in one network so that the other station could continue operation in normal fashion and that the station in trouble would be able to work in perfect safety on the network which had suffered a failure.

Past experience has established that a transmitter using a Class "C" final amplifier and having stray R.F. energy in its tank circuit will generate cross modulation products as though the amplifier behaved as a mixer with 25-30 db loss. If these spurious emissions fall on or near frequencies that are used by other services, it has been found that these spurious emissions in 50 kw plants must be kept at least 120 db below the level of the fundamental. Both the sum and difference frequencies were in use within 100 miles of the transmitting site; therefore, these first order effects had to be effectively removed. The net isolation required was such that attenuations in the order of 100 db at carrier frequency had to be obtained and, consequently, all networks had to be enclosed in well-shielded cabinets.

These problems in terms of defining the performance of the coupling and isolating networks indicated to us that a reasonably complete design of the networks would be necessary before specifications for the network could be written; consequently, we designed these networks ourselves.

Base impedance data from the model measurement work indicated that there could be impedance bandwidth problems. These data from the model work indicated that the antenna impedance would be significantly worse than that specified in EIA Standard TR-101-A for normal load impedance and that actual tests on transmitter performance should be made. An analysis of Class "C" amplifier performance indicates that the optimum load impedance as a function of bandwidth should be the equivalent of a dissipative parallel resonant circuit. Both NBC and CBS arranged for tests to determine transmitter performance into the then expected load impedance. These tests indicated that both the RCA BTA-50H and the G.E. BT-50-A transmitters would meet frequency response and distortion specifications with the expected load impedance if that impedance characteristic was properly oriented. The foregoing transmitter performance experiments also verified the fact that impedance bandwidth characteristics of other natures would not provide the same overall performance.

If the load impedance would be made reasonably constant over a frequency range significantly in excess of the bandwidth to be transmitted, transmitter performance could be further improved and overall operation significantly stabilized. These performance measurements indicated that serious consideration should be given to antenna coupling circuit design which would provide broad band impedance control in the same fashion as that provided by compensation used in television antennas.

The actual antenna impedance, as a function of frequency, was determined around both operating frequencies during the antenna tuning process. These data indicated that the impedance bandwidth problem was worse than that anticipated from the model measurements; a graph of these data is presented on Figure 10. Since suitable performance of the system was directly related to the proper matching of this impedance characteristic to the transmitter, considerable effort was devoted to the optimizing of these matching networks.

Consider for the moment a simple antenna whose resistance is constant and whose reactance varies as a series resonant L-C circuit. The terminal admittance and equivalent circuit of this antenna is shown in Figure 11 a, b. Suppose now, we put a reactive network across these input terminals, (Figure 11 b) and try to improve the admittance match thereby. Assume that the network in parallel with the antenna is a parallel L-C network resonant to the carrier frequency. The effect at frequency f_1, a lower side band frequency, will be that of transforming the admittance from the original value to a new value, along a constant conductance path as shown on the Smith chart of Figure 11 a. Similarly, the admittance at carrier frequency is not changed; and the admittance at f_2, an upper side band frequency, is also improved. It may be seen that for moderate impedance bandwidth problems a significant improvement can be made by proper choice of the L-C ratio of the compensating network. It may also be seen that for impedance mismatches that are sufficiently severe such as that for f_3 on Figure 11 a, that the reactive compensation network no longer offers a significant improvement. Our impedance bandwidth problem was severe enough to warrant a study of more effective methods of compensation.

Previous experiments had indicated that compensating networks using a dissipative element were capable of providing better overall driving point impedance characteristics. The circuit of Figure 11 c is such a network. This compensating circuit will add both susceptance and conductance to the antenna admittance as shown by the transformation of the f_4 admittance on the Smith chart of Figure 11 a. A brief analysis of this type of network indicated that it provided two principal functions: (1) that of absorbing the energy reflected by the admittance mismatch at the side band frequencies and (2) that of providing relatively broad band constant load impedance for the transmitter. Since both of these conditions fit the required performance objective, dissipative compensating networks were considered to provide satisfactory system performance.

The foregoing detailed circuit requirements were applied to the design of suitable isolating and coupling networks, Figure 12 shows the final networks. Since the base impedance was capacitive at both frequencies, a common antenna loading coil L_a performed a common tuning function and reduced the undesired voltages across both the isolating networks. The remainder of the circuit in Figure 12 may be described as follows: The first network at the antenna end of the circuit is an L or a T network for matching the antenna impedance to the transmission line; some of the circuit elements in these networks are rejection traps tuned to the undesired frequency. The T network at the transmission line end is a phase shift network to properly orient the load impedance to the optimum position at the plates of the final Class "C" amplifier. Calculations indicated that two traps would provide adequate isolation and, therefore, the third element could be used for other purposes.

A very low L-C ratio parallel resonant circuit connected in shunt to ground will provide an excellent filter to limit the generation and radiation of spurious frequencies. Calculations established that the antenna impedance could be properly transformed by the first series arm of the WCBS T network so that this shunt L-C network could also act as a reactive compensating network as previously described. These two functions, compensation and filtering, are performed by the shunt network in the WCBS circuit. (It was not practical to incorporate this feature in the WNBC side of the network.) A limited amount of compensation was provided for WCBS by this method. Further compensation of either the dissipative or non-dissipative type can be added, if needed, at this same point. On the WNBC side, the first T network was required to properly orient the impedance characteristic for compensation, and provision was made for compensation at the end of that network. Figure 13 is a photograph of the WCBS network; note particularly that L_{13} could not readily be made with half the present inductance and twice the diameter of the tubing as would be required for a significant increase in bandwidth impedance compensation. Figure 14 is a photograph of the network feeding the auxiliary antenna; this network provides only isolation and matching at the carrier frequency; no provisions were made here for broad band compensation or proper orientation of the load impedance.

An important consideration was that of obtaining maximum Q in the decoupling networks; properly designed coils for operation at this power level will produce Q's in the 500-1000 range. In a tuned circuit utilizing a coil and condenser in either series or parallel, it is important that the circuit connections also be made to provide minimum loss. No turns may be shorted in the coil; and the circuit should occupy the minimum physical space. Conductor sizes must be adequate for the current to be carried, a value of 20 amperes unmodulated carrier for each inch of circumference was used. Care was taken to make equivalent paths for each condenser, when units were used in parallel. Most of the resonant circuits in the decoupling networks were designed to operate at or near full design inductance. Detailed measurements of Q of these circuits have not been made, but those that were made of the antenna sectionalizing network suggest that Q's in excess of 600 were obtained in actual operation of these networks.

Stringent performance specifications were established for all characteristics of the plant. We believe that these performance criteria have been adequately met.

The transmitting site is almost completely surrounded by the New York urban area. It was not possible to find directions with relatively unobstructed sites for the making of the field strength proof. Therefore, the radials were chosen near the nominal cardinal directions 0°, 45°, 90°, 135°, etc. Minor variations of these bearings were made to fit available water navigation paths, parkways or other roads which would provide somewhat improved measuring locations. Four field crews were used each consisting of a driver and engineer. Each crew measured field strength of both stations at each location with careful calibration of the field set for each measurement at each location. Final analysis of these data indicated reasonably uniform radiations in all eight directions on both frequencies and yielding a radiation efficiency of 244 mv/m per kw at 660 kc/s and 256 mv/m per kw at 880 kc/s. These radiation efficiencies are both significantly above the required 225 mv/m per kw. The current minimum on both frequencies had been drawn up to a height sufficient to significantly control fading. As the current minimum is raised on the tower, the magnitude of the current at the loop increases and consequently, losses increase. The resultant radiation efficiencies demonstrate that the construction techniques used have kept the antenna losses to a minimum.

Since the coupling and isolating networks were designed with due consideration to the bandwidth problem, calculations and data were readily available for the values of various elements at side frequencies as well as at carrier frequency. The High Island plant is only a few miles from both old WNBC and WCBS transmitting plants; both stations operate 24 hours a day.

Difficulty was encountered in tuning these networks on the actual operating frequency. Considerable success was obtained in the tuning of these networks for side band frequencies with final trim up on carrier frequency. Figure 15 indicates the approximate normalized impedance characteristic as observed at the final amplifier plates in the WCBS transmitter. A similar impedance frequency characteristic was obtained for WNBC. Since the impedance bandwidth problem is significantly worse at 660 kc/s, a dissipative compensating network along the lines previously described has been built for WNBC's use and is currently under test. Figure 16 indicates the improvement in impedance characteristic available by this procedure; these measurements were taken at the transmitter output terminals, the impedance there should be similar to a series resonant circuit at that point.

The isolation networks were designed with the intention of reducing spurious signals to an absolute minimum. The approximate difference frequency, 219 kc/s, is used by a low power radio beacon at Teterboro Airport some 15 miles from the transmitter plant. The sum frequency, 1540 kc/s, is used in Philadelphia, Pennsylvania. The two spurious signals, 220 kc/s and 1540 kc/s, which could interfere with these services, are the highest order cross modulation products generated. The success of the installed filters in preventing cross modulation can best be guaged by the fact that both the 219 kc/s and the 1540 kc/s signals can be received with no noticeable interference from the WNBC and WCBS signals, within a quarter mile of the High Island transmitter. As a further demonstration of the isolation between the two transmitters, I asked our operating staff to connect a 500 ohm one tenth watt resistor between plate and ground of the final amplifier of the WCBS transmitter and have WNBC operate with 50 kw. I have that resistor with me; and as you can see, it shows no ill effects from that test. If that resistor had dissipated its rated power under the foregoing test, the isolation would have been 57 db. It may be of interest to note here that during tune up of the antenna system as much as 80 watts of the WCBS Columbia Island signal could be obtained in the High Island antenna system, this represents a natural decoupling of about 28 db between sites spaced 1.75 miles. The original 4 mile spacing between WNBC and WCBS resulted in an isolation of only approximately 35 db. It may thus be seen that significantly better isolation between transmitters has been achieved in the joint plant than existed when the plants were separated.

I am sure that you all realize that a project of this magnitude that has extended over several years has required the cooperation and the diligent efforts of many people in both organizations. Specific credit to all of them would take more time than is warranted, but there are two that I want to especially point out at this time. Mr. William Duttera, our Session Coordinator, who was responsible for the original idea, and continued to participate in the project; and Mr. John Seibert of NBC spent many months following the details of the joint construction as well as the details within the WNBC portion of the plant.

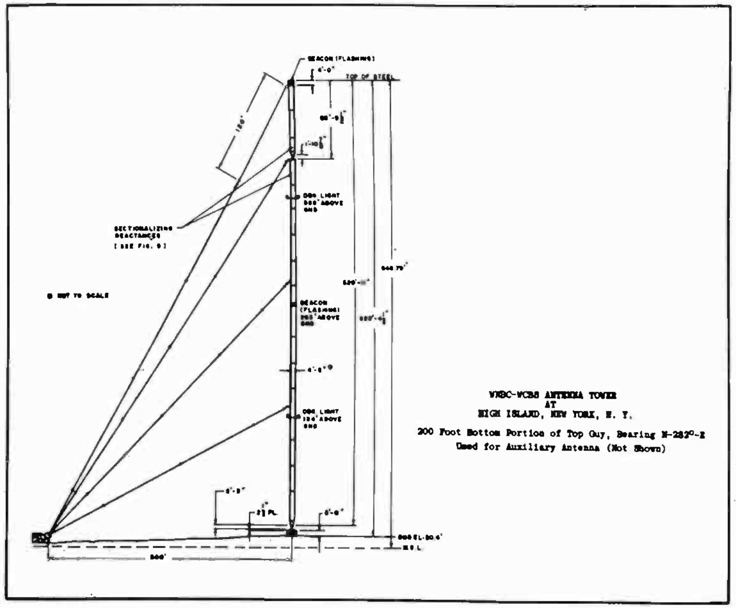


FIGURE 1

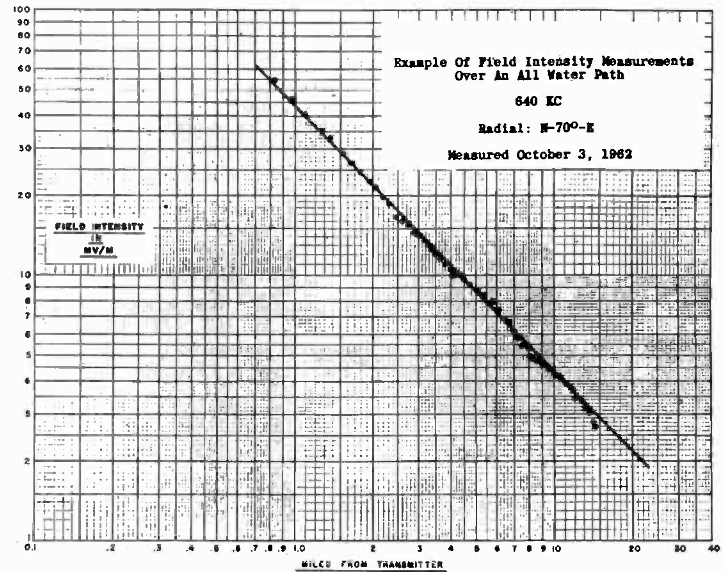


FIGURE 2

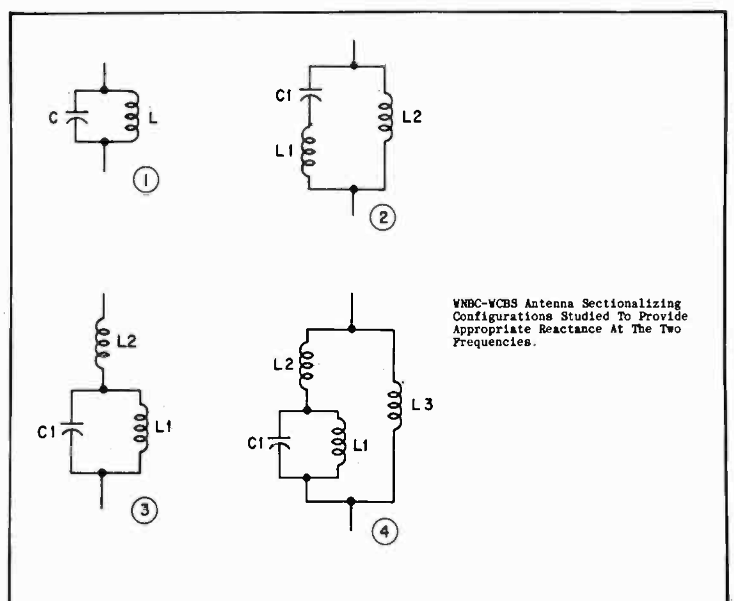


FIGURE 3

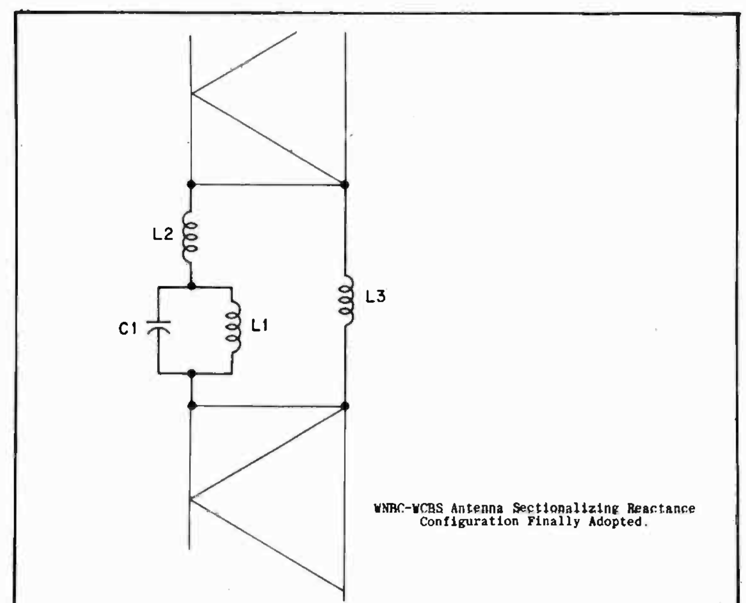


FIGURE 4

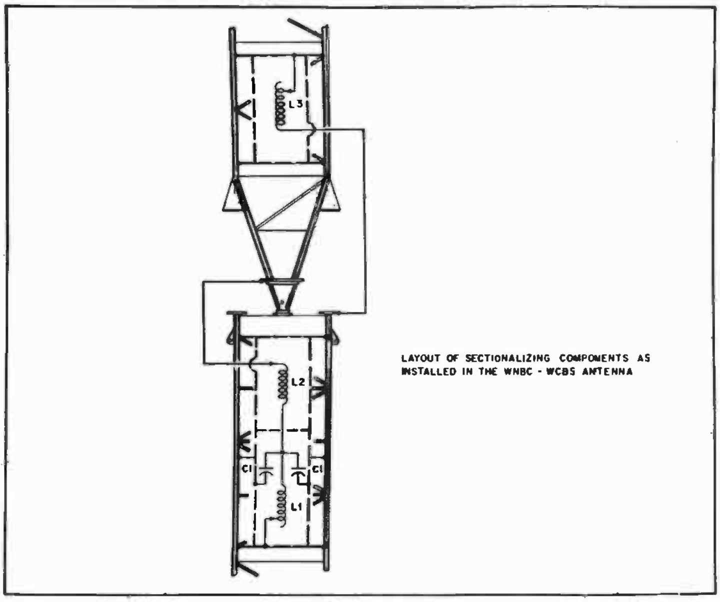


FIGURE 5

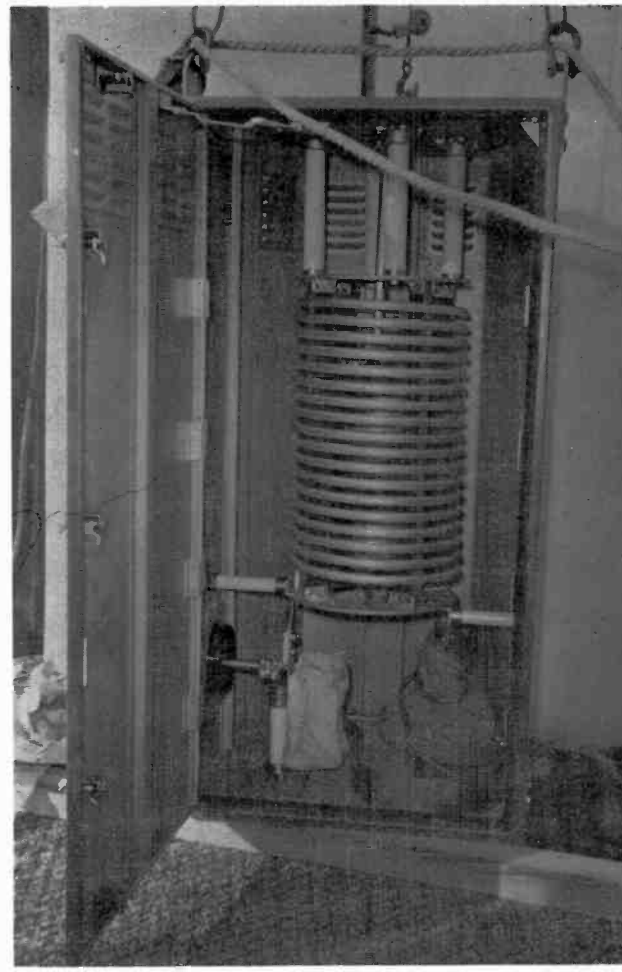


FIGURE 6

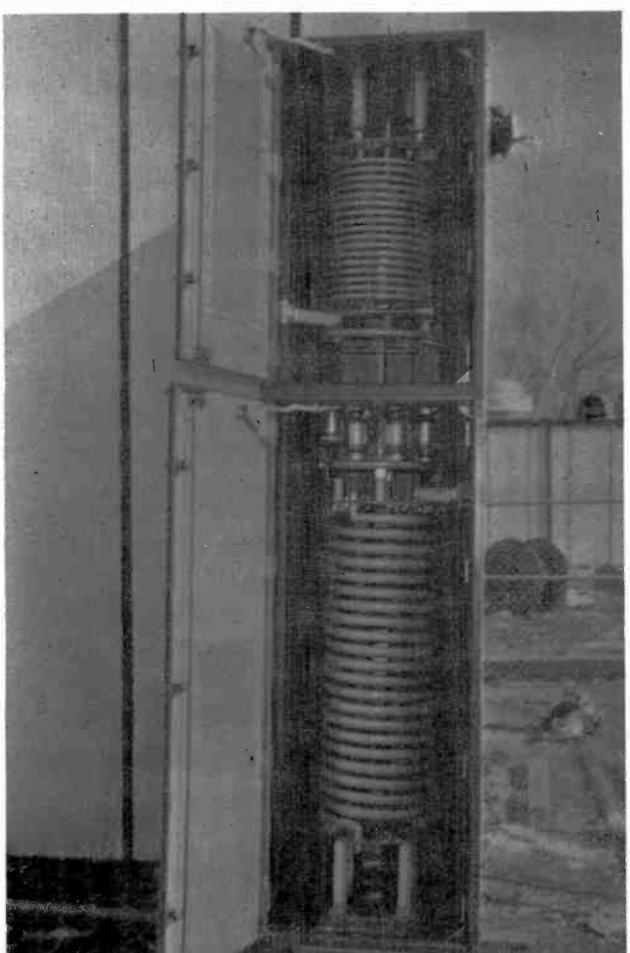


FIGURE 7

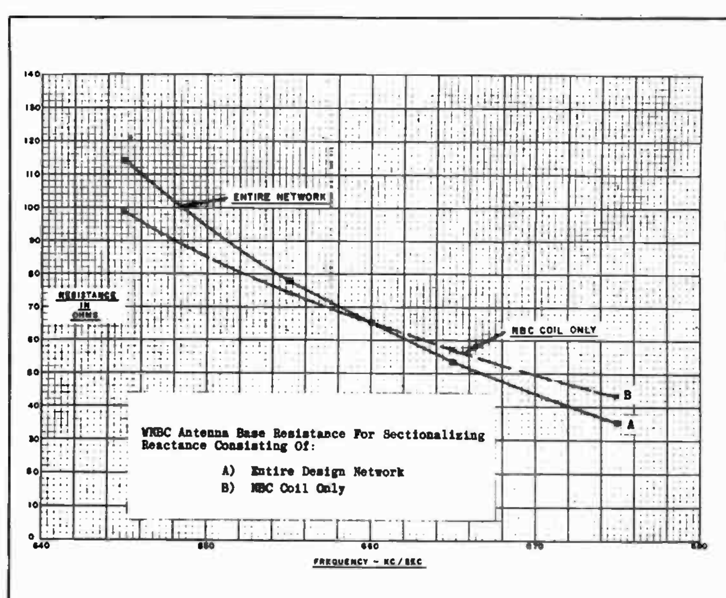


FIGURE 8

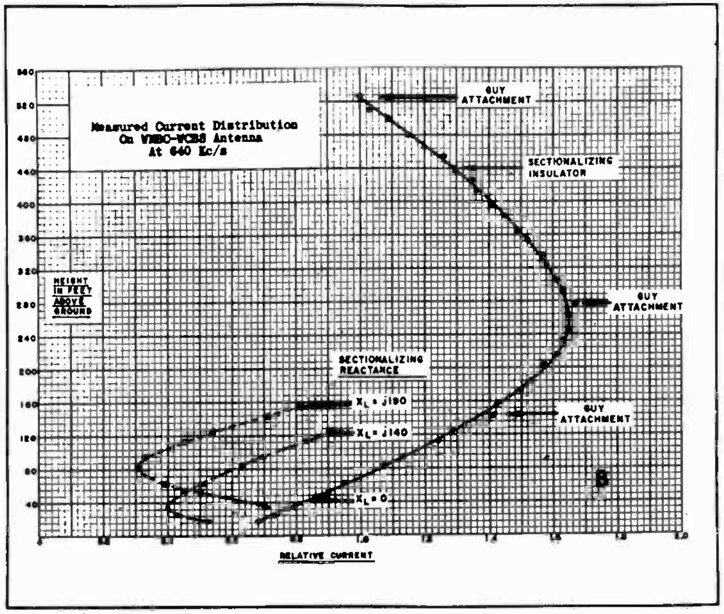


FIGURE 9

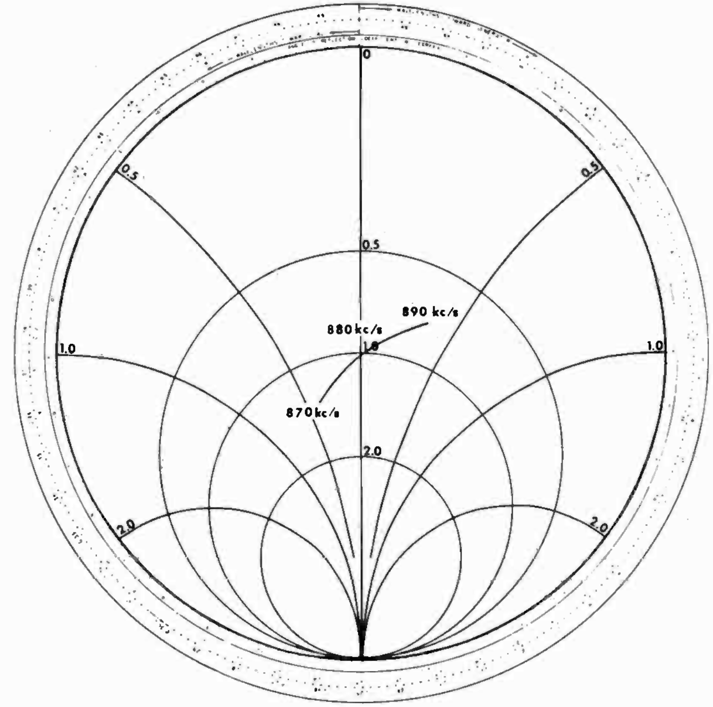


FIGURE 10

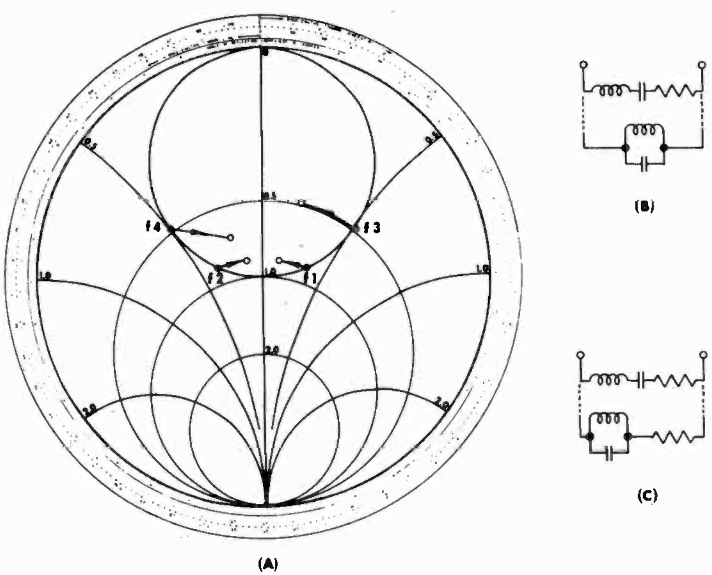
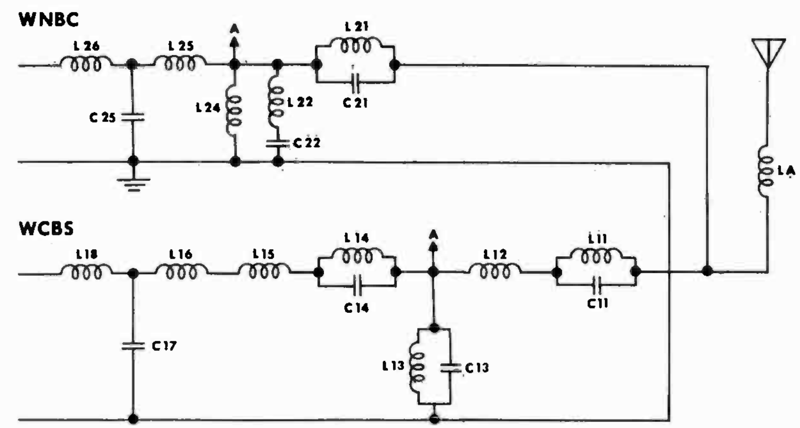


FIGURE 11



COUPLING AND ISOLATING NETWORKS

FIGURE 12

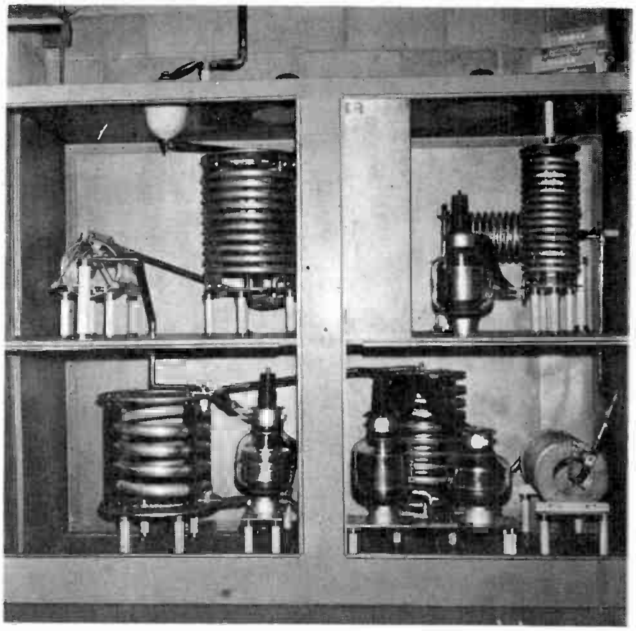


FIGURE 13

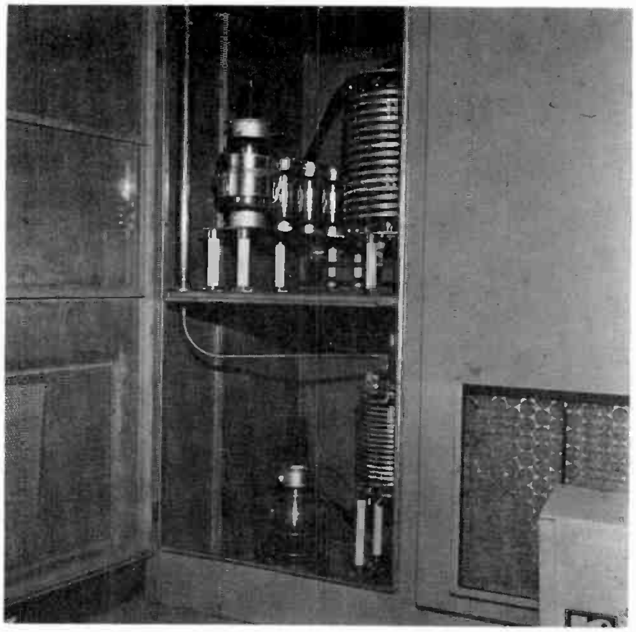


FIGURE 14

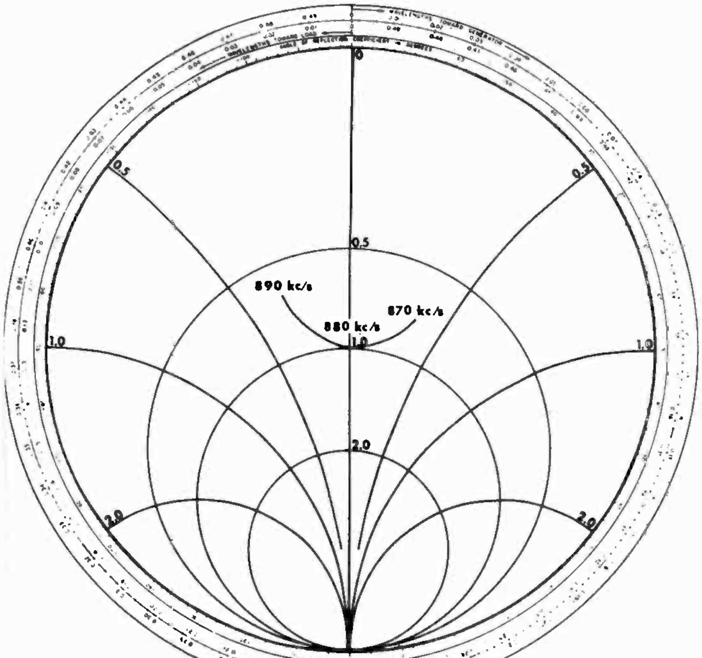


FIGURE 15

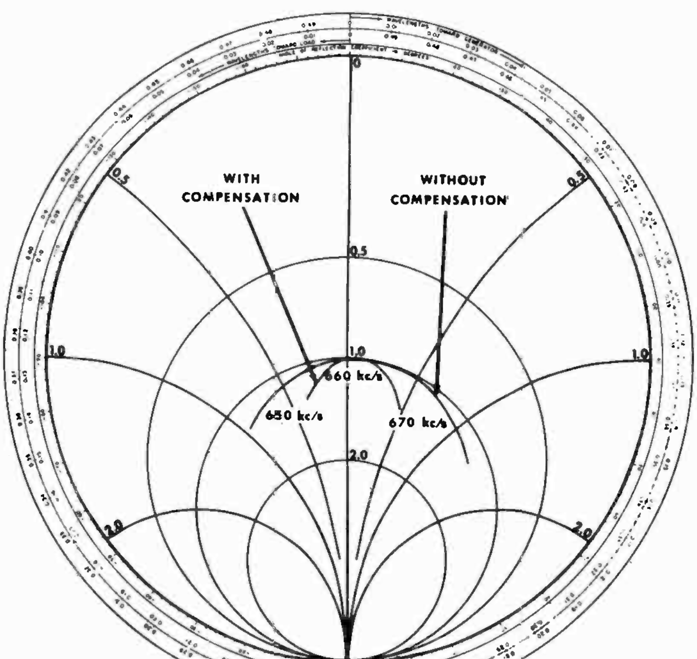


FIGURE 16

HOW TO MAKE AN FM STEREO PROOF OF PERFORMANCE

Prepared by

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and
Charles E. Dixon

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Cedar Rapids, Iowa

HOW TO MAKE AN FM STEREO
PROOF OF PERFORMANCE

Stereo broadcasters are faced with the need to make a proof of performance in order to verify that their equipment is performing at its maximum capabilities. Stereo multiplexing is a more complicated process than unichannel broadcasting. Thus, stereo multiplexing requires additional and more accurate measurements along with more specialized equipment and procedures than those required with monaural broadcasting.

Measurements of percent modulation, frequency response, distortion, and signal-to-noise measurements are no longer adequate for the stereo broadcaster. Since stereo multiplexing involves the transmission of two channels of information, the interaction between these channels is of prime importance. The stereo multiplex frequency spectrum is as shown in figure 1.

The stereo signal consists of a main channel (L + R) signal with a bandwidth of 50 cps to 15 kc, a 19-kc pilot carrier and a subchannel (L - R) double-sideband suppressed carrier with a bandwidth of 23 kc to 53 kc. If SCA is present, it would appear as an FM signal centered about a 67-kc carrier.

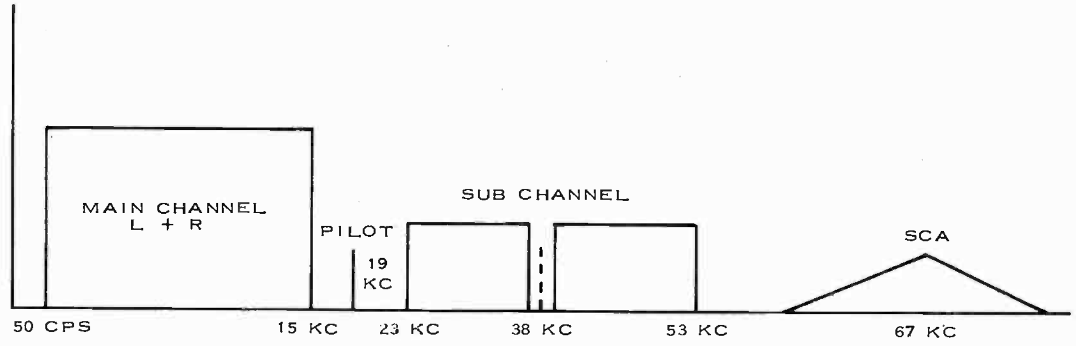

Figure 1. Stereo Multiplex and SCA Frequency Spectrum

To preserve the channel separation between the main and subchannels, the gain and phase shift between these channels must be maintained within a close tolerance through the equipment in which they pass. As an example, for approximately 30 db of channel separation the main channel (L + R) and subchannel (L - R) DSB/SC signals must have amplitudes within ±0.3 db of each other, and the zero crossings of the envelope of the DSB/SC L - R signal and the L + R signal must occur within ±3°. Thus, besides measuring the percent modulation, frequency response, distortion, and both AM and FM noise the stereo broadcaster must also measure pilot carrier phasing and injection level, subcarrier suppression, channel separation, and crosstalk.

The equipment needed for a stereo proof of performance is a low-distortion audio oscillator, audio vtvm, distortion and noise meter, and an FM stereo modulation monitor.

The stereo modulation monitor should have at least the following capabilities:

(1) It should read total, main channel, subchannel, and 19-kc pilot carrier percent modulation.

(2) It should read channel separation, subcarrier suppression, crosstalk, pilot carrier phasing, and noise.

(3) It also should provide outputs for distortion and AM noise measurements.

The modulation percentage metering circuit should be a peak reading device in order to give a true indication of the maximum instantaneous peak voltage which would exist in a complex signal composed of frequencies from 50 cps to 53 kc, the stereo multiplex bandwidth. An average reading circuit with a peak scale will not give a true maximum instantaneous peak reading for complex signals. An average circuit would work on a pure sine wave but there are no stations that broadcast only sine waves. Thus, a true peak reading modulation meter would simplify matters considerably for the monaural broadcaster as well as the stereo broadcaster.

This paper is written around the Collins 900C-1 FM Stereo Modulation Monitor. Measurements made with other equipment should be similar but may involve additional external equipment to the modulation monitor.

Existing monaural FM modulation monitors are unsuitable for stereo multiplexing monitoring because of their limited bandwidth, frequency response, and phase linearity characteristics.

All measurements for the proof of performance should be made with the system adjusted for normal program levels. The system should include all circuits between the main studio mike input and the antenna output. This includes any telephone lines, pre-emphasis circuits, and equalizers except for microphone equalizers. If compression equipment is used in the system, it should be disabled during the proof of performance. If an SCA channel operation exists, noise and distortion measurements should be made with SCA modulation on.

In order to run a stereo proof of performance, certain test signals will be required. These test signals will be a right, left, a L = +R, and a L = -R. The waveforms of these signals as they would appear at the wideband output of the monitor with pilot carrier off, are shown in figure 2. It should be noted that a good indication for channel separation is the relative flatness of the base line for the L or R stereo signal. The most convenient way of generating the test signals required for a stereo proof of performance is to have a matrix network as shown in figure 3.

Figure 4 shows a test setup for a typical stereo multiplex station for a proof of performance.

The frequency response of the system should be measured in both the monaural and stereo modes of operation with pre-emphasis in the system and without de-emphasis in the measuring equipment. The monaural frequency response is run as usual with first a right and then a left test signal for frequencies from 50 cps to 15 kc, noting the output of the signal generator with the percent modulation constant. The stereo response is run much in the same way as the monaural mode response except that now the main channel and the subchannel response must be checked.

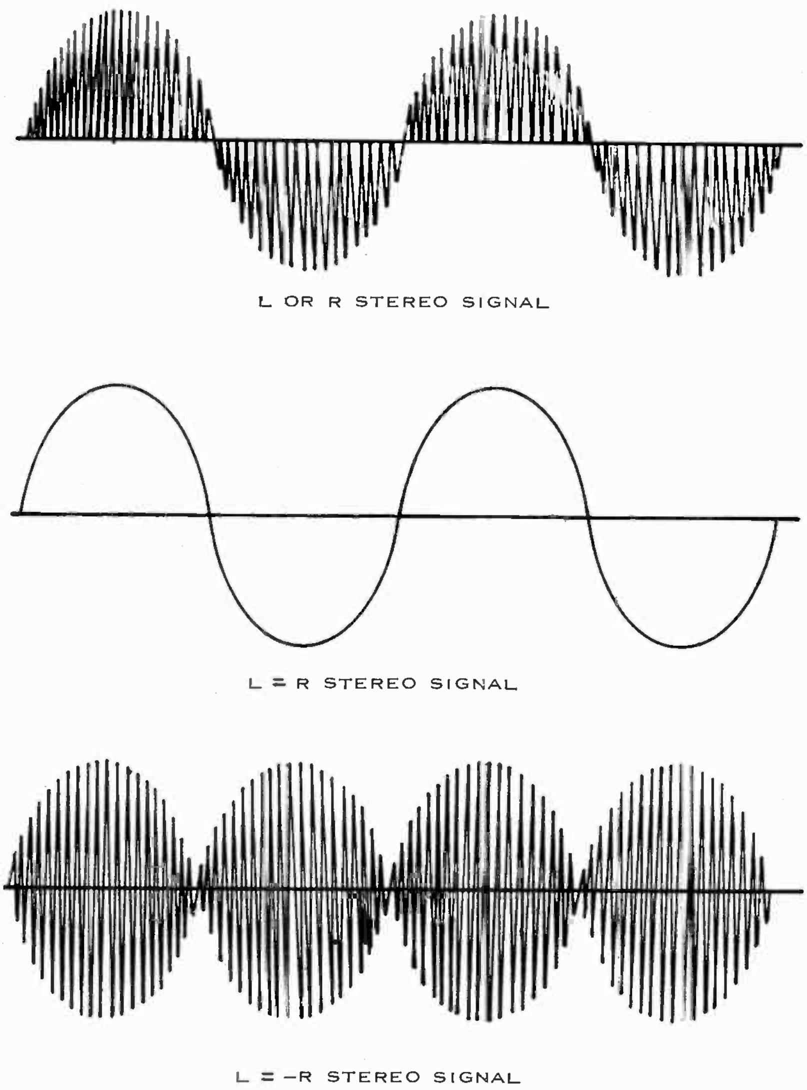

Figure 2. L/R, L = R, L = -R Stereo Signals as Observed at the Wideband Output of the Modulation Monitor with Pilot Carrier Off

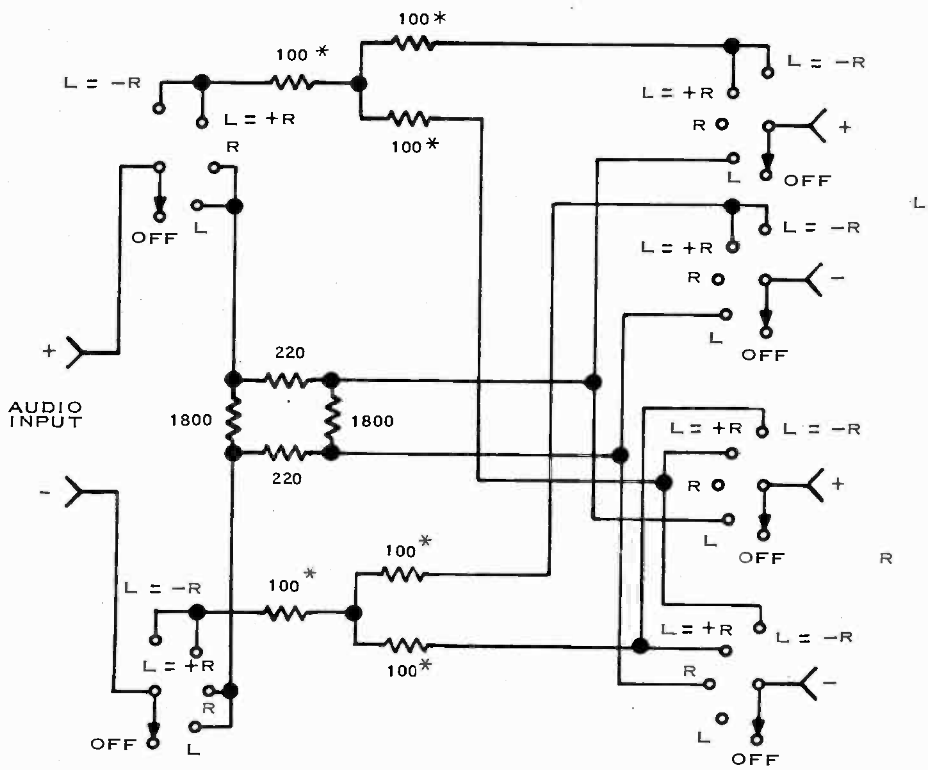

Figure 3. Stereo Test Matrix

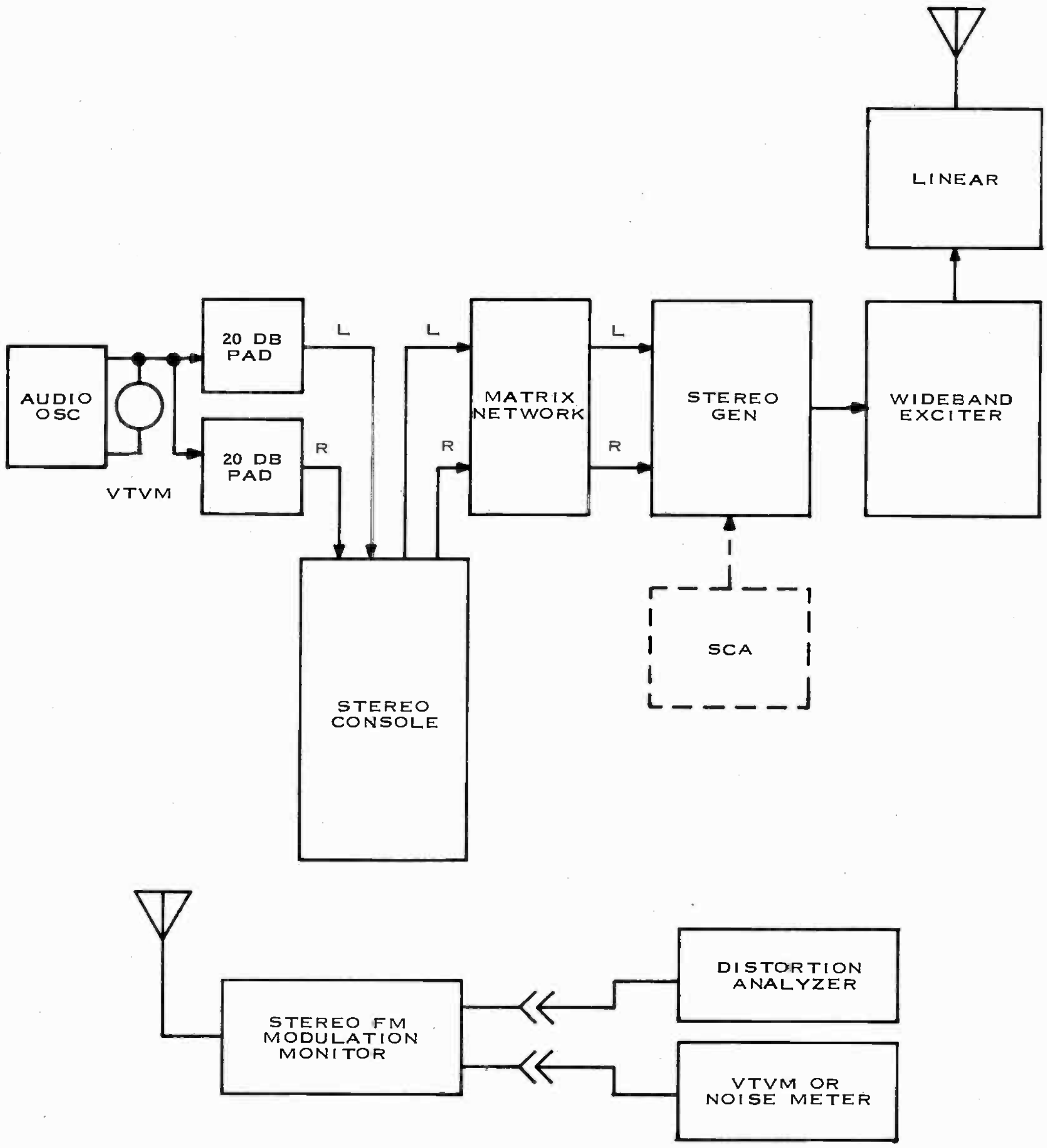

Figure 4. Typical Stereo System and Test Setup

To check the main channel response, a L + R signal is transmitted for frequencies from 50 cps to 15 kc, noting the signal generator output with a constant percentage of modulation. The subchannel response is measured by transmitting a L - R signal from 50 cps to 15 kc, noting the signal generator output with a constant percentage of modulation.

The deviation of the system response should be between the standard pre-emphasis curve and the lower limit as shown in figure 5.

The harmonic distortion of the system may be measured by connecting a distortion analyzer to the distortion meter output on the stereo monitor. De-emphasis should be in when the distortion is measured for both the monaural and stereo modes of operation. Main channel audio harmonic distortion is measured for the monaural mode; distortion for the left and right audio channels is measured for the stereo mode. These distortion measurements should be made for frequencies from 50 cps to 15 kc at the standard percent modulation levels. This is done by switching the monitor to main channel, left audio, and right audio.

The system output noise must be measured for monaural and stereo operations. This is done by transmitting a 100-percent modulation level left signal in the monaural mode with de-emphasis, setting a main channel audio reference level of 0 db on the internal audio voltmeter, and replacing the audio input lines to the console with a good quality resistor matching the input impedance of the console. The sensitivity of the internal audio voltmeter is increased to obtain a reading in decibels on the meter. This is added to that indicated by the meter sensitivity switch for the monaural signal-to-noise ratio in decibels. The right audio channel also should be checked for noise in the same manner. With the system transmitting in the stereo mode, the preceding should be repeated for the left and right audio channels. The 100-percent modulation level in the stereo mode of operation includes the pilot carrier modulation as well as the audio information. The noise levels should be at least 60 db below the 100-percent level for frequencies from 50 cps to 15 kc.

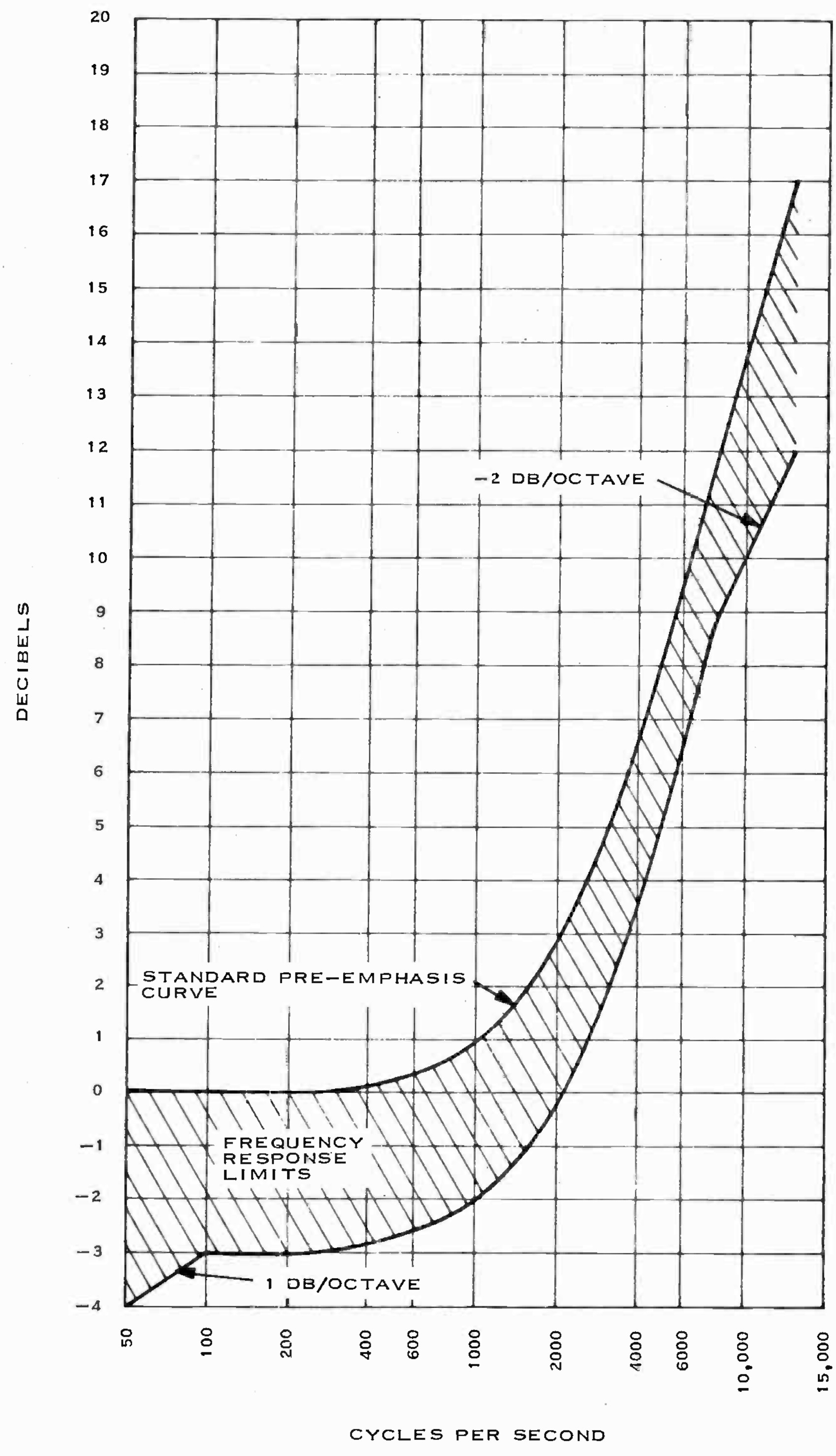

Figure 5. Standard Pre-Emphasis Curve and Frequency Response Limits

The AM output noise may be measured by shunting the resistor across the console input with a piece of bus wire. The r-f carrier level is adjusted on the monitor to read 100 percent; the AM noise level then may be measured at the AM noise meter output on the monitor with a vtvm or noise meter. The AM noise is referenced to a carrier level of 1 v rms.

For the 38-kc suppressed subcarrier suppression measurement, modulation, pilot carrier, and SCA signal should be off. A L = +R 90-percent modulation level signal is transmitted and a 0-db reference is set up on the internal audio voltmeter with the monitor in the main channel audio position. The L = +R signal is removed and the monitor then is switched to the sub-channel audio position. The sensitivity of the internal audio voltmeter is increased until a meter indication is obtained. The algebraic sum of the meter indication and the audio voltmeter sensitivity switch is the subcarrier suppression in decibels.

For a stereo demodulator to give proper channel separation, the 19-kc pilot carrier must have the proper phase relationship with the envelope of the double-sideband suppressed carrier subchannel. Thus, the pilot carrier must be adjusted on the stereo generator so that the monitor indicates that it is properly phased. Once the 19-kc pilot carrier has been properly adjusted the channel separation may be measured.

With the audio oscillator reconnected to the console a 90-percent L-signal and a 10-percent pilot carrier are transmitted. The monitor then is switched to left audio position and a 0-db reference is set up on the internal audio voltmeter. The left signal is removed and a right is applied; the sensitivity of the voltmeter is increased until a reading is obtained. The channel separation of the right channel information from the left channel is the algebraic sum of the meter reading in decibels and the sensitivity switch indication.

The channel separation of the left channel information from the right channel is performed in a similar manner except that a reference level is obtained with a right signal applied to the system. The right audio is removed, a left audio signal then is applied and the channel separation of left channel information from the right channel is determined.

A minimum of 30 db channel separation should be obtained for modulating frequencies from 50 cps to 15 kc.

In making crosstalk measurements from main channel to subchannel and subchannel to main channel the pilot carrier and SCA signals should be off.

For subchannel crosstalk from the main channel information, transmit a 90-percent modulation level main channel signal, L = +R. Switch to the main channel audio and set up a 0-db reference level on the internal audio voltmeter. Then switch to the subchannel audio and increase the sensitivity of the internal voltmeter until a reading is obtained. The algebraic sum of the meter reading and the meter sensitivity switch indication is the subchannel crosstalk from the main channel information.

For main channel crosstalk from the subchannel information, transmit a 90-percent modulation level subchannel signal, L = -R. Switch the monitor to main channel audio and increase the meter sensitivity until an indication is obtained. The crosstalk from the subchannel information to the main channel is the algebraic sum of the meter indication and the meter sensitivity switch.

The crosstalk from main channel to subchannel and subchannel to main channel should be at least 40 db down.

Since the main and subchannel information is composed of matrix signals, L + R and L - R respectively, the left and right inputs should be balanced. This balance must be better than one percent of each other at the input of the stereo generator for the L = +R and L = -R signals when making crosstalk measurements.

Good quality stereo broadcasting should result if all of the preceding measurements are taken and if the data fall within the established limits set forth in this paper.

AUTOMATIC PROGRAMMING AND LOGGING

Paper presented to the Engineering Conference at National Association of Broadcasters at the Conrad Hilton Hotel, Chicago, April 7, 1964

by

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Automatic Programming and Logging as a tool with proper flexibility can become a valuable aid to any radio station. To flexibility, add reliability and we can use key personnel more effectively to improve programming and reduce costs. Add one more factor, tools for management in other problem areas of broadcasting, and we now approach the problem as a whole.

In this discussion we will take a look at ways and means to improve the station sound, to expand many features and news, extend or improve late hour and week-end programming and provide better service to clients. With this approach we shall also analyze and present specific improvements in log preparation, the handling of traffic and availabilities, customer statements and affidavits, FCC reports, as well as accounting and sales analysis.

Some of these areas are of much greater importance to certain stations than others. The answers that are presented can be separated and adapted as required but any or all can be added in harmony.

The ever-present consideration of cost has a pleasant answer. For the savings in every area can more than pay dollars involved in a short time.

I. Now that we have outlined an overall approach to various station problems, let's analyze the specific programming and logging tools that are available today. The Continental system described will accommodate automatic programming and logging for over 24 hours on an unattended basis. It can also provide any combination of live and automatic operation with the benefits of management controls and automatic logging.

A. Since the problems and use of the tools vary widely with different types of stations, let us first consider the basic programming equipment and how it operates for the different requirements.

1. The basic concept of the PROLOG System is the use of the log to control program sources and incorporate accurate automatic logging. With most stations it is desirable to use all basic program material and commercials on tape to assure quality control and benefits of automatic operation. Phonograph records can be retained by personality format stations who can still benefit by many of the advantages of this system. First, let us consider the station which will be primarily operated from tape.

(a) Music requires flexibility for individuality and different moods throughout the day. PROLOG will achieve this flexibility by separation of the music into basic categories on 3 to 6 different transports. These are mixed in varying combinations automatically by coding and readout of the program log. Proper tones are provided for the switching at the end of any music selection.

Two direction professional tape transports had to be developed to provide for long periods of operation without reel changes. The Continental transports provide six hours each on 14-inch reels at 7½ speed with 1 mil tape and automatic reversing. They are 2-track mono or 4-track stereo. They are all transistorized with performance specifications and reliability equal to the finest professional tape equipment.

(b) Announcements of all types can be handled with Continental reel transports with automatic cuing. This allows 10½" tapes to be recorded on standard reel equipment with extra blank time after each item for ease in making changes.

(c) Cartridges in any combination of single and multiple carousel units can be combined for added flexibility. These are all transistorized plug-in units that are individually controlled from the log. The standard switching and cue tones on the second control track are used.

(d) For additional flexibility, most of your present reel or cartridge transports which are solonoid-operated can be controlled selectively as additional tape source machines.

2. Now that we have considered the tape source equipment, let us go to the 'control center' the PROLOG. We will first analyze its automatic operation, then the flexibility of any combination with live announcers.

To understand the Programmer, let's first examine the log. Here we put the station program log to work to control our programming. Exact air time in hours, minutes and seconds is printed on the log opposite each item. To provide continuous control, we are going to use a continuous fan-fold log form 11" wide that can be typed on a standard typewriter. To maintain alignment and spacing we add a pin feed platen and a block key for control symbol, available from all typewriter companies. The log form provides 13 columns on the right hand side. By the use of a code of 3 marks, we control up to 300 sources and control functions. These columns are headed by A, B, and C, plus 0 to 9. Two typewriter lines are used for codes. Here we have two variations of the system with the choice of either of two plug-in electronic modules.

The first is for the station that wants each commercial on an individual cartridge with random select up to 300. This is provided by a 3-digit code using one letter and two numbers. The second provides even more flexibility by using a combination of reel transports for announcements with last minute changes being covered by cartridges. The log schedules available commercial spots as well as all other items. A single mark in "A" column causes PROLOG to pass thru blank commercial times to next scheduled item. The space provides for immediate insertion of last minute commercials. The "B" column is used for a single mark to signal announcer one item in advance that he will be live. When item is finished a signal light flashes arming his mike. He controls the return to automatic with a switch on manual control panel. All logging is automatic. The capacity of the second version is 99 sources with a back-to-back capability of handling short 5 or 10 second items. A separate tape is used for each day of the week with easy changes provided with signal sensing. Override of music and announcements are possible with tones on second track.

The preparation of the log does not require any close timing so that even a high school girl with only a minimum of instruction can type this log. There are only a few basic requirements. Each fan-fold page of log becomes either a 15 minute or 30 minute segment of programming depending on the number of items. Second, the last item in each program segment (or page) is always a music selection. When preparing the log, a copy of the previous week's log for the same day is used as work copy thru the week with changes and additions written in during the week by traffic department. Estimates of 14 to 17 minutes for 15 minute segment are approximated by adding announcement times indicated to music. An estimate of 2½ minutes per music selection is close enough. The PROLOG will automatically adjust each segment to real time so that station ID's will be within 1½ minutes plus or minus to the quarter or half hour without fading. There is also provision for an accessory, The Exact Timer and Fader, which will control as many exact time starts in a 24-hour period as desired.

Here is a photograph of the complete PROLOG unit as a control console. There are 2 units, the one on the right, the Programmer; the left, the announcer's control panel. This manual control unit can be remotely operated if desired. Let's analyze the operation of the PROLOG: While the log has been typed in multiple copies, only the original is placed in the Programmer by inserting fan-fold stack in drawer under the unit. The log is fed up in the front over the view area and around control drums in the top to return to the completed stack in second drawer at bottom. At the top is a photo-electric readout that has a separate cell with focused light over each column to read 'go' or 'no go' when marks appear. The combination of 3 marks sends a pulse to appropriate coded source. At this point it performs an arming function only. This gets the cartridge ready, starts the drive motor on reel machines, and lights a "ready" indicator lite on source machine. It also sets up display of the code of next source on manual control panel. The readout head is a plug-in module resting in a pre-aligned socket over columns. The light sources are long-life focused lamps operating below rated voltage. The readout cells are mounted at top of a stainless steel tube of fibre optics which have wide tolerance in sensitivity as well as alignment within columns. The paper is moved forward one item at a time with the readout accomplished while passing under head. The rest position between items is blank. This movement is controlled by tone on tape at end of preceding item. This same tone pulse switches audio to armed source, operates a printer which prints exact time in hours, minutes, and seconds in air time column at left of each item. This prints from switching tone at end of item, to provide verification that commercial was completed. If a cartridge bound up and failed there would be no tone at the end; therefore no printing of time. After a four second audio and air time failure, system bypasses defective source. The blank air time is noted on removing log from equipment and suitable correction and make-good provided. This may also be connected to an alarm system.

We have now seen the movement of this log within a single page or time segment. A second movement of the log adjusts the program to real time at the end of each segment. This is accomplished by synchronous timer which controls a solonoid and motor control moving the paper forward to the first item in next segment. This synchronous timer is set to move log at quarter or half hour minus 1½ minutes, thereby arming first item in next program segment that much in advance. It will then wait until item playing is finished before audio switches on tone. Thus, if previous program segment was over-programmed with log advancing on real time before last item was started, Time announcements to the closest minute are provided automatically by an accessory which is coded in when desired the same as any other tape source.

In Radio today last minute changes are normal so flexibility is required. Perforated program sheets with back adhesive are available. By typing a new item complete with code this item may be torn off and applied over any existing item on log for quick change. The log coming up is available by opening the door of console and thumbing through the fan-fold stack. The top panel also lifts up for last minute changes either by strip or live with write-in.

Since we are on the subject of flexibility and changes, let's consider the other part of the PROLOG, the manual control panel. The announcer now can take over at will yet let the system do the work. A few simple controls give him access to all sources and functions.

The upper double bank of lighted control switches correspond to the control columns on our log. Here is the ABC and the two banks of 0 - 9. As each arming pulse is supplied from the readout head, the code is displayed here on the lighted switches. At any time during the previous item the operator can press the 'arm cancel' button and arm any desired source he may choose. He can press the 'Interrupt on the next tone' which alerts him with a light indicator interrupt until returned to automatic. This transfers audio to his mike - on the completion of item playing. If his live interruption takes much time, he may observe on the log that commercials are still programmed ahead in that segment. He can press the line advance switch and skip an item at a time until he arms the desired commercial. When ready, by pressing 'Return to Automatic' he can go back to item armed. The real time end of segment movement will continue to advance at the quarter or half hour ready to go thru station break and other items automatically upon his transfer. All items coming from tape sources are automatically logged with printer. He can also operate the printer with a manual control.

For a personality-type program sequence, the announcer can be coded into the log in place of music source. This will automatically handle all station breaks, taped intros and commercials, switching to him as indicated. His alert light is flashed on at the beginning of the preceding item the same as other source. If he fails to take over during the four seconds, audio failure transfers to next item as in completely automated mode. Operator thus is relieved of all switching and logging except to press a button to return when he has completed his part. He can play records or use tape sources as required. The Emergency button gives him immediate access to live operation without waiting for completion of item playing.

Here we can see some typical PROLOG Systems.

The first is the basic 4 transport system with PROLOG. This provides 3 source transports for music with 18 hours before any repetition. The fourth transport has all of the announcements in sequence to match the log. This is an ideal completely automatic system for the small AM or FM station.

The second system shown illustrates flexibility utilizing 5 reel machines with 4 music sources and 1 reel machine for announcements. Two individual tape cartridge units are included for taped news, or special features and last minute changes; three carousels provide 72 different cartridges which are individually controlled. The PROLOG is not shown here but is included. This system is in operation in our booth on the Exhibition Floor.

Systems are combined according to the station's needs. They are made up of plug-in modules so that minimum systems may be expanded with additional tape equipment and features added as desired.

II. We have discussed the first phase of the station's requirements. Now let's consider the second phase.

Additional benefits and increased efficiencies can be obtained by combining Continental's PROLOG system with automated business and accounting machines. Many radio and TV stations have set up various types of automatic accounting and business machines but to date it has not come into wide usage because of no thorough understanding of the Broadcast Industry's problems by manufacturers and suppliers of such equipment. I would like to cover now how Continental's PROLOG equipment is compatible with the IBM 402 series, 50 model, key punch, sorter and accounting machine.

First, I'm going to outline briefly such a proven system that is presently in use in KIMN (a high volume 24-hour AM station in the Denver market.) This has been installed recently in several other stations. It uses a minimum complement of IBM equipment as shown and is operated with one girl. The card punch, the sorter and the 402 accounting machine. The entire combination rents for less than the salary of one girl. The Broadcast system using IBM equipment, now offered by Continental, was developed by a CPA, Bud Knoll, who gave up private practice to become a Vice President and part owner of KIMN. He is also President of Accounting & Data Processing Co. of Denver with whom Continental is now associated to offer the Broadcast Industry completely automatic programming and accounting equipment and consultation. He and the Vice President and General Manager of KIMN, Ken Palmer, tried IBM with four girls doing the work. To learn the possibilities of IBM in broadcasting, they went to IBM school for an extended time. After a year of study changing forms and IBM control panels, they arrived at the present system using one girl.

Equipment, installation, training, and consultation service is available through Continental Electronics.

The operator can be the present traffic girl, who is taught keypunching and machine operation, or a keypunch operator who can be taught traffic. Keypunch and machine instruction can be obtained at IBM schools and requires 20 hours. This system is based on producing the log automatically, updated availability lists with time openings and product competitive clearance protection, all statements with affidavits, accounting, FCC reports, rep commissions and sales reports by salesmen and product classification and management summaries upon demand.

The log with PROLOG column codes is printed automatically from punched cards in 15 minutes the last thing each day. The log is produced with accuracy without human error. Punched cards are made up from sales order which in turn is completed with assigned times provided from availability lists. A punched tape can be produced simultaneously with punched card for fast automatic transmission by wire to a central office.

Various combinations of Continental PROLOG Systems and the Broadcast System using IBM equipment can offer stations answers to their individual needs with very substantial savings to pay for the equipment and services in a short time.

Continental also offers the Alto Fonic Taped Program Service in mono and stereo in different categories to meet many different formats. This service is offered on a rental library basis with a one-third change each month including all the new releases that are applicable. This is designed to meet the needs of the PROLOG system.

You will be interested in the consideration given to reliability and service. The entire system is transistorized. All electronic units are plug-in modules. All relays are enclosed and plug-in; mechanical adjustments are not critical and easy to set. The Continental rotating frame consoles for all tape units provide complete service accessibility from the front while operating. Equipment can be placed flush against the wall.

A complete model 300 system with a typical music and talk format is in operation here. That, together with the complete demonstrations and individual conferences with specialists in all phases, are available while you are here.

EXCITING SEVERAL AM AND FM STATIONS ON A SINGLE SERIES FED TOWER

By
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Presented
at the
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Conrad Hilton Hotel
Chicago, Illinois
April 7, 1964

Due to the phenomenal growth of the AM, FM and TV stations during the past 10 years, one of the major problems faced by any new station in Honolulu was to find an antenna site.

This problem is especially acute in Honolulu where there are at present 16 AM stations, two FM and four TV stations. Ten AM stations, one FM and four TV stations are located within an area of 1.4 square miles. The value of real estate ranges from $10.00 to $75.00 a square foot within this small area and today it is almost impossible to locate an antenna site due to the heavy congestion.

The logical approach to the problem then is to use a common tower for two or three stations. At present we have five towers in Honolulu that radiate a total of 11 AM and two FM stations.

To combine two or three AM stations into a single tower is no trick at all as long as the frequencies are fairly well spaced. To excite a TV or a FM antenna from a single AM tower is common practice and used all over the country today.

Our problem was that of exciting a FM antenna, mounted on an AM tower that was fed by two AM stations.

One method of doing this would be to shunt feed the tower with the AM signals, thereby making it possible to ground the FM feed line. (Fig. 1) This idea was abandoned due to the necessity of using a sloping feed line which would have required more space than we could afford and also, the increase in the high angle radiation from the feed loop was undesirable.

By changing the antenna into a grounded folded unipole as shown in Fig. 2, the FM line can be grounded without affecting the AM operation. We did not employ this method because of the mechanical construction involved. The best bid that I obtained to install these outriggered lines was in the neighborhood of $6,000.00 for a very simple configuration. Aside from the construction cost, this would have been a very good method as the feed point resistance would be raised and the reactive components in the AM isolation networks would be smaller, due to the smaller antenna currents.

In order to series feed the AM tower and still be able to ground the FM line at the base of the tower, four other methods were given consideration.

The first method was to use a FM iso-coupler (Fig. 3) which is a high frequency coupling coil used to physically break the FM feed line from the tower and isolate the AM signal while coupling the FM signal. After investigating this method, we were informed that the iso-coupler was plagued with arcing problems and we were discouraged from using it. Perhaps there may be some iso-couplers manufactured today that will do the job as it would certainly simplify matters.

The second approach was to use the brute force method used by some stations. (Fig. 4) This method obtains its isolation by winding the FM feed line into an inductance at the base of the tower. As we were using 1 5/8" semi-flexible coax cable for the FM feed line, the idea of winding this huge inductance seemed rather crude. Furthermore, the losses that would be incurred in the FM signal due to the extra feed line required for the coil were not acceptable.

The third method, which has many possibilities for more complex installations, was to isolate the FM line by building it out to a 1/4 wave section at both AM frequencies. The FM line is mounted with insulated hangars along the tower and connected to the tower at the top as shown in Fig. 5. The line is grounded to the main ground system at the base of the tower. If the isolated section of the FM line is not a 1/4 wave at the lower frequency, we can build it out to a 1/4 wave with a capacity across the line and the tower at the base of the tower to cancel the inductive reactance exhibited by a line section under a 1/4 wave. This is the common technique applied to isolate an AM tower with a TV or FM installation. If we had a second or third AM exciting this tower, we must go a little further to isolate the line. We can make the line into a 1/4 wave section at the higher frequency by shorting the line out with a series LC network. As this will upset the 1/4 wave length at the lower frequency, we must add an inductance across the series network to tune it into a parallel network at the lower frequency. We now have an AM line that is a 1/4 wave at two AM frequencies at the base of the tower and the line can be grounded without affecting the impedance of the tower. This technique can be applied to perhaps a third or fourth AM frequency and I believe that this is an ideal method of isolating the FM feed lines where the radiation resistance of the antenna must not be disturbed. Although we were enthused about this method of isolation, we wanted a system that was as simple as possible.

The final configuration that was installed is illustrated in Fig. 6. In this particular system, we have taken an entirely different approach to the problem. Instead of concerning ourselves with the problem of isolating the FM line, we make it an integral part of the entire system. True, this will upset the feed point impedance of the series fed tower but then, the thing that we are really concerned about here is the ability to ground the FM line and still obtain a reasonable feed point impedance for the AM signals. The FM line was insulated from the tower and grounded at the base of the tower. The line was connected to the tower at the FM antenna input. As this point was close to a 1/2 wave at the higher frequency, it would also reflect a very low impedance at the higher frequency. The measured impedance was 1.45 + j14.5 ohms. The object now was to raise the input impedance to some practical value at the higher AM frequency by employing the impedance inversion characteristics of a 1/4 wave line. With the RF bridge connected at the input, a shorting stub was used along the line from the top until a reasonable impedance was found at both frequencies. Table One is a tabulation of the impedances at the various shorting points. The final shorting point was at 140 feet above the base of the tower where the impedance was 25 - j56.7 ohms at 1380 KC and 37.5 - j6.74 ohms at 590 KC.

We did not go below this point as the reactance at 598 KC was zero and the impedance was almost a perfect 1/4 wave at 590 KC.

The antenna now presented an input impedance close to a quarter wave tower at both frequencies.

The AM traps were tuned in the normal manner and 50 ohms, 1 5/8" transmission lines were used for the two AM feeders.

Field intensity measurements showed that the antenna performed similarly to a normal series fed antenna.

TABLE ONE

Height of Shorting Bar Above Base of Tower	590 KC	1380 KC
265'		7.0 - j19.5
205'		13.6 - j34.4
180'		16.5 - j40.5
170'		19.0 - j43.5
160'	36.5 - j8.4	21.2 - j49
150'	36.8 - j7.7	22.6 - j52
145'	37.0 - j6.8	23.9 - j54.6
140'	37.5 - j6.74	25.0 - j56.7

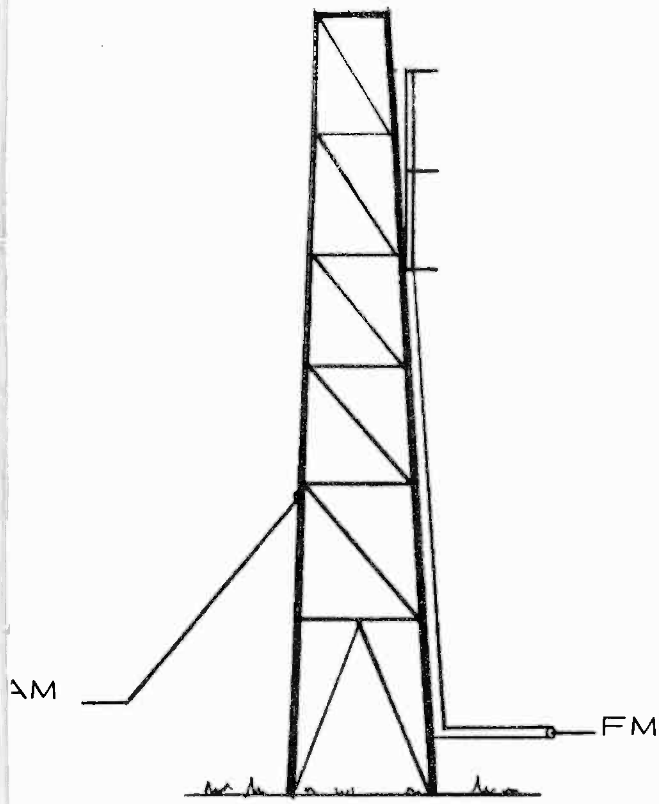


FIG. 1

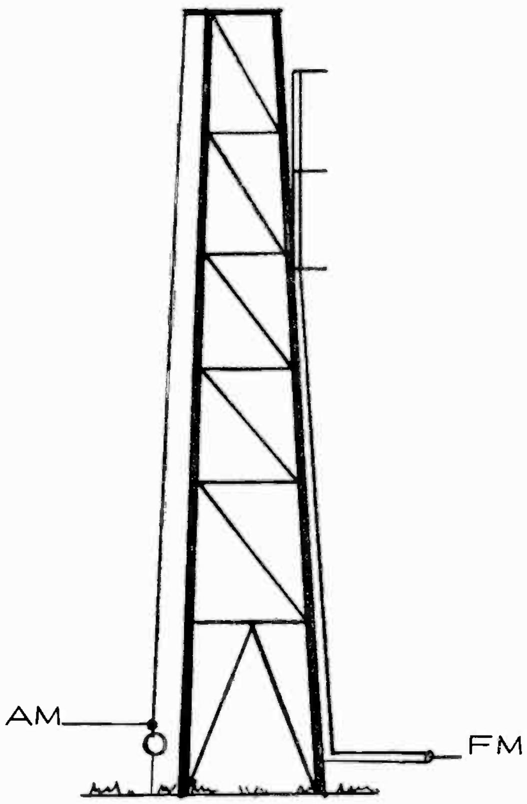


FIG. 2

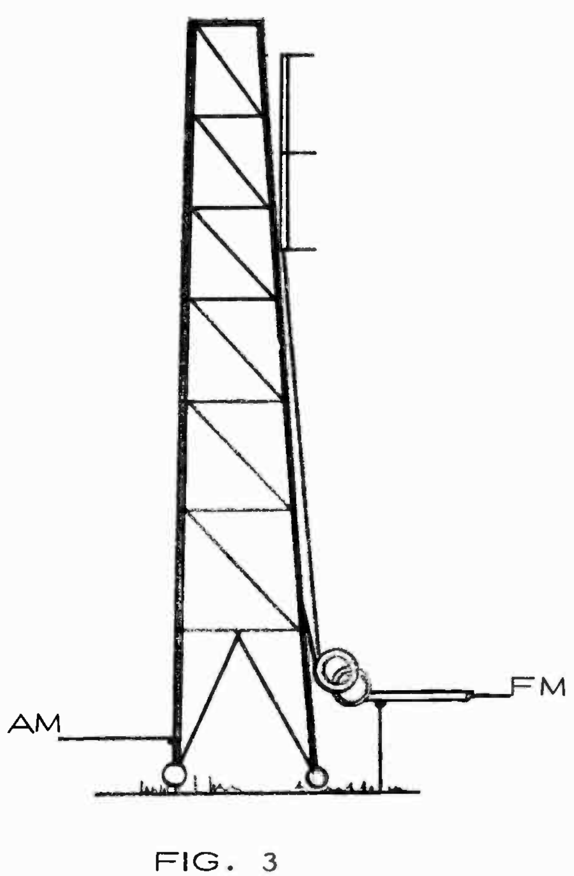


FIG. 3

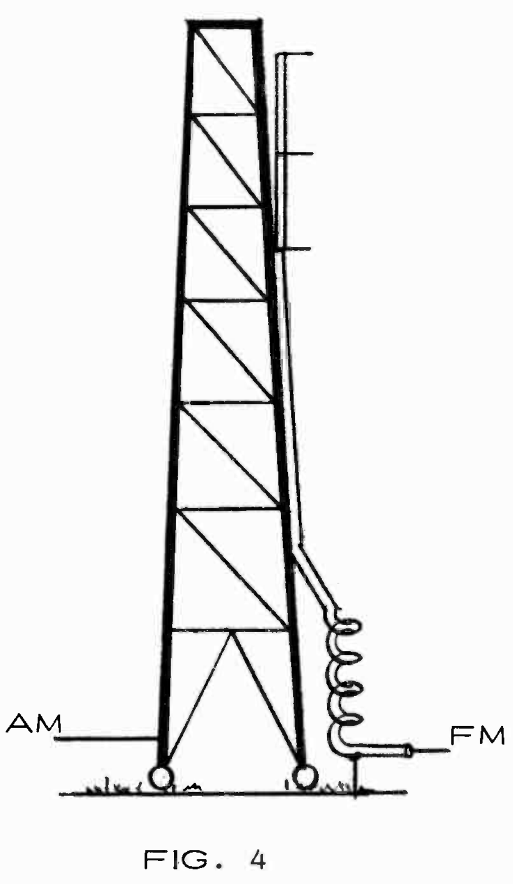
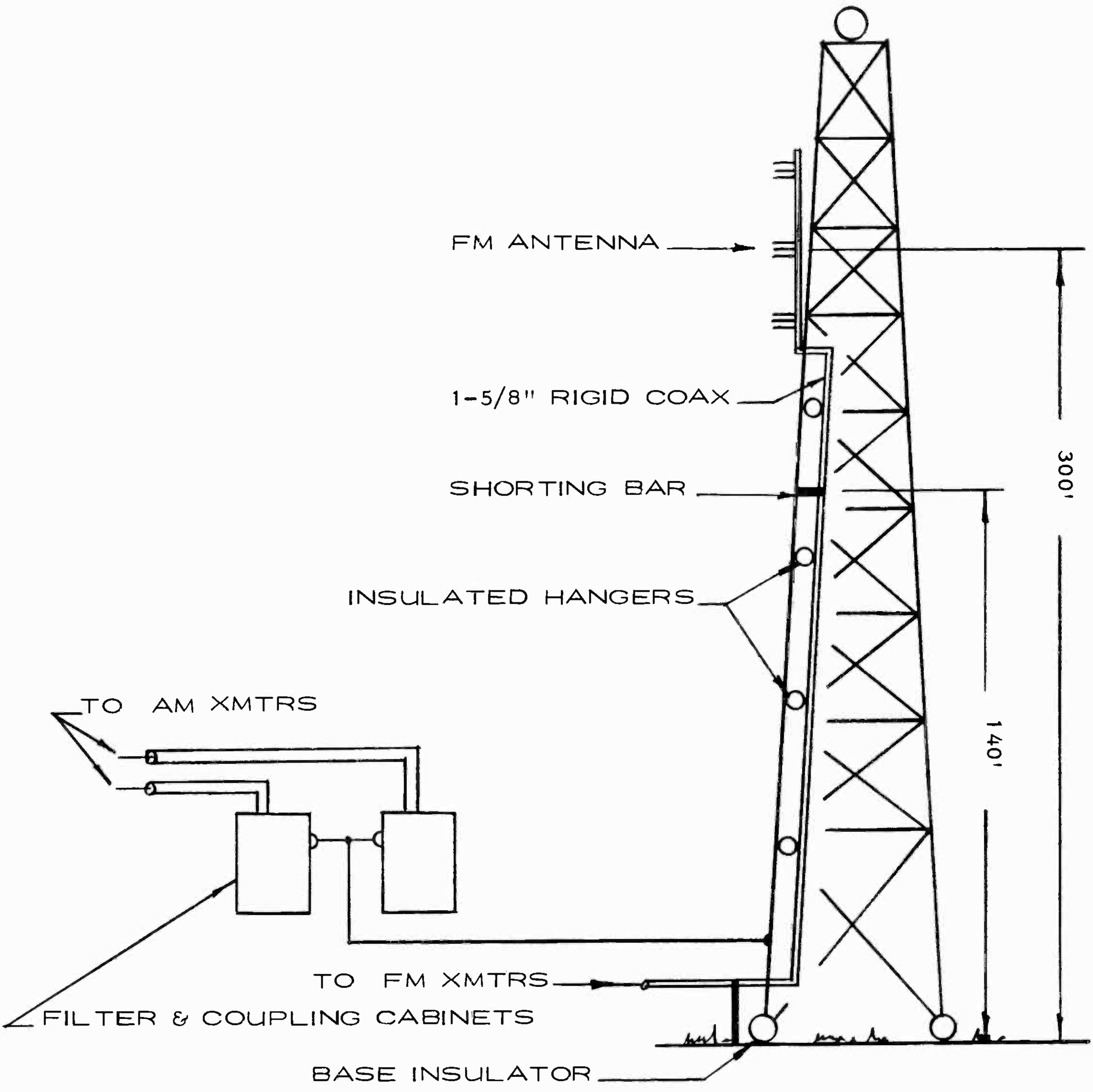


FIG. 4



DETAILS OF TOWER

FIG. 6

VERTICALLY POLARIZED FM ANTENNAS and POWER DIVIDER

E. S. GAGNON, MANAGER PRODUCT MARKETING

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

Now, some 18 years after the end of World War II, FM is taking its second wind, with this resurgence of FM broadcasting transmission by Dual Polarized FM Antennas has been developed. Vertical Polarization in conjunction with horizontal polarization provides the maximum coverage of the area a station serves.

Advantages of a dual polarized FM antenna system are: (a) improved reception by receivers using vertical antennas, specifically automobile radios and home receivers with built-in antennas, (b) signal levels may be increased in the null areas of a horizontal antenna.

The FCC FM Rules and Regulations require the transmission of horizontal polarization. Revisions made some years ago authorize the transmission of a vertical component which, in no event, is to exceed the effective radiated power authorized.

The Commission's Rules and Regulations on this subject are as follows:

Paragraph 3.310, Definitions in the FM Technical Standards:

"The term 'effective radiated power' means the product of the antenna power (transmitter output power less transmission line loss) times (1) the antenna power gain, or (2) the antenna field gain squared. Where circular or elliptical polarization is employed, the term 'effective radiated power' is applied separately to the horizontal and vertical components of radiation. For allocation purposes, the effective radiated power authorized is the horizontally polarized component of radiation only."

Paragraph 3.316, Antenna Systems, Paragraph (a):

"It shall be standard to employ horizontal polarization; however, circular or elliptical polarization may be employed if desired. Clockwise or counterclockwise rotation may be used. The supplemental vertically polarized effective radiated power required for circular or elliptical polarization shall in no event exceed the effective radiated power authorized."

Paragraph 3.310, states the effective radiated power authorized is the horizontally polarized component of radiation only. Paragraph 3.316 on antenna systems states, the vertically polarized effective radiated power shall not exceed the effective radiated power. Therefore, an amount of power equivalent to the effective radiated power in the horizontal plane may be radiated by a station in the vertical plane. This does not preclude the fact that specific application must be made under Paragraph 3.257 requesting authority to make a change in the antenna system, if we are talking about an existing station or a CP that has been granted.

The radiating elements of current horizontal FM antennas are modified dipoles. These are spaced one above the other to obtain the desired antenna power gain. See figure 1.

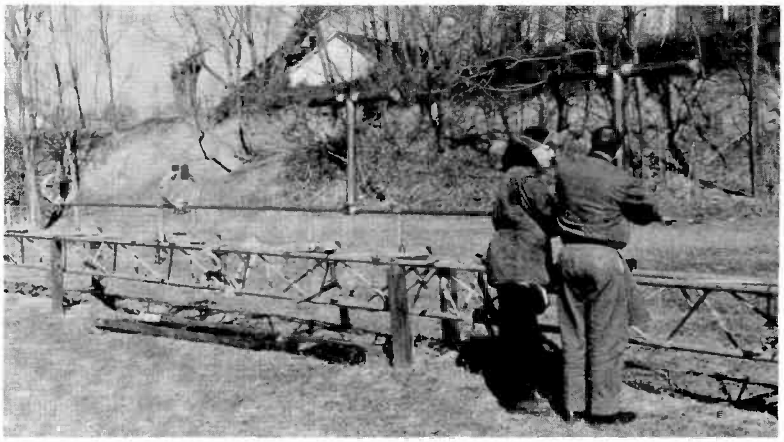


Figure 1

It is this power gain times the antenna input power that determines the effective radiated power of a given FM station.

It is standard practice to stack the antenna radiating elements or bays approximately one wavelength apart. The bays are then fed in phase along a transmission line that may support from one to sixteen bays or radiating elements electrically connected in parallel. See figure 2. The impedance of each dipole, antenna element, or bay is made greater than the transmission line impedance by the number of bays. The input impedance of the antenna, however must be 50 ohms to meet the standard coaxial line transmission impedance.

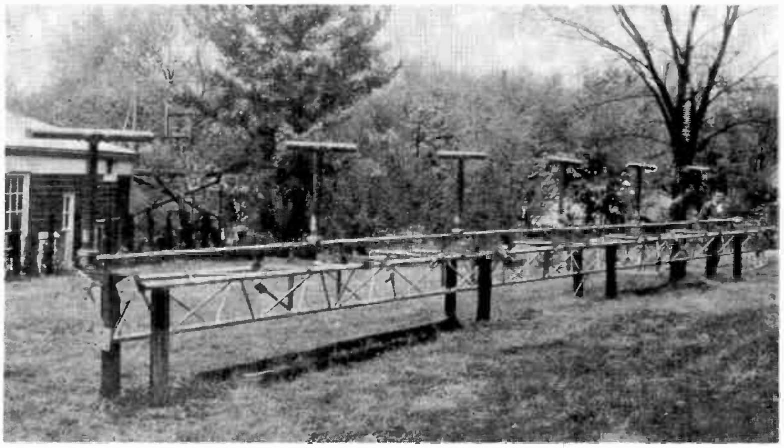
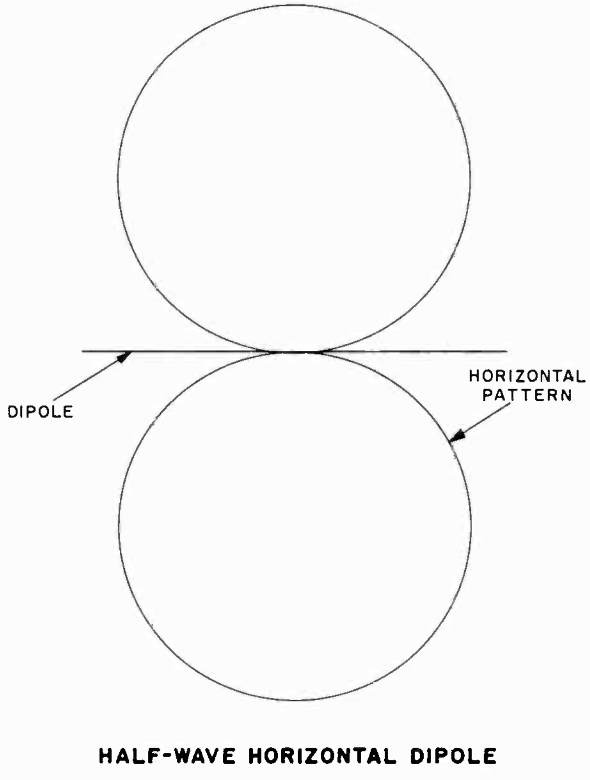


Figure 2

We mentioned earlier that the standard FM antenna on the market is a modified dipole. Now the horizontal radiation pattern of a dipole is a Figure 8. See figure 3.

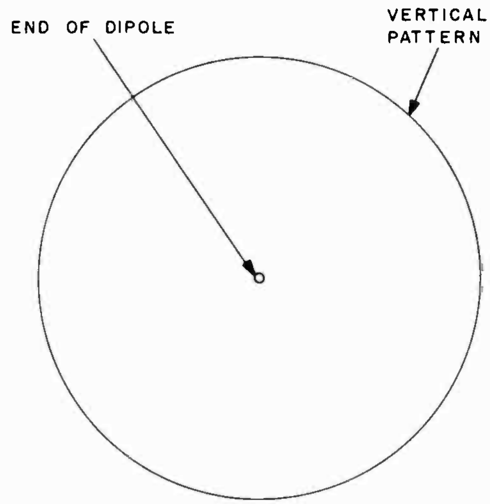


HALF-WAVE HORIZONTAL DIPOLE

Figure 3

If we take the dipole and bend it into a semi-circle, we have a circular dipole and, for all practical purposes, an antenna that will radiate a uniform omni-directional signal within plus or minus one db in free space. The circular dipole is usually end loaded with capacitive plates to provide a more uniform current along the antenna length.

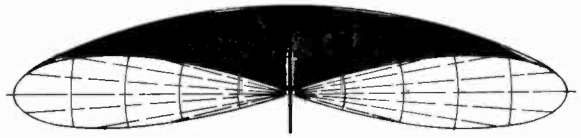
The standard horizontal dipole with a Figure 8 horizontal radiation pattern has, when we look at the end of the dipole, a circular vertical pattern as shown in figure 4.



HALF-WAVE HORIZONTAL DIPOLE

Figure 4

Up to this point we have been discussing the dipole as we normally know it in the horizontal position. Let's tip the dipole up on end. The horizontal becomes the vertical and the vertical becomes the horizontal and we have a circular radiation pattern from the dipole antenna. The resulting radiation pattern is graphically shown as a cross sectional view through the antenna in figure 5.



RADIATION PATTERN FOR A VERTICAL DIPOLE

Figure 5

A vertical antenna now in production and use is the Type 300 shown in figure 6. The circular free space radiation pattern is within plus or minus one db. The radiating element is approximately forty-five inches long with a thirty-six inch horizontal choke and matching section between the coaxial feedpoint and the radiating element. All sections are three and one-eighth inches outside diameter.

The matching section provides a low VSWR and proper impedance when more than one element is installed and separated by one wavelength section of feedline. The choke is to provide electrical balance without openings, which would subject the Antenna to ice and moisture, and thus necessitate the use of deicers.

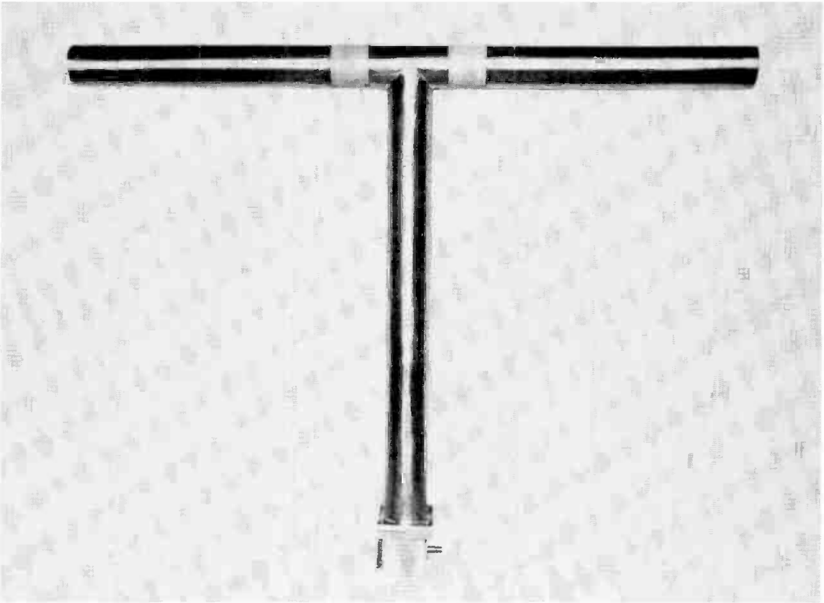


Figure 6

The connecting block at the end of the horizontal choke and matching section may be provided to accommodate the following optional feed systems.

1. Series feed with 3⅛″ rigid line.
2. Series feed with 1⅝″ rigid line.
3. Parallel unit feed with ⅞″ Spir-O-Line and a central power divider.

The antenna is supplied with custom mounting brackets as shown in figure 7. This bracket may be adopted for side or corner tower mounting.

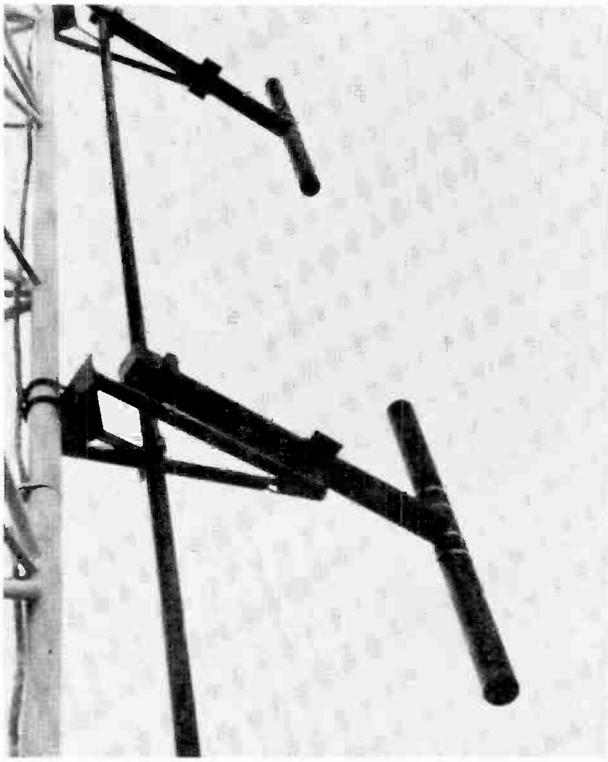


Figure 7

Deicing the vertical antenna element is not necessary due to the broad bandwidth characteristics of the dipole plus the broad cross section and completely enclosed balancing choke section previously described.

Electrically, the antenna covers a frequency range of 88-108 megacycles. The standing wave ratio is 1.1 to 1 or less as tuned at the factory. Each element has a power rating of three kilowatts.

Vertical antennas may be used in combination with other types of horizontally polarized ring or V antenna, but, as we have stated before, it is not permissible as the sole source of radiated transmission energy under existing Rules and Regulations.

Consider the combinations of dual polarized antennas possible. Horizontal antennas are available, consisting of from one to sixteen bays on either 1⅝" or 3⅛" line. The vertical Type 300 is available in similar configurations. There are three general methods which may be used for mounting the combinations.

The first configuration, figure 8 is with the horizontal elements mounted above the vertical elements. The center of vertical radiation is considerably lower than the horizontal center of radiation, a large section of tower must be available to mount the complete unit.

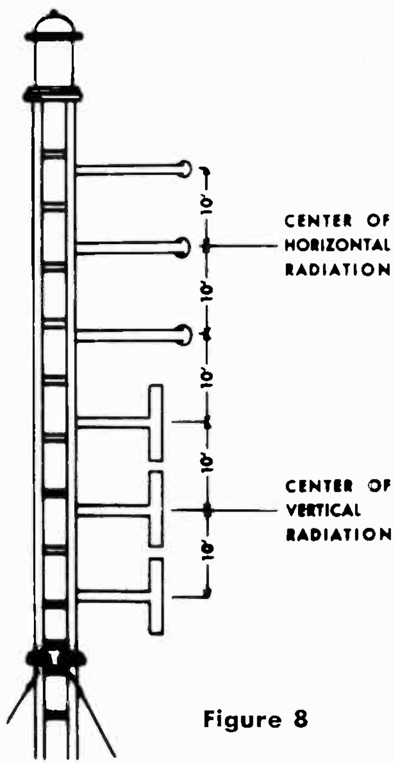


Figure 8

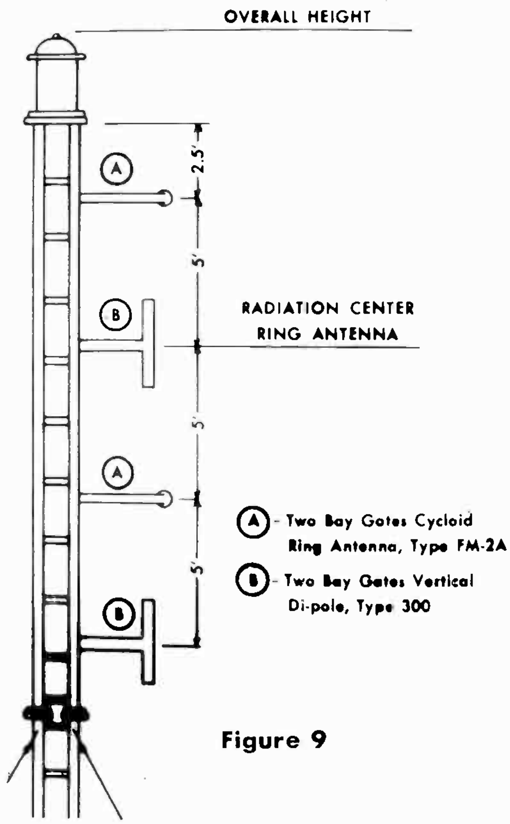


Figure 9

A second method, figure 9, is intermingling of the horizontal and vertical bays. This requires less tower space and places the vertical center of radiation approximately five feet below the horizontal.

A method of mounting, figure 10, which tends to equally distribute the total weight of the antenna on the tower is with the vertical elements on one side of the structure and horizontal elements on the opposite. This system of mounting and intermingling of the bays, will be, we anticipate, the most common prescribed methods of installation.

Antennas consisting of one to nine radiating elements are end fed. Antennas with ten elements and more are center fed. If the antenna consists of an odd number of elements, the feed point is at a point one-half bay below the center. In other words, an eleven bay antenna is fed at a point one-half way between the sixth and seventh bay, or 55 feet from the top.

EXPANDED VIEW OF FM RADIATOR

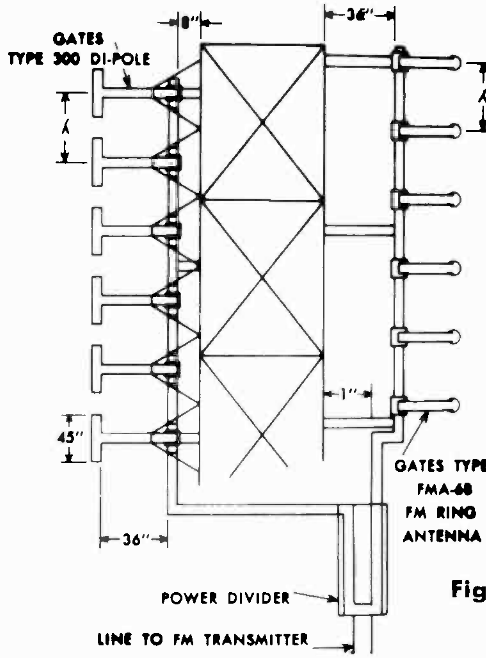


Figure 10

We have not mentioned power dividers. Our discussion has centered around the description of the antenna, installation, and combinations thereof. Normally, we have one transmitter supplying RF to the antenna.

Now with dual polarization we have the gain of the horizontal elements, the gain of the vertical bays, and the power supplied to each. The gain of the vertical bay, or bays, is not identical to that of the equivalent number of horizontal bay, or bays. See figure 11.

GATES CYCLOID FM ANTENNA
GAIN AND PATTERN DATA
DUAL POLARIZED

Figure 11

	HORIZONTAL			VERTICAL		
No. of Loops	Power Gain	Field Gain	Mv/M/KW	Power Gain	Field Gain	Mv/M/KW
1	0.9	0.95	131	.950	.975	134.7
2	2.0	1.41	194	1.969	1.403	194.0
3	3.0	1.73	238	3.120	1.766	244.2
4	4.1	2.02	278	4.198	2.049	283.2
5	5.2	2.26	311	5.310	2.304	318.4
6	6.3	2.51	345	6.393	2.528	349.4
7	7.3	2.70	372	7.500	2.738	378.5
8	8.4	2.90	399	8.571	2.928	404.6
9	9.4	3.07	421	9.755	3.123	431.6
10	10.5	3.24	446	10.960	3.310	457.6
11	11.5	3.40	468	11.870	3.445	476.1
12	12.7	3.56	490	13.195	3.632	501.9

For example, three bays of horizontal have a power gain of 3 and a field gain of 1.73, while an equivalent number of vertical bays has a power gain of 3.12 and a field gain of 1.766. Therefore, if we want to operate with the same horizontal and vertical E.R.P. and are using one transmission line to the antenna, we must control the power to the vertical and horizontal assemblies. This may be done with a power divider. With the many combinations of antennas, R.F. power and resulting effective radiated power, you can see the power divider is presently customed designed for each specific installation.

A variable transformer, figure 12, may be used between the power divider and vertical and horizontal antennas to assure proper matching and power distribution.

Fixed power dividers are available, assuming we have exactly matched loads on the power divider output. For example, if we want to divide ¾ of the available power and supply it to the horizontal antenna and the remaining one-fourth to the vertical, and we know the input power, a standard power divider may be provided. Currently the loss in the power divider has been assumed to be the loss obtained from an equal length of transmission line.

I regret we are unable to provide at this time actual comparison field measurements of a horizontal installation with a combined horizontal and vertical system. This project still remains to be completed. Clearly it must be realized that a large amount of work within the industry remains to be done in assembling detailed field information on elliptical polarization.

The photograph, figure 13, is of an actual installation consisting of two Cycloid bays and two Type 300 vertical elements. Reports on the results of current dual polarized installations are most gratifying both from the listener, the station, and the manufacturers' viewpoint.

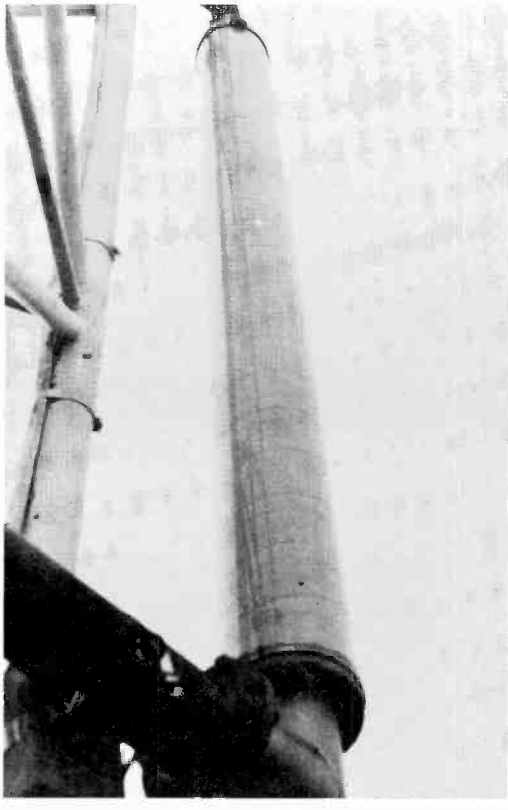


Figure 12

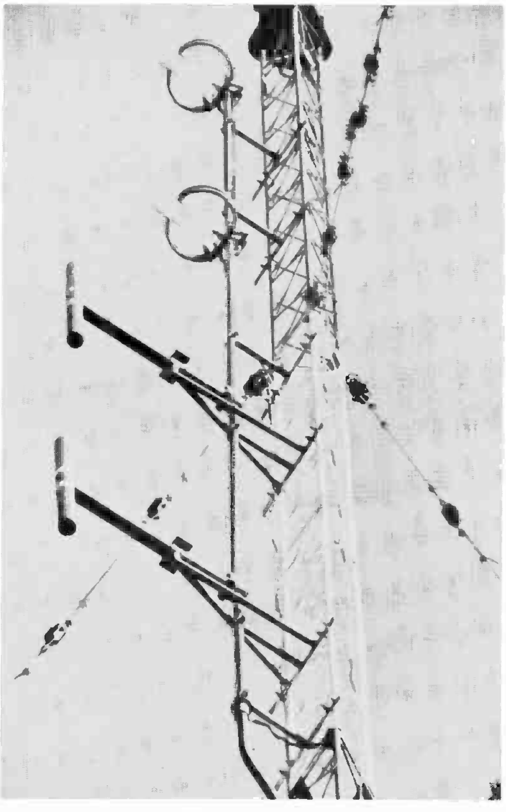


Figure 13

AN AUTOMATIC TRANSMITTER SWITCHING SYSTEM

Fred L. Zellner, Jr.
Director of Technical Operations-AM
American Broadcasting Company

NAB - 1964

In recent years the remote control of AM and FM transmitters has become a desirable form of operation from both the technical and economical sense of broadcasting. The American Broadcasting Company has been engaged in this type of radio operation at its plants in San Francisco, Chicago, Detroit and New York.

During the course of this extensive and varied operation there have risen many instances where the ability to switch from the main transmitter to the auxiliary or standby transmitter is desirable. Since there is a terrific psychological pressure on the engineer or technician "racing the clock" trying to get equipment on-the-air he is liable to make several quick, blind stabs in the dark at analyzing the indications given by the remote control instruments, resulting in excessive loss of on-the-air time.

In June 1962 the American Broadcasting Company began a program of complete rehabilitation of its radio transmitting plant at KQV, Pittsburgh. The basic design concepts to be followed necessitated equipment which could be adapted to remote control operation. The control point was established to be located at its studios and offices at Seventh and Smithfield Streets in downtown Pittsburgh. Complete automation of all equipment was deemed necessary as unlike in the old days of broadcasting, the control of the transmitting equipment would be in the hands of studio personnel unfamiliar with the idiosyncrasies of transmitter operation in addition to being subjected to the pressure of modern day radio studio operations, where in many cases an unsympathetic attitude would be taken if it were necessary to take time to switch on another transmitter eventhough off the air. At this point a more searching approach was taken to examine the problems at hand. A survey of the operation problems encountered at our other locations was made. This left little doubt in our minds as to the proper approach. In many cases we found outages had occurred which would not have been necessary if the operator had been familiar with transmitter problems. We also noted that many stations were reporting less down time as a result of converting to remote control. This could be attributable to maintenance of equipment by personnel who are still familiar with it; also a completely different situation may arise as to down time when the equipment is being operated by new personnel located at a studio location.

The equipment installed at KQV is as follows! a five and one kw ITA transmitter, an ABC automatic emergency transmitter switcher, phase cabinet and associated equipment of solid-state design. In addition, a complete automatic emergency power plant with automatic power transfer.

FIGURE #1 - View of KQV Transmitter Room (fromt)

FIGURE #2 - View of KQV Transmitter Room (rear)

The ABC automatic transmitter switcher system consists of an ITA carrier/audio off monitor working in conjunction with protective relays in the main transmitter and certain auxiliary relays and contactors in the antenna system and auxiliary transmitter. The system is designed to sense and determine conditions at a transmitting station under which transfer to emergency operation should take place and to make such transfer automatically.

This type of equipment would relieve the operator at the control point having to make decisions which could be hit or miss, especially if he is under the pressure encountered in a studio operation. Such transfer, when made to emergency operation, will have to be restored under appropriate conditions manually. When the station is remote control operated, it will usually be necessary that such restoration be made by an operator who is on call for such emergencies.

FIGURE #3 - Block diagram of transmitter system layout

The functional sequence of the system is as follows: if an overload should occur in the main transmitter it should recycle twice, and if the third overload occurs within thirty seconds of the first it should lock out the main transmitter and cause transfer to the emergency or auxiliary transmitter. If for any other reason carrier of main transmitter should fail, ten seconds after such failure transfer to the emergency or auxiliary transmitter should take place. The filaments of the emergency or auxiliary transmitter are to be lighted at once. If a transfer does not take place the transmitter is to be restored to its normal standby conditions after five minutes. If for any reason modulation on main transmitter ceases for 20 to 30 seconds a relay should switch to the alternate program feed and cause an audible alarm to sound. In addition, contacts on the relay are available for activating an indication on the remote control equipment.

The transfer from normal to emergency operation is accomplished by the operation of the power transfer relays, associated with the main transmitter. This relay or relays operate as a result either of overload lock-out or absence of carrier of 10 to 15 seconds. This relay transfers the main antenna relay to the emergency transmitter and applies power to both the filaments and plates. The filament power may have been previously applied depending upon what the circumstances may have been.

In an operation of this type it is necessary that the emergency transmitter be equipped with silicon rectifiers in the high voltage supplies. The transmitter must be capable of coming up to full operation in not more than ten seconds. If this should require filaments being run at half voltage at all times it should be provided for in the circuit arrangement.

FIGURE #4 - 1kw transmitter in normal standby node

FIGURE #5 - 1kw transmitter in normal operate node

If a break in the carrier has occurred within five minutes of the transfer to emergency operation, the filaments of the emergency transmitter will have been turned on or brought up to full voltage as a result of the operation of the carrier off monitor and the emergency or auxiliary transmitter relays. If such a carrier break occurs and no transfer takes place, the filaments will be turned off or returned to the standby voltage after five minutes.

FIGURE #6 - Front view of ITA/ABC carrier/audio off monitor

FIGURE #7 - Back view of ITA/ABC carrier/audio off monitor

FIGURE #8 - Schematic of ITA/ABC carrier/audio off monitor

In this unit a sample of the modulated main carrier is applied to the unit at J1. The tuned input circuit feeds a IN34 diode rectifier, the output of which is fed to 3 triodes. Triode VIA amplifies the audio modulation which is rectified and applied to the modulation relay tube VIB. Relay K1 in the plate circuit of VIB operates when there is no modulation for approximately 20 seconds. This relay is interlocked with the audio system and transfers the program feed.

Triode V2B is fed through a low pass filter and is arranged to operate relay K4 immediately upon failure of carrier. This relay circuit may be set to operate with a reduction of carrier if so desired. The circuit is interlocked with the filament control circuits of the emergency or auxiliary transmitters and upon its activation brings the filament voltage up to its normal value.

Triode V2A is fed through a resistance capacity network having a 10 to 20 second time constant. This is so arranged that relay K2 can be caused to operate after carrier has ceased for ten seconds. A time delay relay K3 is provided to prevent the operation of this trip out relay until after plate power has been applied and carrier has had a chance to be established. All relay contacts in this unit are rated at ten amps 120 volts. The specific circuit arrangement and relay types involved in the power transfer relays will depend upon the overload protection and the "lock out" circuits in the main transmitter. Such protection should be arranged to provide automatically for restoration of plate power in the event of overload trip out. This action should "lock out" only after three overload trip outs in less than thirty seconds. When "lock out" occurs auxiliary relays should be so arranged as to provide closing contacts for the switching of the antenna and for the turn on of power in the emergency or auxiliary transmitter.

FIGURE #9 - Antenna relay (transfer)

FIGURE #10 - Antenna switching relay schematic

This arrangement is presently in use at our transmitter installation at Lodi, New Jersey, which consists of a General Electric BT-50 50kw main transmitter and a 10kw Continental Electronic emergency transmitter.

FIGURE 11 - Relays used in the GE BT-50 transmitter (Lodi, N.J.)

The lock out of relay YK11 opens the control circuit at contacts 3 and 4. By providing auxiliary relays as shown, the transfer operation will take place provided no control voltage appears at contact 4 and provided there is control voltage on contact 3. After turn on has taken place this voltage can be removed, that is, the main transmitter can be shut down manually if desired.

The operation of relay K2 in the monitor unit will also cause a transfer to emergency operation if for any reason there is no carrier for 20 to 30 seconds with plate voltages applied to the final stage of the main transmitter. Relays or contactors in the emergency transmitter should operate on a self-locking basis so that continuous closure of the initiating relays will be unnecessary. This permits control of the emergency transmitter when it is desired to shut it down and return to main transmitter operation.

Coupling for the RF sample of the main transmitter output to the Carrier Audio Off Monitor is arranged conveniently to feed RG11U coaxial cable. The coupling supplies not in excess of one watt of RF power to the input of the monitor unit. Input condenser adjustments are such that .3 milliamperes of rectified carrier (30 volts across 100,000 ohms) flows. Excessive input may destroy both the input load resistors and the carrier rectifiers.

The operation of the automatic switching equipment at KQV has been relatively successful since its installation in September 1962. The use of the adjective "relatively" does not infer a negative attitude towards this equipment, but only a realistic approach to a prototype item which, like all prototype gear, has a tendency towards problems in the early days of operation. One of the problems that we discovered almost immediately was that the manufacturer had specified that the AC for the ABC Automatic Transmitter Switcher should be fed from the control voltage of the 5kw main transmitter. Since this was true, blowing a fuse in either leg of the 220 volt 3 phase supplying the stage or opening by overload of the control circuit breaker rendered the switching unit inoperative. This problem was solved very simply by supplying AC to the unit from a source separate from the transmitter.

Another problem, and one that we are living with for lack of an answer, is that any failure in the two RF circuits of the switcher itself will take your perfectly good main transmitter down and bring up the standby. The reason for this is simple, the solution not so simple. The two RF guiding circuits interpret any loss of bias as transmitter fault, no matter the reason. But while it may be irritating to the operator for a defective component in a piece of automation gear which is supposed to guard against trouble to instead cause trouble, it as a fault can be tolerated, since it happens only rarely when your components have been choosen with care and have sufficient safety factors.

A couple of actual failures that have occurred at KQV read this way from the transmitter log:

July 14, 1963 - 8:31 AM - parasitic resistor opened in 4/400 driver stage 1kw up on automatic and no lost air time.

October 14, 1963 - 5:40 AM - shorted .01 mfd bypass in 4/400 stage 1kw on air automatically, no lost air time.

August 14, 1963 - approximately 2:42 PM - trouble in audio power supply at studio. Audio switched to emergency program source automatically, no lost air time. This audio failure occurred while the transmitter man was making antenna base current readings and could have resulted in a severe loss of air time had not switching of program feeds been automatic. The studio man at the same time was unaware that he had a problem because he was in the midst of a heavy production schedule. Had he been without automatic switching an outage of something exceeding 5 minutes probably would have occurred. With automatic switching we lost nothing.

One thing that cannot be stressed too strongly is that the transmitter staff has to be completely, and I repeat, completely familiar with the operation of this system otherwise you may find yourself in the position of being off-the-air with two good transmitters in the building. When the main transmitter is down it is necessary to run this transmitter on the dummy antenna for test and trouble shooting purposes. It is also necessary to disable the automatic switching to accomplish this. Failure to disable both before trying the main on the dummy will shut down the standby. If the operator understands the correct functioning of his equipment this will present no problem, but if he comes apart and tries, as has happened, to manually throw the antenna switch he is in trouble. Therefore, it is imperative that when trouble occurs the operators understand exactly what the equipment is supposed to do, stand back with his hands in his pocket until automatic switching has taken place, then set about correcting the original fault.

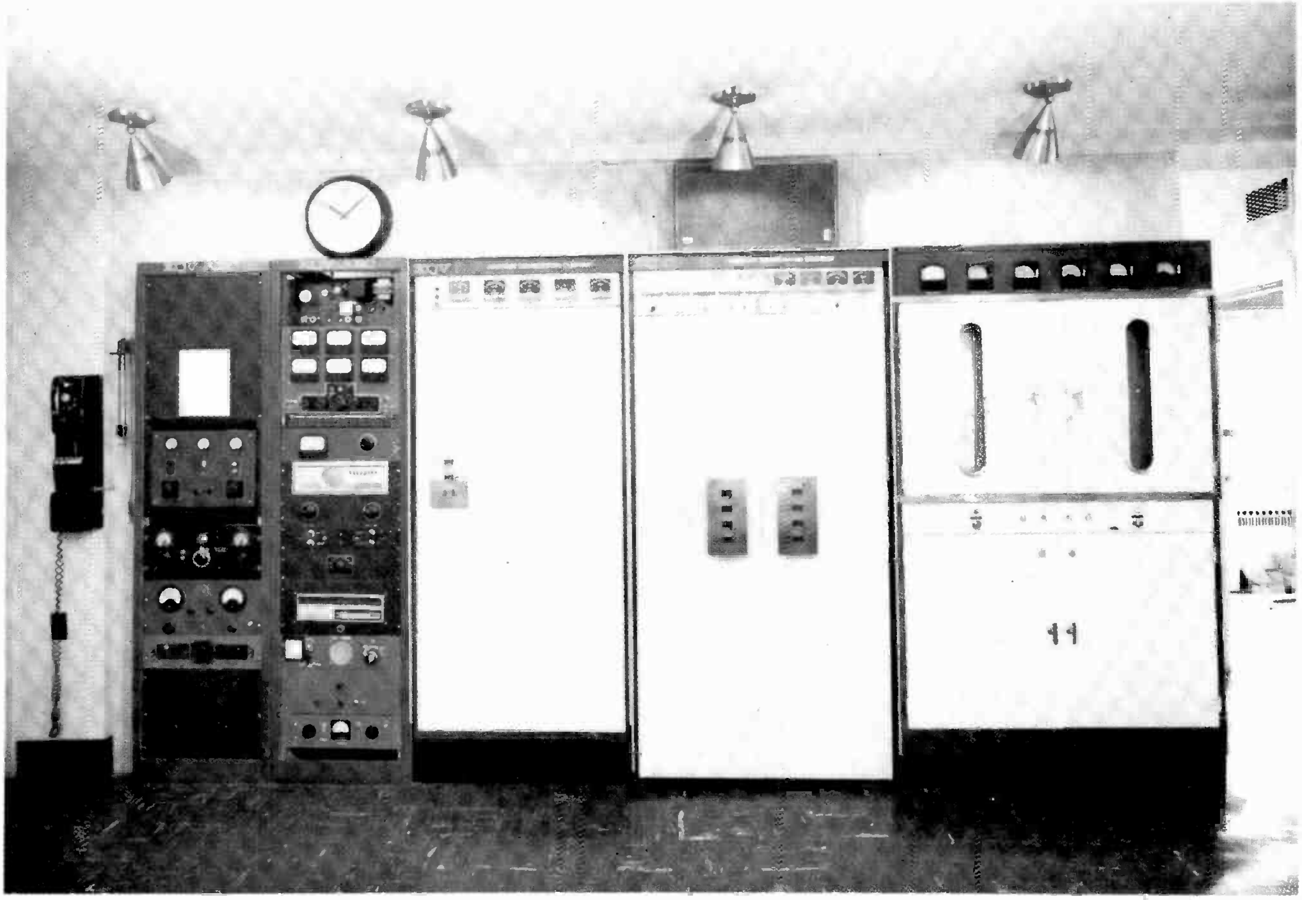


FIG. #1 - FRONT VIEW OF KQV TRANSMITTER ROOM

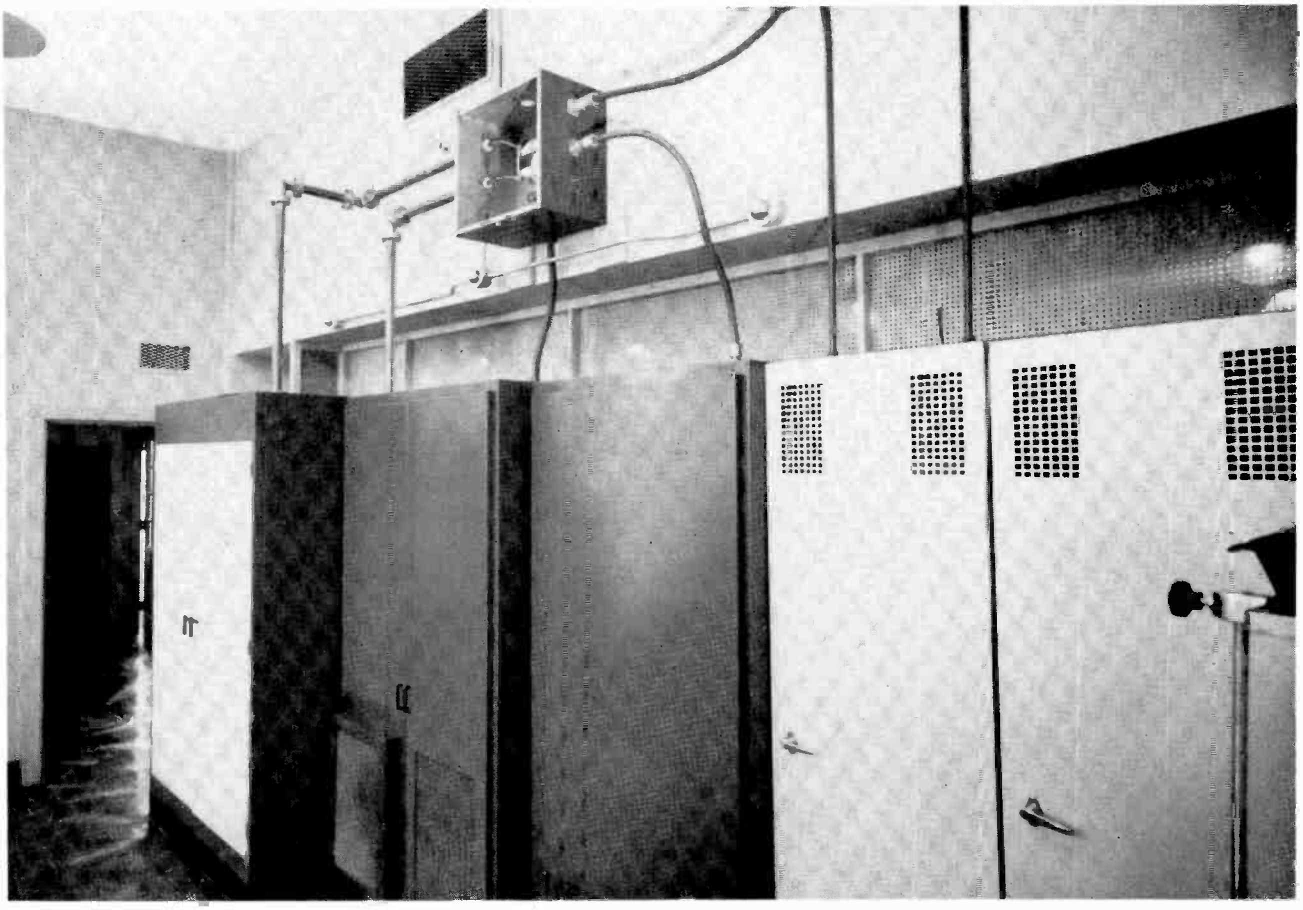
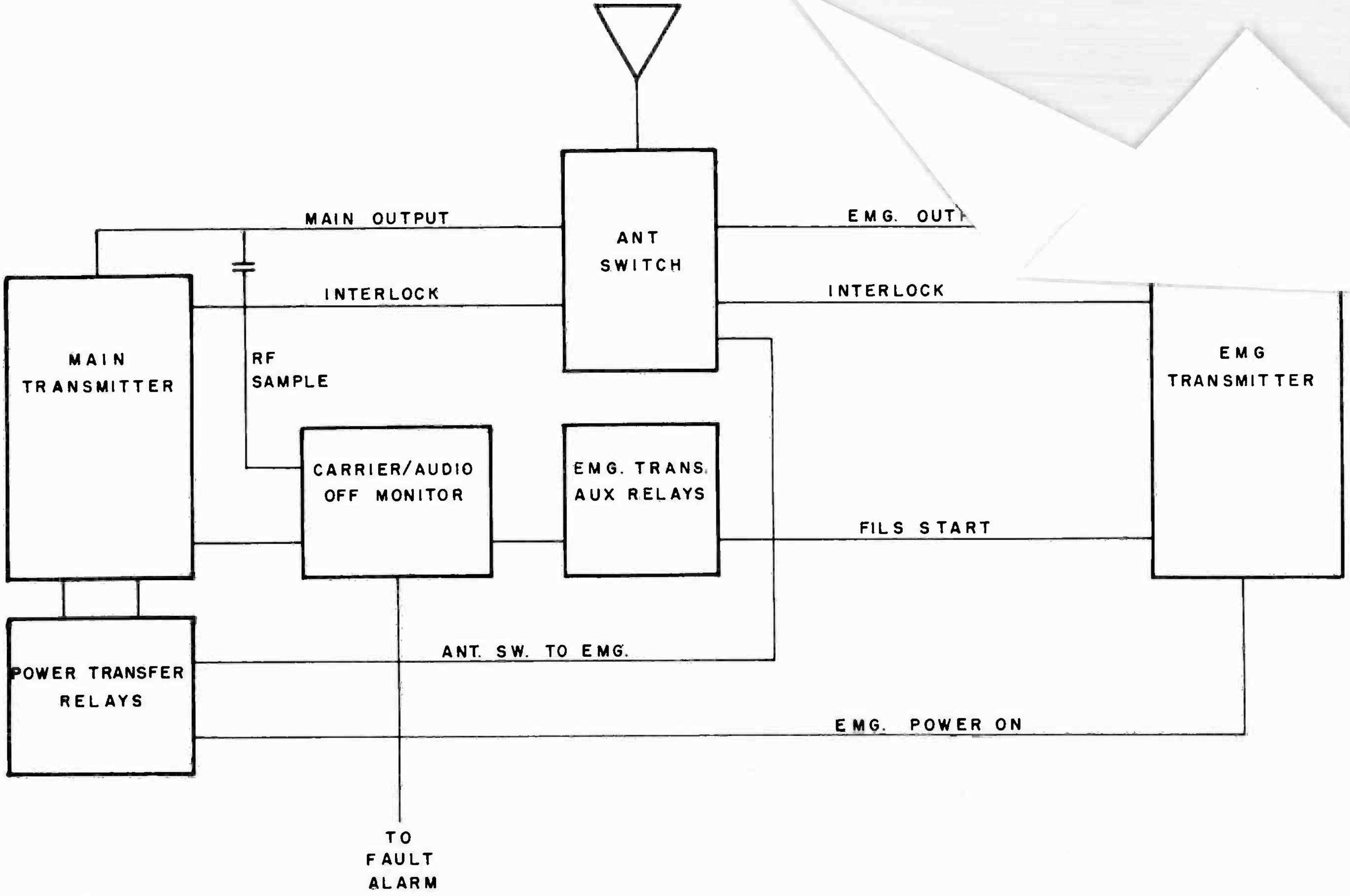


FIG. #2 - REAR VIEW OF KQV TRANSMITTER ROOM



AUTOMATIC EMERGENCY TRANSMITTER SWITCHING SYSTEM

A B C ENGINEERS

FIGURE #3
Block Diagram of Transmitter system

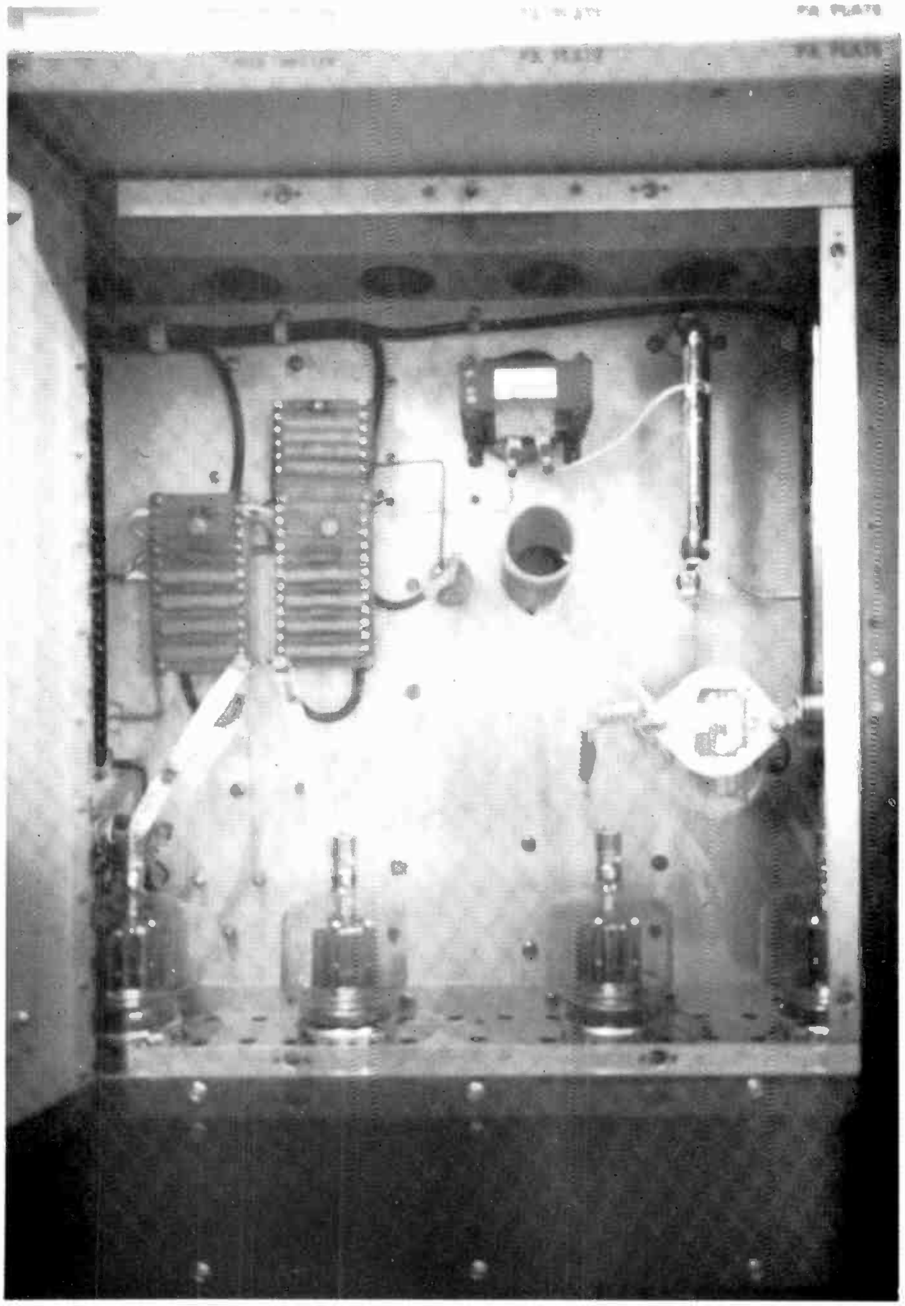


FIG. #4 - TUBES IN 1KW TRANSMITTER IN NORMAL STANDBY NODE

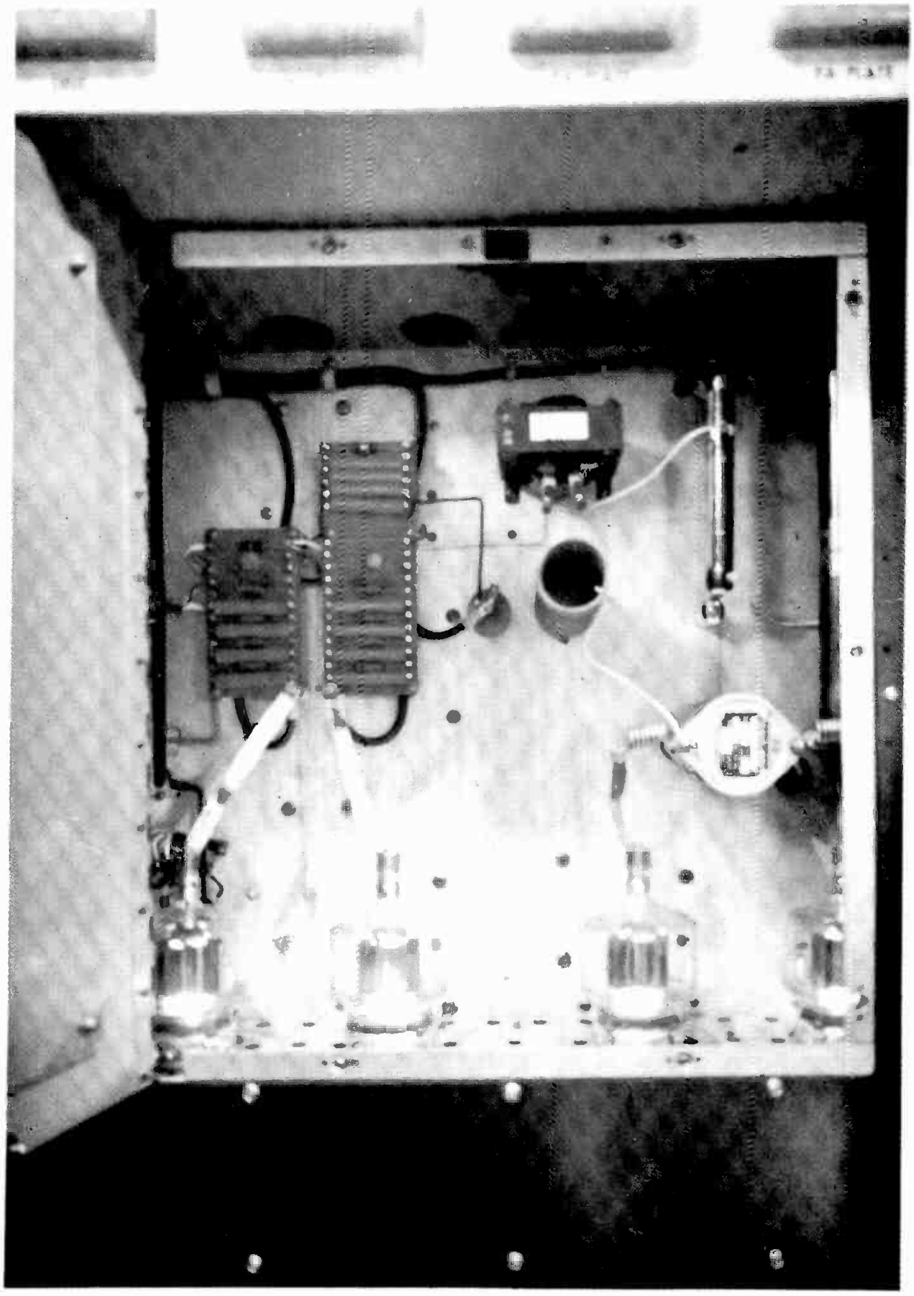


FIG. #5 - TUBES IN 1KW TRANSMITTER NORMAL
OPERATE NODE

FIG. #6 - FRONT VIEW OF ITA/ABC
CARRIER/AUDIO OFF MONITOR

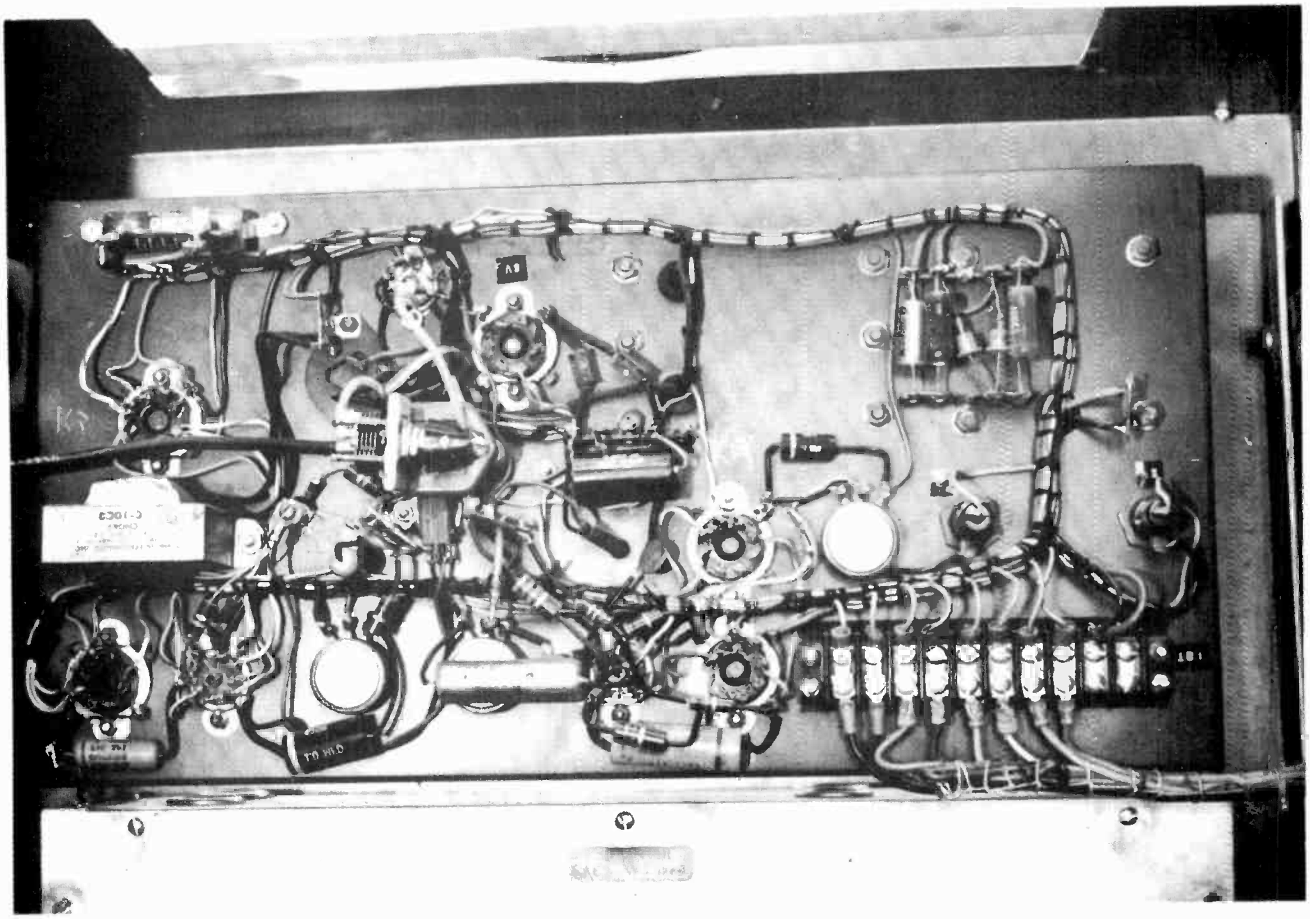


FIG. #7 - BACK VIEW OF ITA/ABC
CARRIER/AUDIO OFF MONITOR

NOTE: ALL CAPACITORS IN UF UNLESS NOTED
ALL RESISTORS IN OHMS UNLESS NOTED
ALL RELAYS SHOWN IN THE UN ACTUATED POSITION.

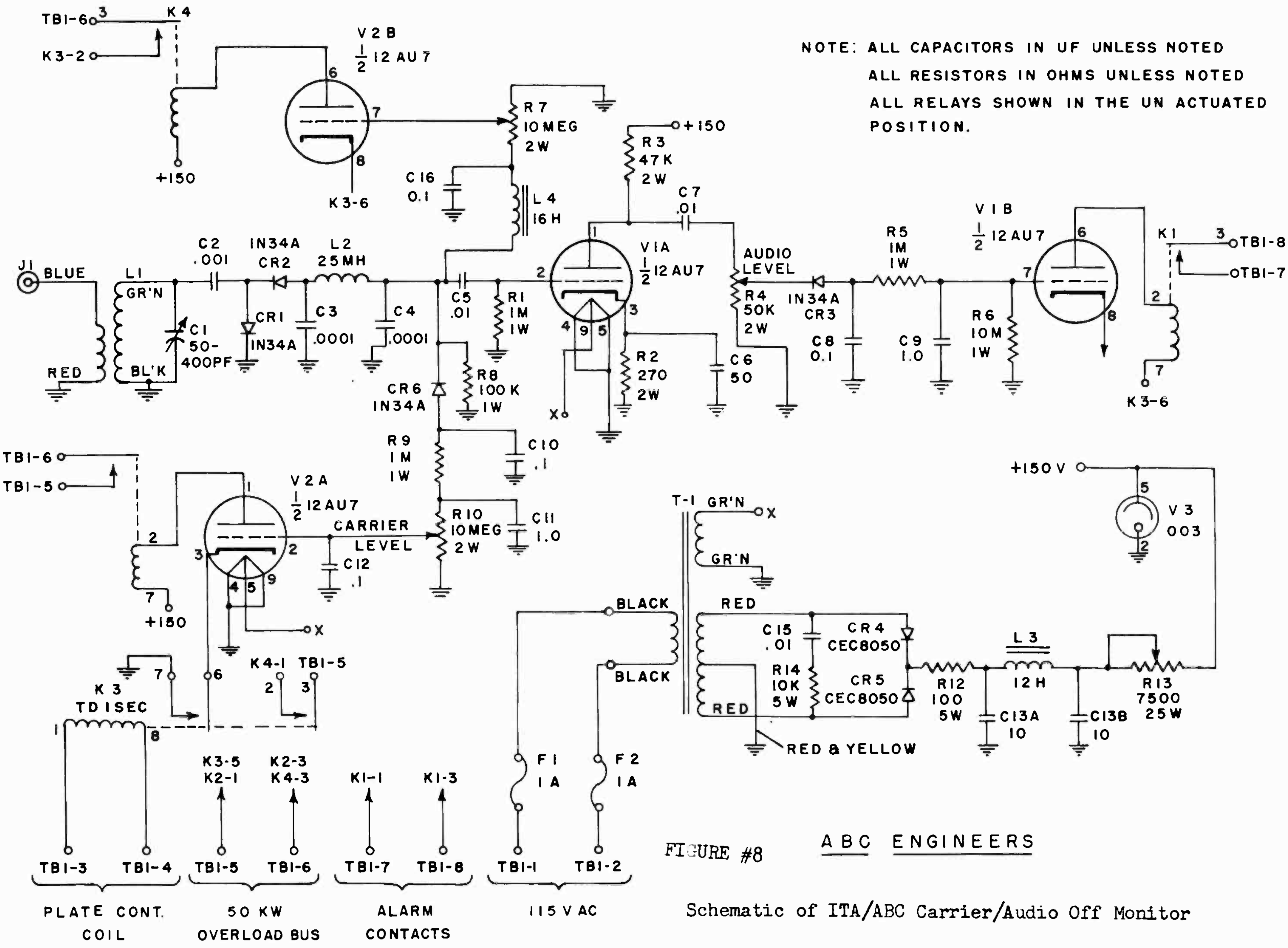


FIGURE #8

ABC ENGINEERS

Schematic of ITA/ABC Carrier/Audio Off Monitor

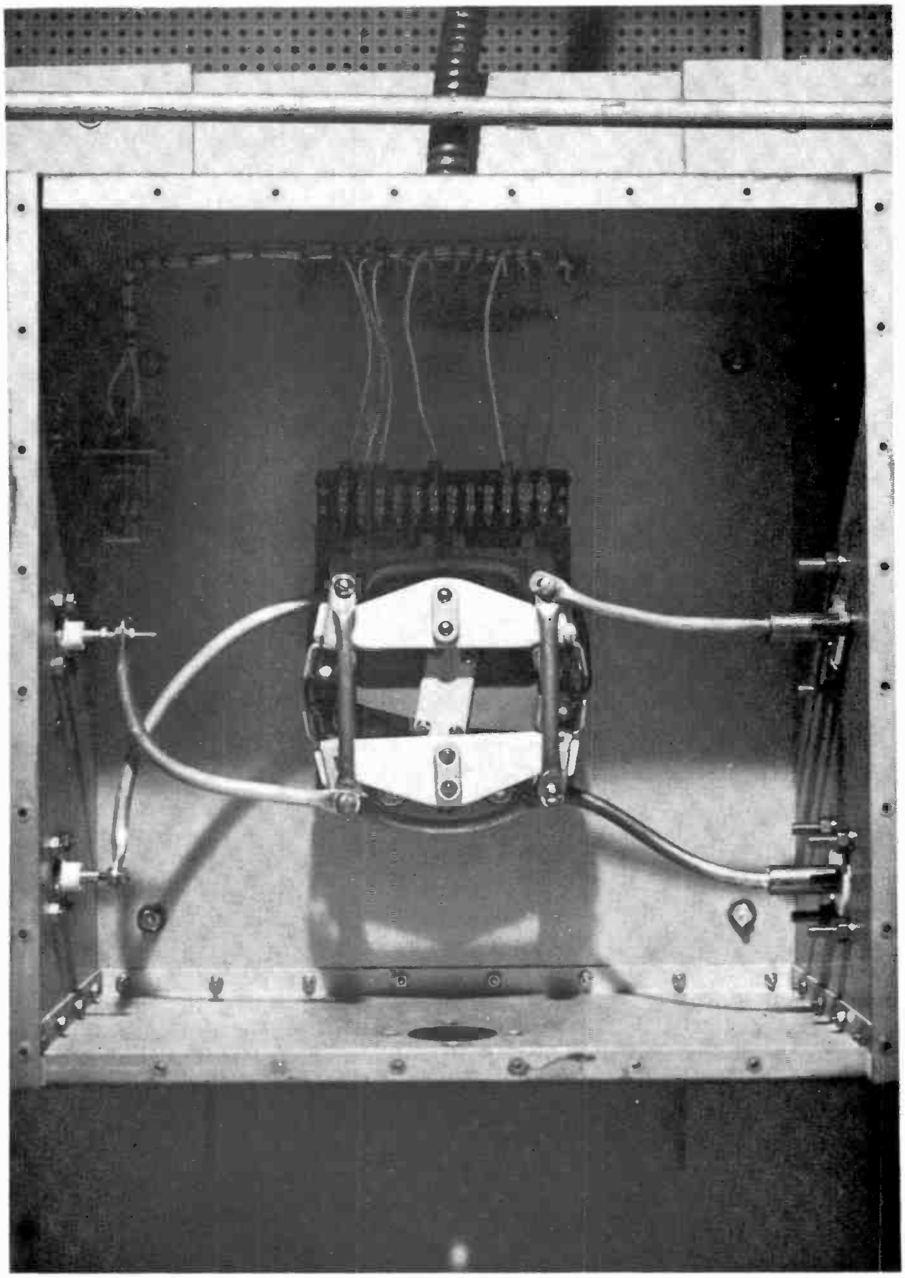
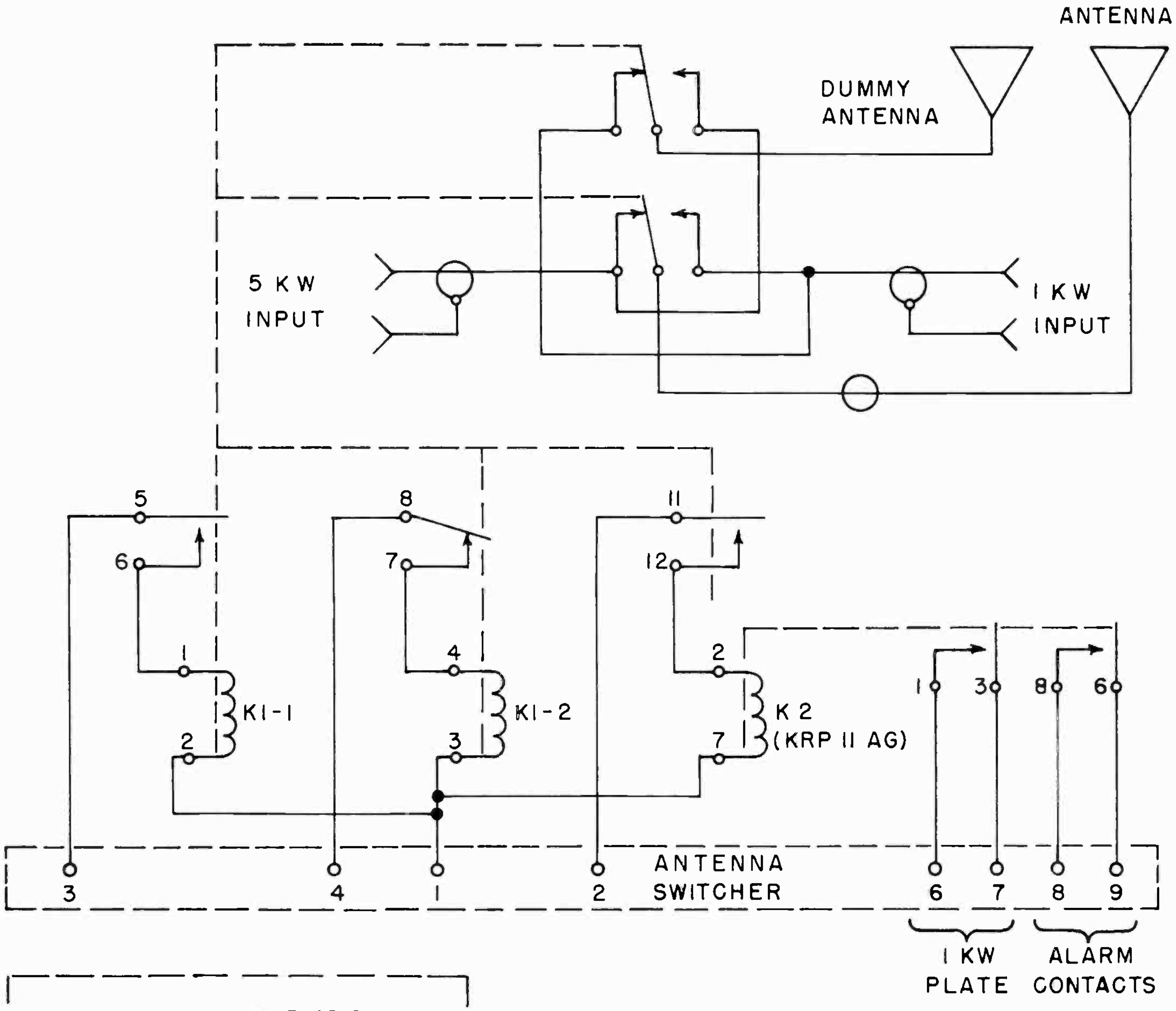
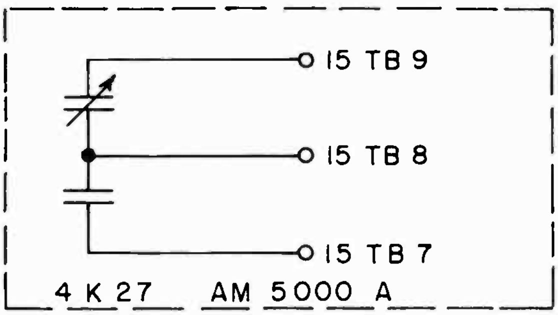


FIG. #9 - ANTENNA RELAY (TRANSFER)



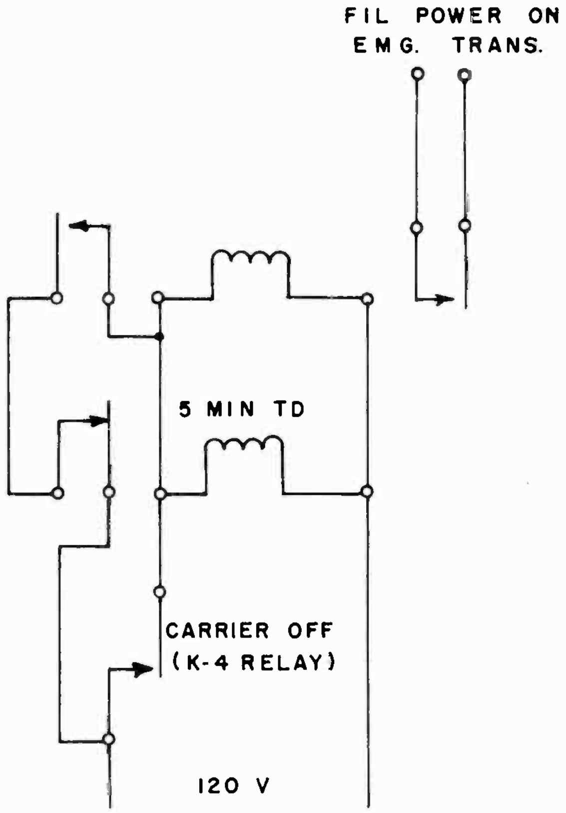


NOTE SWITCH SHOWN AS 5 KW
CONNECTED TO ANTENNA

A B C ENGINEERS

ABC TRANSMITTER SWITCHING RELAY
SCHEMATIC

FIGURE #10



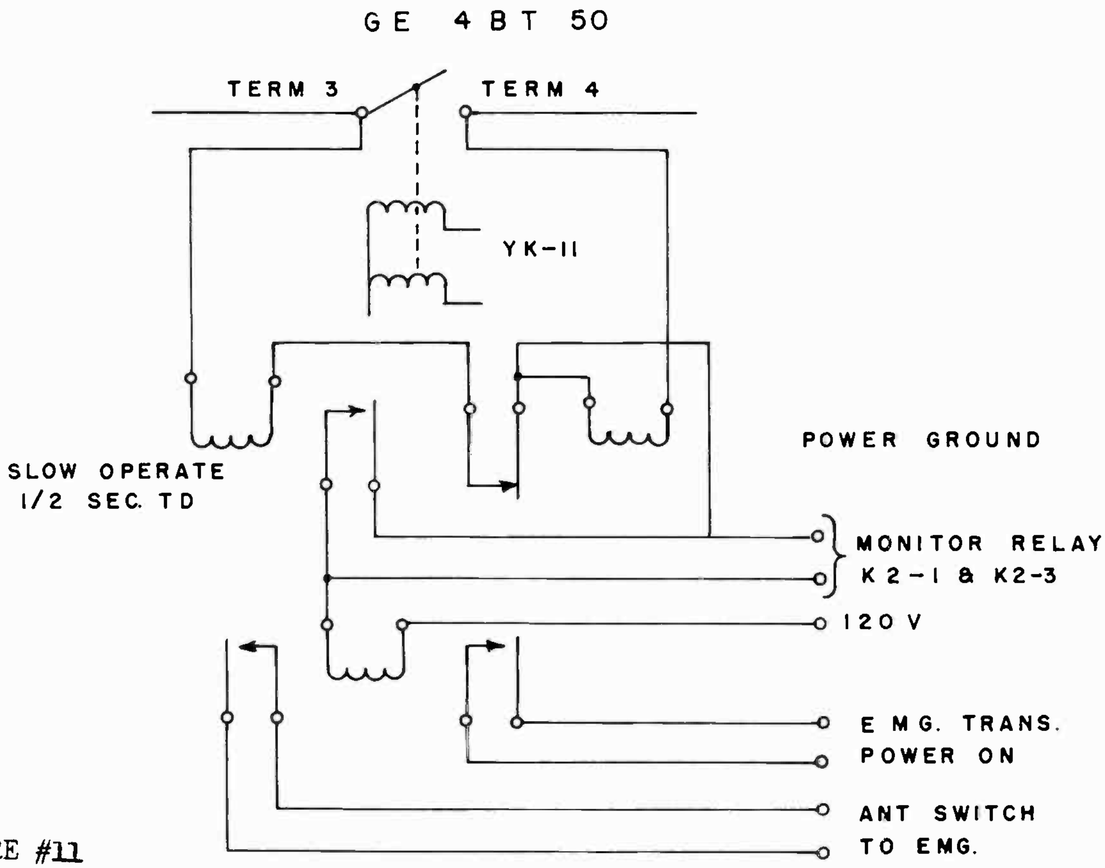


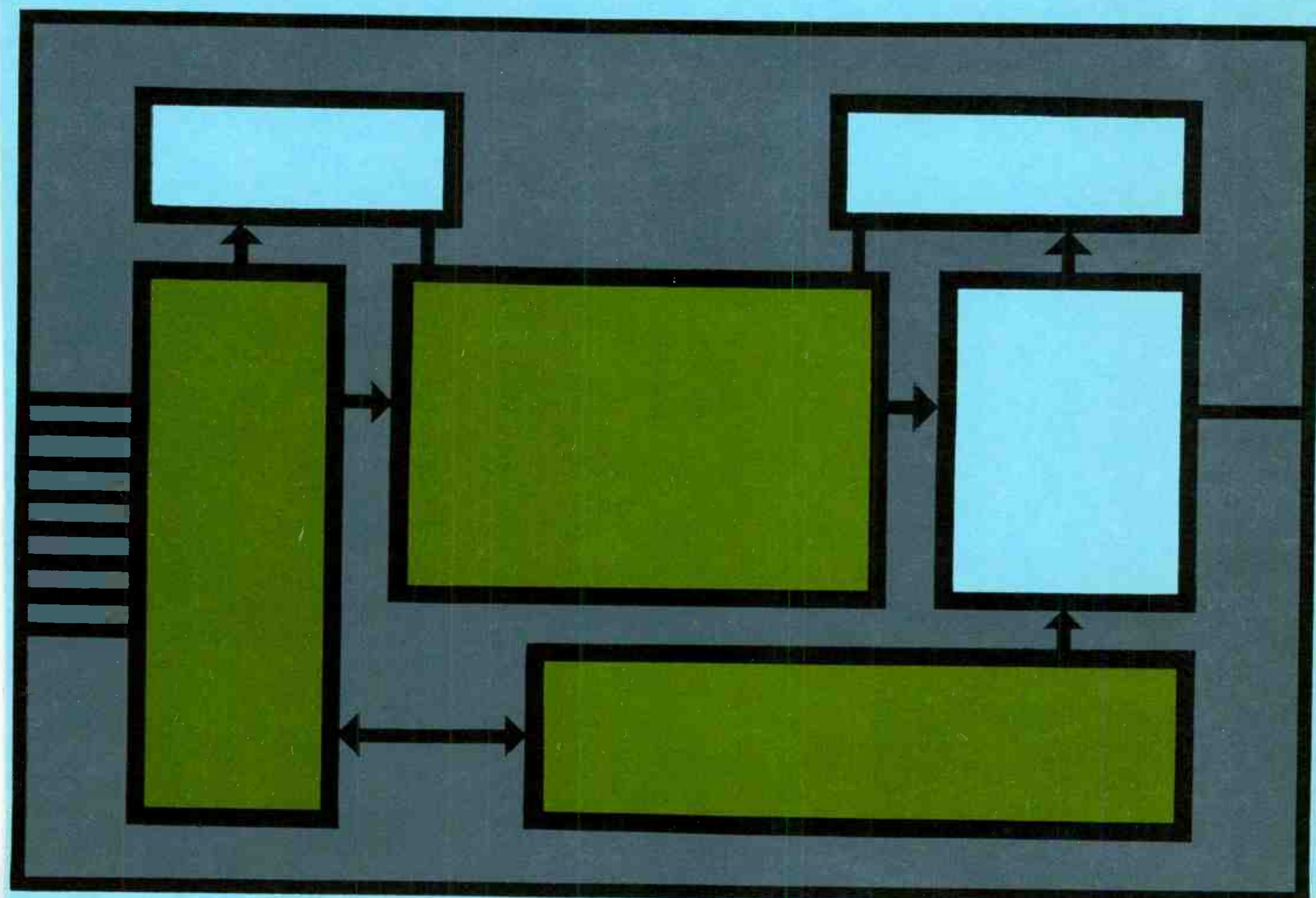
FIGURE #11

lays used in GE BT-50
C Transmitter-Lodi, N.J.

ABC ENGINEERS

INDIANA GENERAL UNICON

...an automatic television program controller with a magnetic core memory



UNICON

Automatic Television Program Controller

PREFACE

UNICON is the name given to a family of automatic television programmers produced by Indiana General Corporation. UNICON — a contraction of "Universal Controller" — effectively describes the prime design target of the UNICON development project. Specifically, the goal was: THE DEVELOPMENT OF AN AUTOMATIC PROGRAMMER CAPABLE OF CONTROLLING ALL THE PROGRAMMING STEPS AND EFFECTS REQUIRED FOR MAINTAINING CONTINUITY OF PROGRAMMING. THIS MUST BE DONE WITH AS MUCH OR MORE VARIETY (FADING, MIXING, ETC.) AS PRESENT MANUAL OPERATIONS ALLOW.

As a part of an initial design study, every television station in the country was canvassed. This was done by personal visits or by means of a mail questionnaire. Personal visits included stations operating with every existing type of automation available. The results of the investigation are themselves most significant. A total of 205 stations answered the mail questionnaire. This number, combined with the 55 stations visited, results in a very significant sampling of the industry. From the survey it was possible to determine the size and the operational features required for a programmer which would be most attractive to the vast majority of TV stations.

In the design of a programmer, it is absolutely essential to consider its effect on the organization of a control room with special emphasis on manual operation. The most efficient automatic programmer would have little value if it adversely effected the ability to handle sequences manually. The programmer and the switcher should be organized so that all controls, manual and automatic, are always active. Manual and automated events could, therefore, be mixed in any manner desired. Only in this way is it possible to exploit the programmer to its fullest potential, if it is to be more than a "station break" device.

The size of the control room crew for live shows is determined to a great extent by the most elaborate switching sequences which may be encountered. This crew size could be reduced if these few sequences could be automated by loading them into the programmer, with their starts programmed manually. The programmer thus becomes an important part of the control room in periods where manual operation is required for artistic reasons.

It was for this reason that as a part of our study a significant effort was devoted to the investigation of the organization of switching systems for combined automatic and manual operation. This resulted in the development of switching configurations which are significant in themselves, and merit serious consideration even when automation may not be contemplated. The flexibility of operation obtained per dollar of equipment cost is most attractive.

With UNICON it is valid to claim that we have reached an ideal position regarding automation. That is, without regard to improvements in operation, error elimination, etc., the cost of the equipment is self liquidating in direct savings of labor.

PART I

The Operation of a Core Memory

One of the important blocks in the machine is the core memory. A brief discussion of the basic configuration and operating principles will be given here.

The function of the memory in the system is the storage of the program. Since the program consists of 25 words of 12 characters each, the total store capacity of the memory is 300 characters. Each character consists of 5 binary bits, hence, the total bit capacity of the memory is 1500 bits. Twelve 5 bit characters are assembled in registers to make up one instruction word for the programmer. The memory operation is random access by word and sequential access by character, within a word. The memory is organized as a coincident current memory consisting of five frames of 300 cores per frame. The cores are arranged within the frame in arrays of 25 rows by 12 columns.

In order to understand how a core memory operates, it is important to know the basic element of the memory, the magnetic core. The magnetic core in this memory is a ferrite toroid of 50 mil-inch outside diameter and 30 mil-inch inside diameter. The core exhibits a magnetic hysteresis loop which is rectangular in shape. (See Figure 1) This unique feature of the core is what makes it suitable for application as a memory element. If we examine the rectangular hysteresis loop presented in Figure 1 (this is an ideal loop) it can be seen that for applied magnetic fields lower than the threshold field, fields lower than point Hc of Figure 1, no change of flux will take place. Once a field exceeding this threshold field is applied, flux is switched from one remnant state of the core to the other remnant state i. e. Br^+ to point Br^- in Figure 1. Once this field is removed, the flux state will not return to its original remnant state but assume a new stable position in the opposite remnant state.

The property exhibited by the core, of remaining in a remnant state after the magnetic field has been removed, is the property used for storing information in these cores. The actual mechanism for storing information is achieved as follows. If arbitrarily we assign the binary state "ONE" to the positive remnant state and the binary digit "ZERO" to the negative remnant state, we have then achieved a memory cell capable of storing either a "ONE" or a "ZERO" information bit.

To enable the storage of meaningful information these cores are arranged in arrays. Figure 2 shows a 4 x 4 array. The size of an array determines the number of words or characters a memory is capable of storing. A number of these core arrays are then electrically connected together as shown in Figure 3. The number of these arrays determines the number of bit capability per word or character. Each core in the array is coupled by two selection wires, crossing through each core perpendicular to one another, (these are the wires labeled the X and Y wires in Fig. 2) one sense wire and one digit wire.

The selection wires are used to select a desired core or storage location in the array. The diagonal winding, threading the cores in the array is the sense winding. The function of this winding is to sense the flux switched in the core when selected. It is a balanced winding wound for optimum noise cancellation. The inhibit winding is pulsed when a "ZERO" is to be written into the memory. Because of the way these X and Y wires are arranged (See Figure 2) only one core lies at the intersection of any one X and Y wire. If a pulse current of magnitude less than the threshold value of the core is simultaneously applied to one of the X and one of the Y wires, only the core at the intersection of the X and the Y wire will experience sufficient magnetic field intensity to be switched from one remnant state to the other. All the other cores coupled by the selected wires will be experiencing magnetic fields less than the threshold field, therefore, no flux will be switched in these cores. Flux will be switched only in the core at the intersection of the selected X and Y wires. As an example, if in Figure 2 a field is applied to the wires labeled X1 and Y3 then only core (1, 3) will have sufficient field amplitude to cause the reversal of flux.

For determining the contents of the memory the magnetic field is applied to the selection wires in a way which will tend to switch the core from the "ONE" state to the "ZERO" state. If the interrogated core is storing a "ONE" i. e. in the positive remnant state, then a flux reversal will take place, the hysteresis loop will be traversed from the Br^+ state to the Br^- state. This flux reversal couples a voltage on the sense winding which threads every one of the cores in a given array as indicated in Figure 3. If the core is storing a zero then it is already in the "ZERO" state, therefore, no flux reversal occurs when applying the magnetic field and no voltage is coupled to the sense winding. As can be seen then, the information is actually destroyed when interrogating the core (in the process of interrogating the core was switched from the one to the zero state.) To make the core a long term memory, the interrogating cycle is followed by a regenerate cycle in which, under control of the digit line and a temporary store (flip-flop), the proper information is regenerated into the core.

The sense and digit lines are individual and discrete lines for every one of the core arrays in a memory. The X and Y wires are threaded through the same columns and rows of every one of the arrays, so that when magnetic fields are applied to the X and Y wire, one and only one core in every core array is interrogated, and information is read out in parallel on the sense windings of each core array. As mentioned above, the memory of this machine consists of 5 such core arrays, therefore, 5 of these cores are interrogated and read out in parallel.

Up to this point, discussion was only made on the operation of the core element and how it is organized into a component part of the overall memory system. In Figure 4, a block diagram of the memory system built around the core arrays is shown. As indicated, the following electronic elements are required in the memory system. The *address register* holds the location of the information to be selected in the core arrays. The *decoding network* decodes the "X" and the "Y" current switch that will generate the current pulses for producing the magnetic field required to select the cores. The *sense amplifiers* amplify the core output to the required logical levels. The *data register* converts the pulse outputs from the cores into the levels of desired duration. There is one sense amplifier servicing every digit frame, and one inhibit driver for every digit array. The *timing circuits* function to generate the required timing pulses to operate the memory system.

The memory system in the programmer is capable of two modes of operation. One mode of operation is the load mode under which a new program is loaded into the programmer. The second mode of operation is to unload mode. Under this mode the information is unloaded from the machine during memory scan operations. Memory scan is done at a one thousand character per second rate. Load and unload operations can be interlaced in the programmer. Memory locations can be addressed in the memory in a random manner for loading information into the memory, or for displaying contents of memory locations by means of switches on the memory control and display panel. Figure 5 indicates a typical core output. Figure 6 shows the core stack of the memory.

PART II

The UNICON Programmer

UNICON is not a computer! It is a special purpose, stored program, digital control machine with a magnetic core memory. It is capable of controlling 50 video sources, coordinating their output signals with the proper mixture of audio material and feeding these to the output line of the station, properly organized, without interuption or error. All functions related to the control of both audio and vidio sources, including the ability to vary transition speeds and to super (or mix) events, are performed without any manual intervention. Because of the depth of its memory UNICON is capable of performing these functions without supplemental storage such as paper tapes or cards (although it will accept them). Loading is performed directly by the control room operator.

AUTOMATIC CONTROL IS PROVIDED FOR THE FOLLOWING OPERATIONS

1) Preselect

At times it is necessary to select specific material prior to the time that a source is to be placed on the air. This may involve the selection of an audio cartridge, or a slide on machines which are capable of random selections. Preselect of a mode of operation on a processing or special effects amplifier may also be performed. 100 decodes are provided for this purpose.

2) Pre-roll

Prior to being switched "on air", many devices require fixed stabilization periods. The system automatically scans the memory to determine if a preroll condition exists and turns the machine on at the proper time. Provision is made for two values of pre-roll.

3) Preview

In Preview, the proper cross-point on the preview buss of the video switcher is energized. Any necessary projection lamps are turned on and the multiplexer arranged to permit previewing of the event. If an event entering preview shares the same multiplexer with the event "on air", it is necessary to inhibit the flipping of the multiplexer. The system provides for sensing this condition and as a result inhibits the transmission of "flip multiplexer" pulses until switchover occurs. Preview switching is always delayed until the "on air" transition has been completed to insure that signals are not switched while needed on the line.

4) Program

When an event reaches Program or On Air status, control pulses for the transition (in the manner specified) of the video signal to the program buss are generated. At the same time, control pulses are developed for feeding and mixing audio material.

In addition, multiplexer, lamp and start pulses are regenerated as a safety measure and to operate any multiplexer which was blocked in preview.

5) End Event

When an event leaves the air, control pulses are generated to stop machine sources, or to change slides, if specified in the instruction. Programming slide changes combined with the preselect mode should reduce the problem of duplication of slides significantly. Control pulses are also provided to inhibit switching at the audio buss if the audio of the next event is to be derived from the previous video source.

DATA STORAGE AND THE INSTRUCTION

A 1,500 bit dynamic, coincident current magnetic core memory is incorporated into the programmer for instruction storage. The basic instruction word is made up of twelve, five-bit characters (4 bits data and 1 bit parity). Therefore, the memory has a capacity of 25 instruction words. Since the event On Air and the event in Preview are no longer in the memory, the system has a capacity of 27 events.

Figure 7 is a composite diagram which shows the organization of the instruction word, the basic layout of a typical event display unit, and a chart of the characters used for memory. The 12 characters are organized into fields as follows;

Operate	2 Characters
Audio	2 Characters
Video	2 Characters
Control	4 Characters
Next Address	2 Characters
Total	12 Characters

OPERATE FIELD — (2 Characters)

The first character of the instruction word specifies the type of transition which is to be performed.

0	0	No Switch
1	CT	Cut
2	F1	Lap Dissolve or Fade at a fast rate
3	F2	Lap Dissolve or Fade at a slow rate
4	MX	Mix or Super
5	S1	
6	S2	
7	S3	S1, S2 and S3 are unassigned codes whose functions may be selected from a large group of capabilities which are optional. These selections may be made without modification to the system.

As an event enters Preview a pulse is generated over one of eight lines corresponding to the code programmed in the instruction (this is the Preview Set Up Pulse). As the event is transferred to On Air, a second pulse occurs over a duplicate set of lines (Transition Pulse). These pulses may be routed to processing equipment in the studio to perform their necessary operations.

The second character specifies the selectable machine control functions which may be desired at the end of an event. They are;

0	0	No Switch
1	ST	Stop. This code is used when it is desired to stop the machine identified by the video field. In the case of a slide projector this code might also be used to change a slide while dousing the projection lamp.
2	CH	Change Slide. This code is used to make a slide change while keeping the lamp on, thus permitting slide changes while on air.
3	AL	Audio Lock. Audio Lock permits the retention of audio which is derived from a video source, while switching video. When this is programmed, the Audio Lock Line is pulsed as the event leaves the air.

CONTROL FIELD — (4 Characters)

The first character of the Control Field specifies the mode of control under which the Programmer is operating. The codes are:

0	0	
1	1	
2	2	
3	3	
4	M	Manual
5	CL	Clock Time
6	Q	Cue
7	P	Preselect

The modes of control of UNICON are Elapsed Time, Manual, Clock Time, Cue and Preselect. 0, 1, 2 or 3 are used to designate Elapsed Time, making this the first character of a 4 character Duration Field. This gives an elapsed time capability of up to 39 minutes and 59 seconds for a single event. (When an event controlled by Elapsed Time is placed On Air, a backward counter, coupled to the Control Display Field of the On Air Event Display, and controlled by a one second pulse generator, starts counting down. When it reaches 0, switch over occurs. During this count-down, the memory is scanned continually to determine if any events to follow require Pre-roll. If this condition is detected, the action is initiated.

Cue, Manual or Clock Time Events are those for which the exact duration is not known; or where, for the purpose of coordinating many locations, a switch is to occur at a specific Clock Time. A method has been developed to handle all three of these modes in the same way, merely generating the pulse that initiates the change differently. For Manual, the pulse is generated by pressing a button on the keyboard. For Cue, the pulse is generated automatically by some feed back device in the studio (metallic cue strips on projectors or cue tones on tape machines). Clock Time is generated from a digital clock if one is used in the plant. When any of these three modes have been specified, a duration value is entered in the last three characters at the time the instruction is loaded into the memory. This specifies the number of seconds prior to the change of events when this pulse is to be generated. Since the lead time for a cue may vary, it is desirable to be able to load this as a variable in the duration field.

When Clock Time is programmed, a second instruction word is utilized. The Operate and Audio Fields are loaded with zeros. The two characters of the Video Field and the four Control characters are loaded with the Clock Time in hours, minutes and seconds.

When Preselect is programmed, the Video Field is used to select the desired code and all other characters of the Operate, Audio and Control Fields are loaded with zeros. A Preselect instruction never reaches on-air status. Upon entering the preview register, the instruction is executed immediately and discarded.

AUDIO FIELD — (2 Characters)

The Audio Field of the system is organized to permit control of four audio channels simultaneously. Each channel may be controlled in one of three modes; Full Level, Under (approximately ½ level) and Off. Any two of these channels may be turned on at one time with the remaining two off. One channel would be turned on at the Full Level and the other at Under.

The first character of the Audio Field is used to select the channel which is to be on Full and the second character selects the Under channel. Therefore, the characters for each of these fields are identical, and limited to five possibilities, which are:

0	0	No Audio
1	SW	Switcher Buss
2	A	A Buss
3	B	B Buss
4	AN	Announce Buss

The Switcher Buss is one on which audio derived from a video source is fed. This buss generally follows the video switching. (One of the selectable features of the system is the ability to switch these audio and video sources separately).

The A and B busses would be used for audio tape devices or turn tables on which pre-recorded announcements or music could be fed. One channel might be used for selectable sources which are used frequently and could be selected at random, and the second channel for items which are used only once. The Announce Buss would be used for live microphones, for announce booth or similar installations.

An audio amplifier has been designed to operate with this system in which all of the changes in state of any of the four audio channels are fast fades. Therefore, the audio switching always gives a soft effect. Furthermore, if the switcher organization developed in conjunction with this programmer is employed, the Operate Code may be used to control the mode of audio switching as well as video, thus programming audio fades similar to video.

Three output lines are provided in UNICON for each of the four audio channels (making a total of 12 lines). As transitions occur, one line to each of the channels is pulsed in the combination specified by the instruction to set up the channels in the desired manner of Full, Under and Off.

VIDEO FIELD — (2 Characters)

The video field is made up of two characters. This field is fully decoded so the system is capable of recognizing 100 different combinations.

1) When the instruction is used as a Preselect, these decodes are used to make the desired selections as the event enters Preview. A single pair of contacts is provided for this purpose for each of the 100 decodes.

2) When the instruction is used as an Elapsed Time, Manual, Cue or Clock Time Event, the field is used to select the video from which the program material is to originate. (In special cases where split audio switching is employed this will identify the audio source). Fifty decodes are fully implemented as outputs — provided with six sets of contact closures to control all of the functions which might be required for a video source. The specific decodes used to identify these fifty outputs may be selected in the field in order to accommodate the different requirements of each station without modification to the system.

Since the significance of a particular decode will change depending on the type of instruction, special displays were designed to project dual legends wherever they might be applicable. A large numerical character is placed above a small alpha or alpha-numeric legend. The first character of the field may be used to identify a type of video source (T-Telecine, VT Video Tape, ST Studio, R Remote). The alpha designation of the second character is used only to designate locations on a multiplexer, with the third code used to identify a slide projector. Thus, with a minimum of interpretation the display can be used to identify preselects or video sources in any manner required by the station.

If for some reason more than 50 source decodes are required, additional contacts may be added in the field by the simple addition of relays and connectors. UNICON can actually control 100 video sources.

NEXT ADDRESS FIELD — (2 Characters)

The last two characters are used to select the location of the next instruction in the memory. The operator is now, in effect, made the programmer of UNICON. By making a selectable function of the order in which events loaded into the memory are acted upon, it is possible to add or change events in the Program Schedule without disturbing information already loaded into the system.

For example, if 20 events were loaded and it was determined that a few events must be inserted between events 5 and 6, this could be done without disturbing the loaded portion of the memory. The instruction loaded in cell 5 would have its Next Address Field changed from 06 to an empty memory location. The new instructions would be added. The last operation would be to direct the sequence back to cell 06 at the end of the insertion.

The importance of this field cannot be over-emphasized. This is the only automatic programming system available which makes adding or changing events a simple task, making the system suitable for controlling many types of live programs and news shows.

SOME ADDITIONAL COMMENTS ON THE ORGANIZATION OF UNICON OUTPUTS.

The Timing Diagram, Figure 8, illustrates the relationship of the various contact closures which may be made during a one second interval, depending upon the sequence of events. These contact closures are used to route the plant control voltage to the proper machines. (If required, the duration of these pulses may be changed, however, only one value may be used for the entire facility).

The contact closures shown in Figure 8 are classified into groups which are identified by headings across the top of the diagram. It is most significant to note that there is a short delay between each operation, and to note the order in which these pulses occur.

All of the pulses listed vertically at the left of the diagram, (except Transition, Audio Output, Audio Lock and Preview Set Up), are related to and identified by the decode in the video field of the instruction word. If all of these control functions determined by the video decode were performed simultaneously, considerable redundancy would have to be provided in the output circuitry to select the various machines going on air, leaving air, entering preview, etc. Furthermore, it is desirable to delay any functions to be performed on the machine leaving the air until after the change over is effected. Setting the new event up in Preview approximately 150 milliseconds after line switching has occurred permits a more varied organization to the switching system. For example, Preset and Cut Bar switching procedures must be considered when automation is contemplated. Oscillating control paths may develop if the functions of placing a new event in Preview is performed when the cut bar is operated.

The method of handling signal switching control is of particular significance. A truly versatile control system must have the ability to control switching sequences involving a variety of fading and mixing of sources in addition to simple transitions. The routine of placing a source on the Preview Buss of the switcher as an event enters Preview and the transferring of it to line is no longer valid. In fact, the routines involved become quite complicated. This complication is further compounded by the variety of operational procedures various stations wish to employ.

There is a Source Selection Line for each of the 50 codes used to identify video sources. As may be noted from Figure 8, these lines are pulsed when an event enters Preview *and* when it goes On Air. Ninety-six sets of contacts are provided through which these Source Selection Lines may be routed. Depending upon the needs of a particular plant, the number of these contact sets assigned to each video switcher input may vary.

For each input, a set of contacts would be required for each switcher buss you wish to control separately. To control Line, Preview and an Auxiliary Video Buss, three sets of contacts would be required. A fourth set of contacts would be needed to switch audio separately. (That is, if a control room is organized so that audio, from a video source, can be switched separately, this function may be programmed in UNICON).

Once UNICON is instructed as to the significance of the various codes in the Operate Field, it routes the Source Selection Pulse to the proper switcher buss automatically. Once again, depending upon the type of switching system employed, all of the logics exist in the programmer to direct these source pulses properly. Furthermore, this organization of the system may be performed in the field and therefore, changed in the field. The fact that all of the necessary logics to perform this operation are included, eliminates the need for incorporating the control logics into automatic fading devices, and or need for special switching systems.

EQUIPMENT DESCRIPTION

UNICON is made up of three categories of equipment.

1) The logic and output frames are rack mountable units which may be located in studio equipment racks remote from the control position. Included with these frames are power supplies and blowers for forced air cooling.

All logic circuitry is implemented with solid state components and packaged on printed circuit boards. The output switching points and drivers for the displays employ high-speed, wire-contact relays. The core memory and internal pulse generator for timing control are included in the logic frame.

2) Four Display Panels (must be in operator's line of sight) are provided. See Figure 9.

On Air — Displays the instruction word for the Event On Air. The Operate and Next Address Fields are omitted from this unit.

Next Event — The event in Preview's entire instruction word is displayed here.

Auxiliary — The event following the event in Preview is displayed here. When loading the system manually or searching the memory this unit is utilized.

Next Clock Time Event — This display is provided to show the time at which the next transition will occur based on Clock Time.

The photo (Figure 9) shows a typical arrangement of the three event displays, and the Next Clock Time event. Considerable development went into the design of this unit permitting the display of a 12 character instruction in a 3½" x 19" unit.

3) Two Memory Control and Display Panels and One Input Keyboard (must be within operator's reach.)

The Memory Control and Display Panels shown in Figure 10 are used to indicate the load status of the 25 memory cells as well as to permit certain address and control functions to be performed.

The square indicator button is used for selecting a memory cell when searching or loading manually. A three position toggle switch above it is used to lock an instruction in memory or to skip an instruction in memory.

Three Indicator lamps are provided in each of the square buttons to indicate when the cell is loaded, when it is addressed and a parity error if it should occur.

The Keyboard, Figure 11 is used when entering data manually, to search the memory and for certain operational functions which may be required from time to time. Located to the left of the 10 digit data entry keyboard is a line of five switches which are provided to:

1) Hold—Delay transfer programmed in UNICON

2) Take — Advance transfer in UNICON

3) Manual — Generate Manual transfer pulse when programmed

4) On Line/Off Line—To disconnect UNICON's outputs

5) Manual Load/Automatic Load — Permit selection of automatic and manual load

The buttons to the right are used to address, display and control the memory.

1)) Load — Displays character being loaded on Auxiliary Display

2) Next Next Event — Displays event after one in Preview on Auxiliary Display

3) Search — To use Auxiliary Display to examine a memory cell

4) Reset Display — Resets Auxiliary Display

5) Change Preview — Clears Preview register and display and places the following event into preview

Above the keyboard under a hinged cover are controls for turning the system on and for resetting the parity detection unit. Since they will be used infrequently they have been located in this manner.

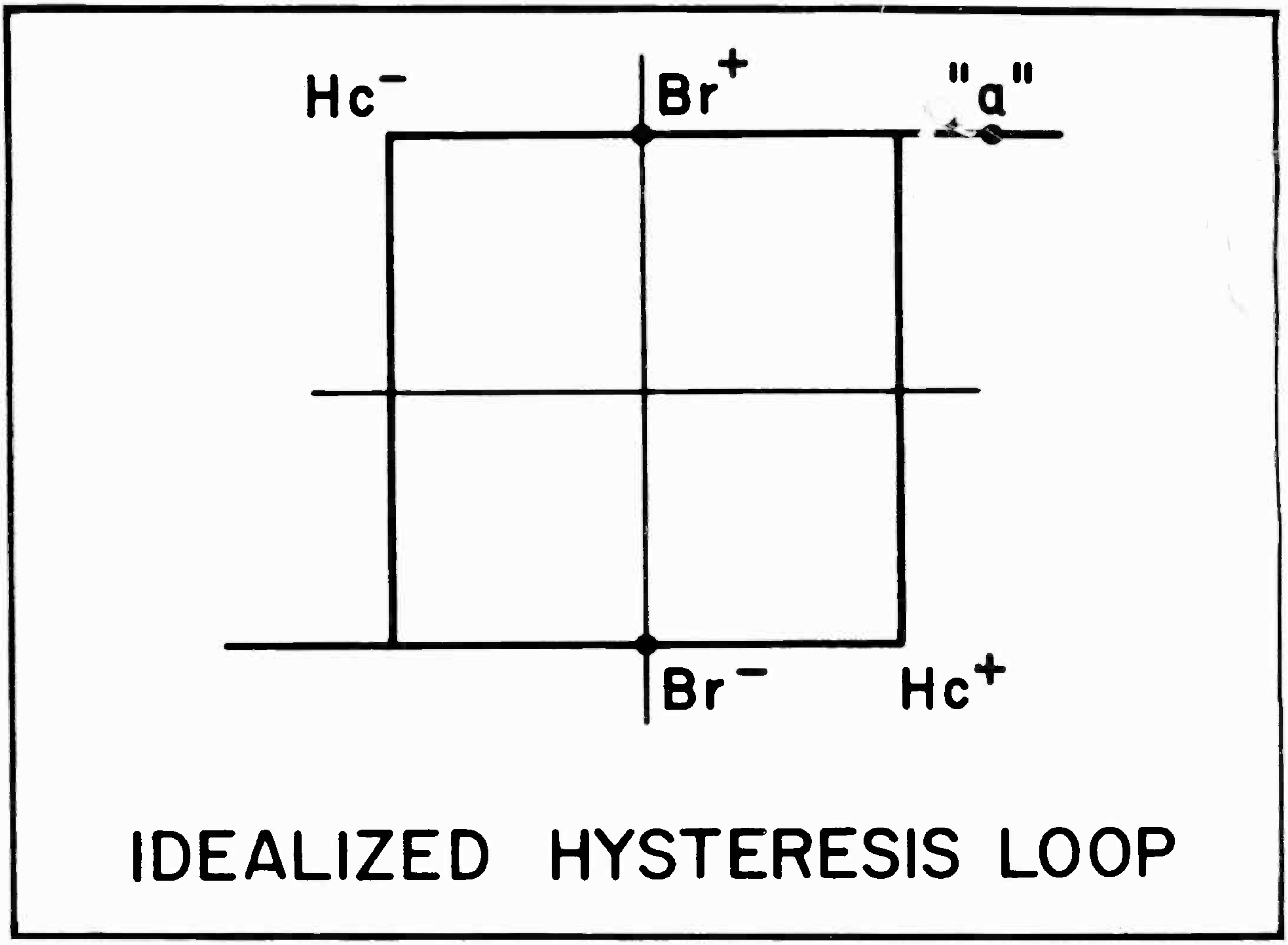
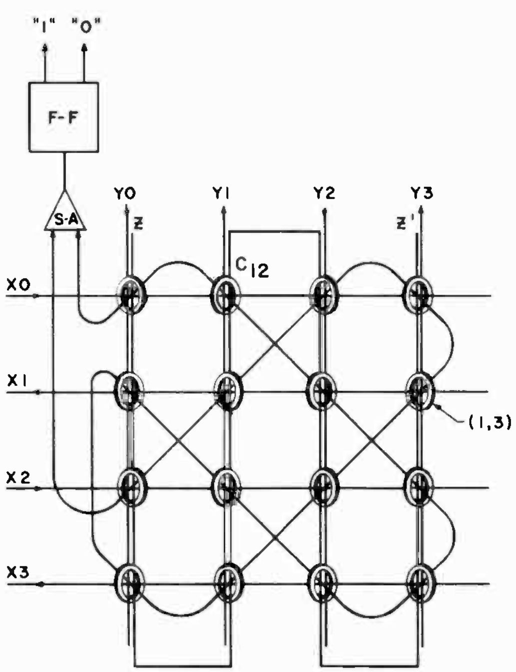


FIGURE 1



SIMPLIFIED 4 x 4 CORE ARRAY

FIGURE 2

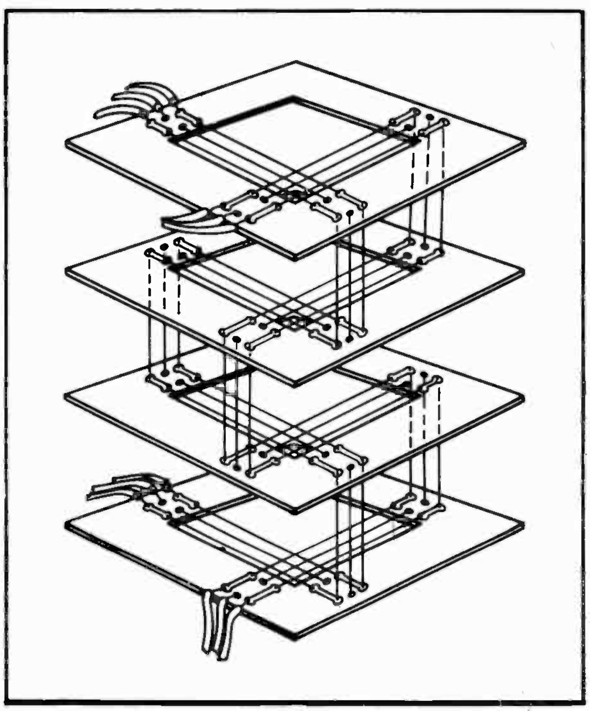
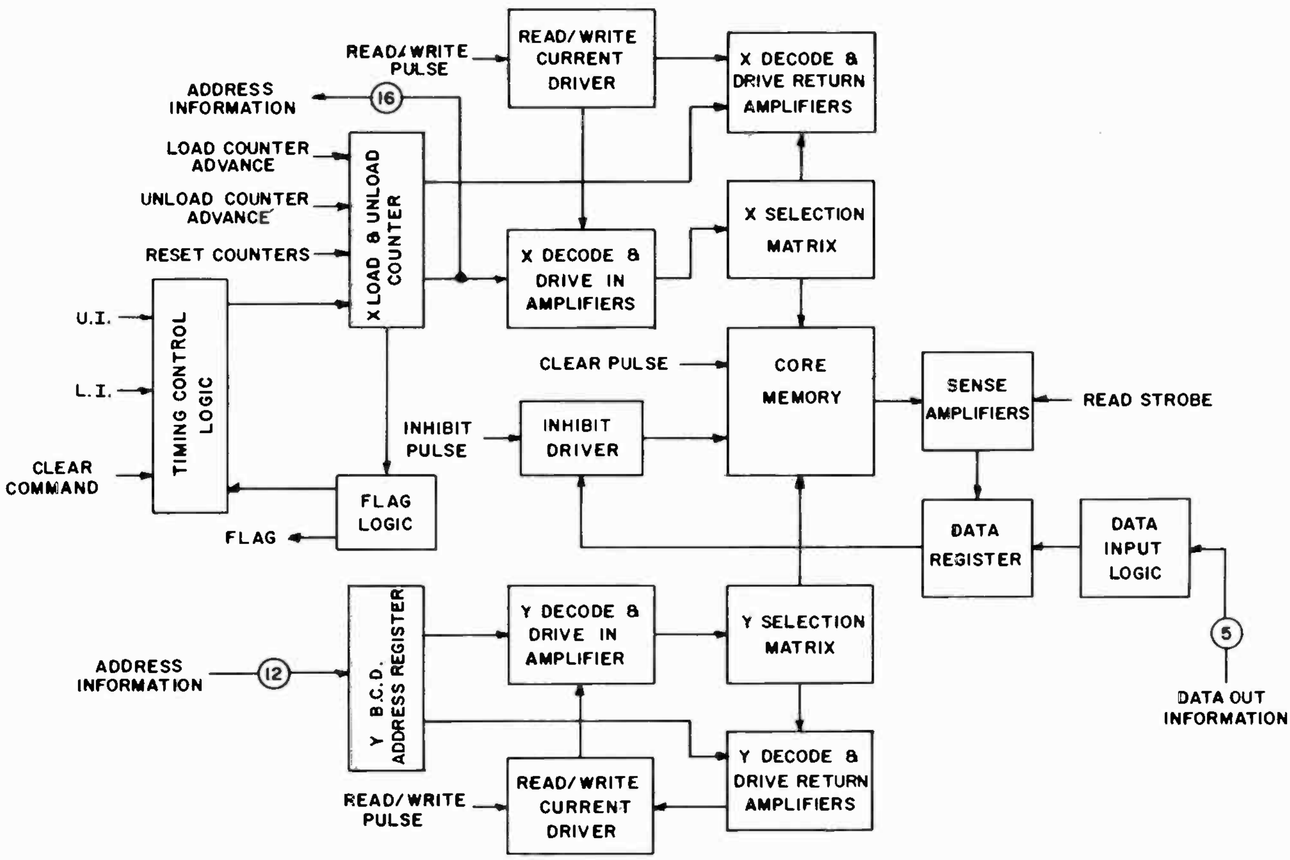


FIGURE 3



MEMORY BLOCK DIAGRAM

FIGURE 4

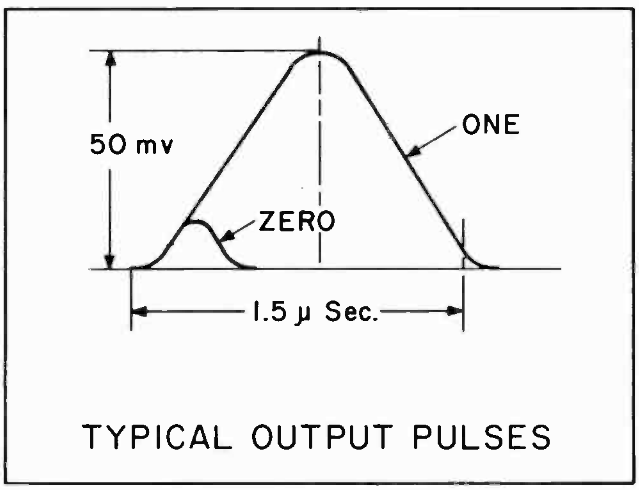


FIGURE 5

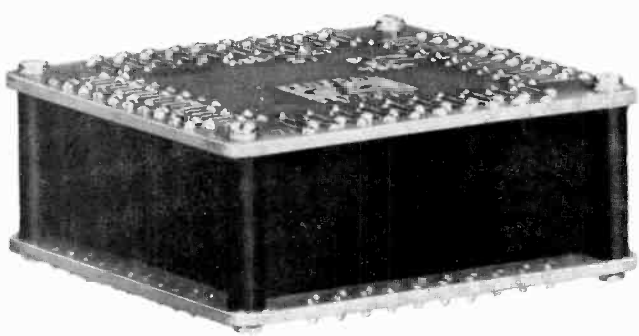


FIGURE 6

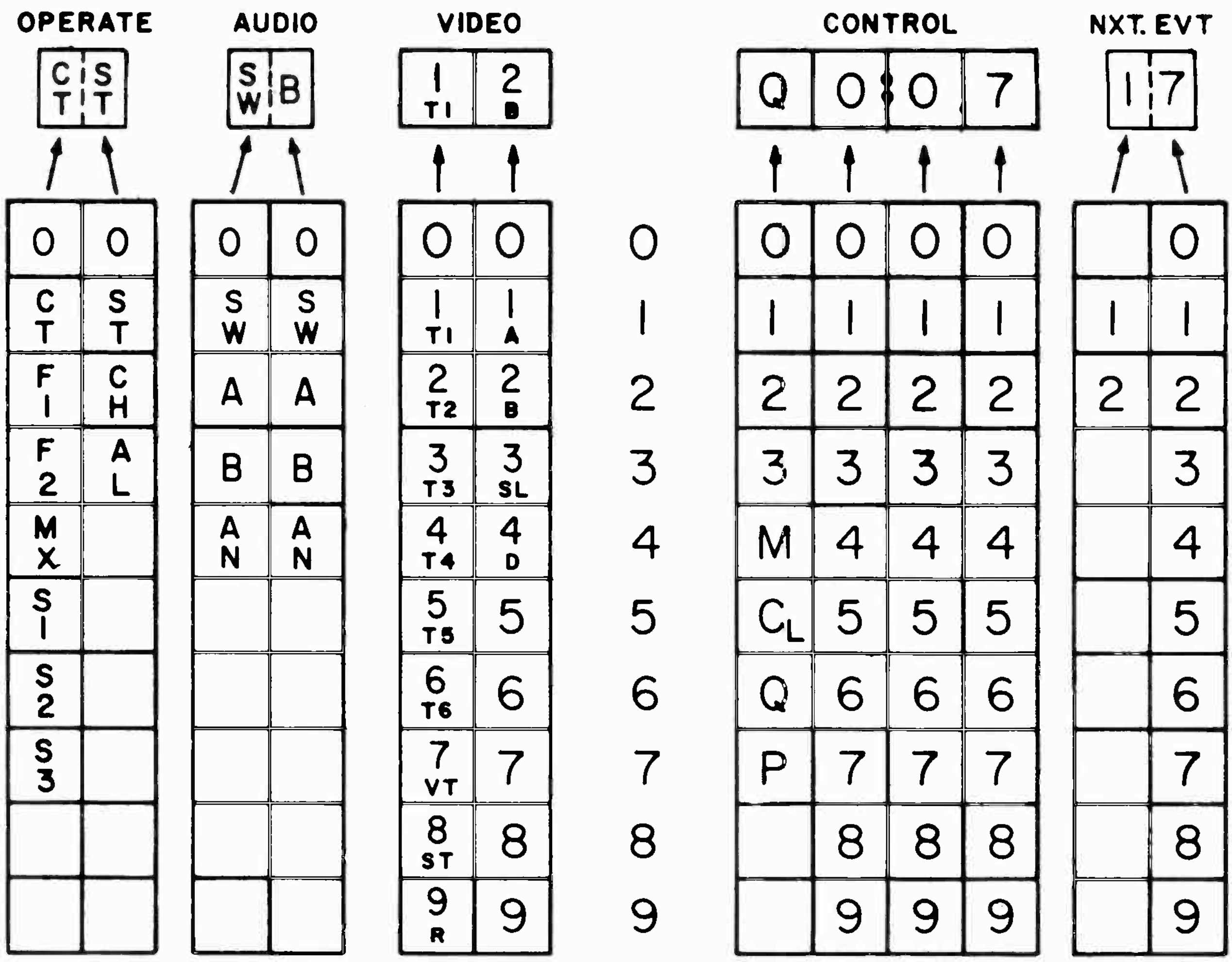


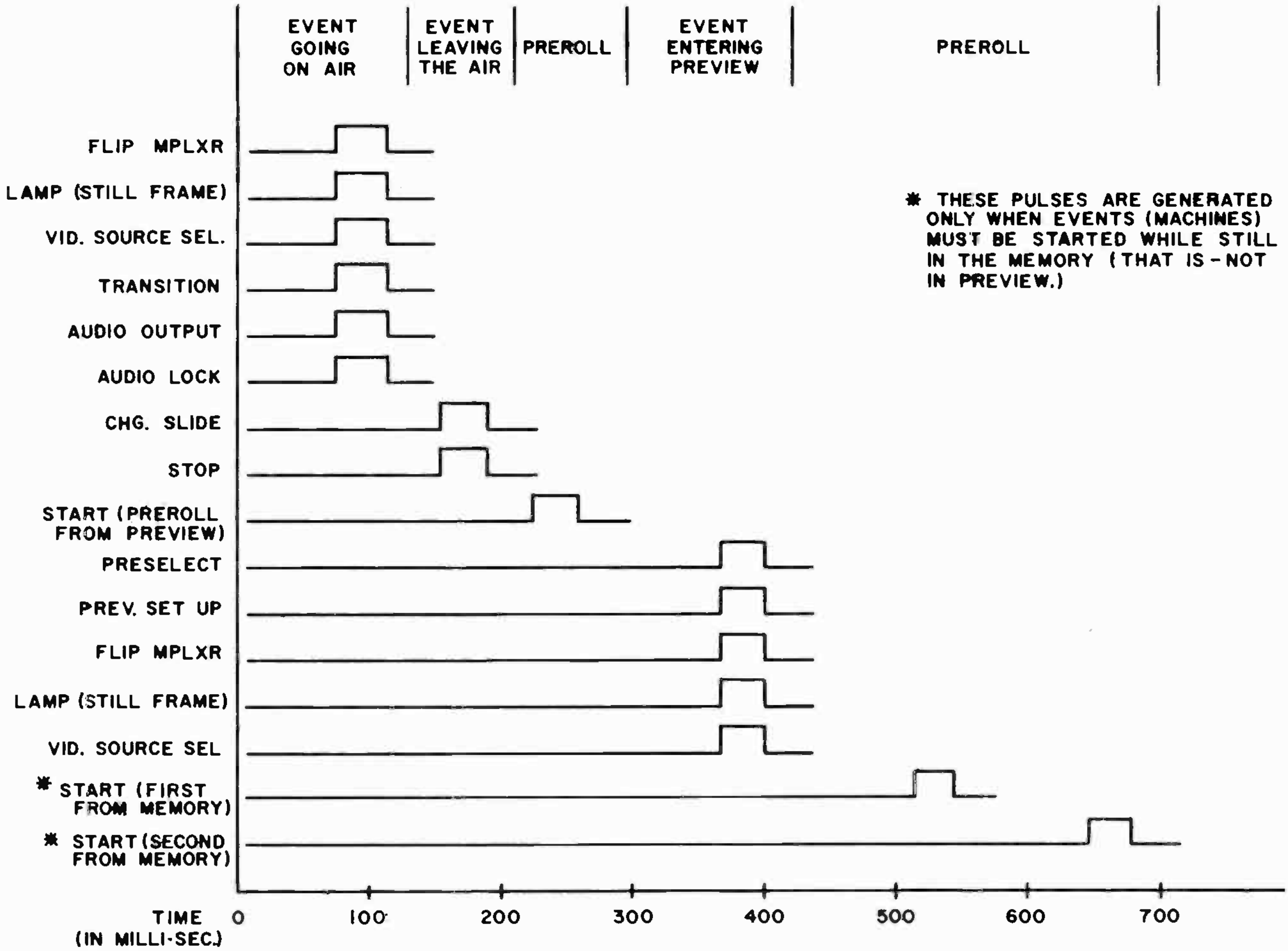
CHART SHOWING ORGANIZATION OF DISPLAY WITH LEGENDS

ST - STOP
CH - CHANGE SL.
AL - AUDIO LOCK

T - TELECINE
ST - STUDIO
R - REMOTE
VT - VIDEO TAPE

M - MANUAL
Q - CUE
C_L - CLOCK TIME
P - PRESELECT

FIGURE 7



TIMING CHART INDIANA GENERAL PROGRAMER

FIGURE 8

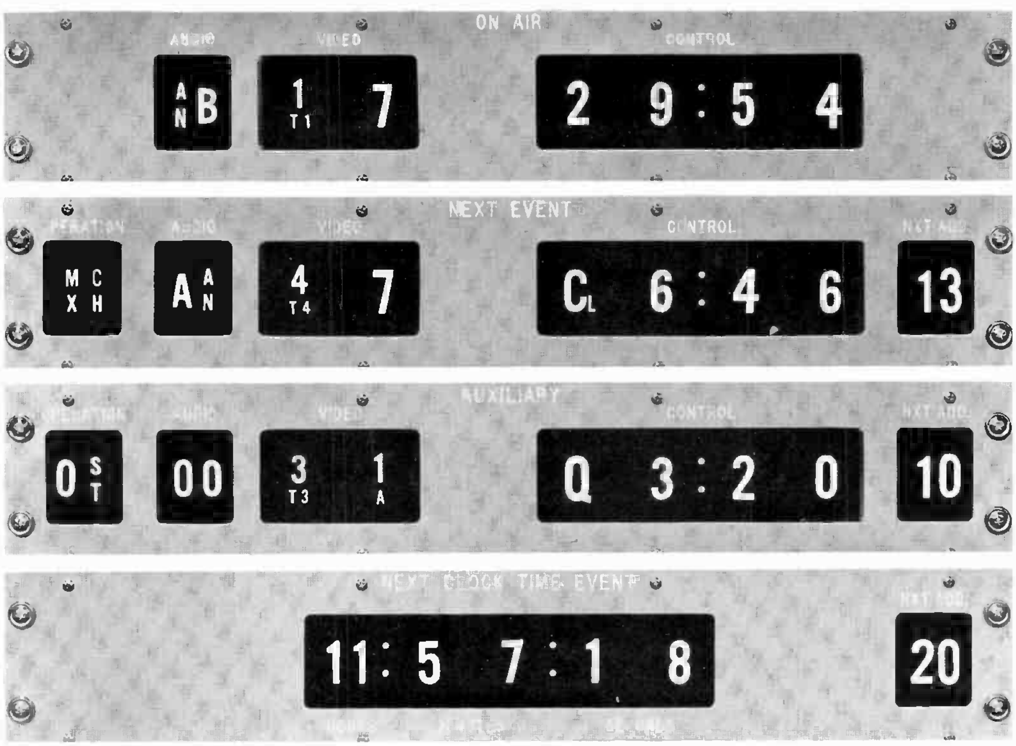


FIGURE 9

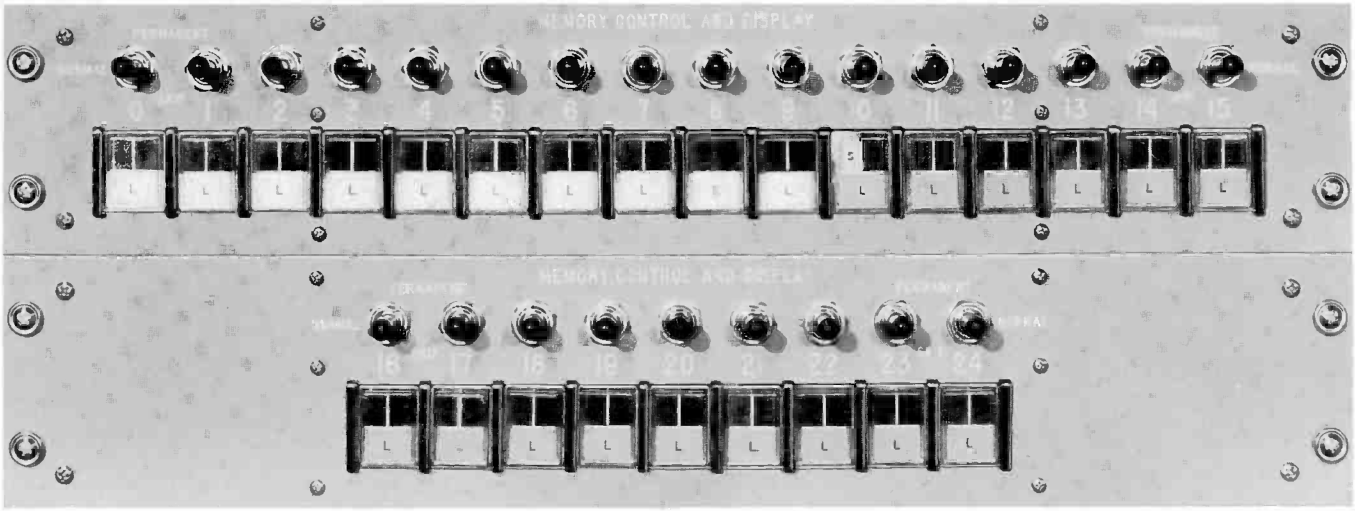


FIGURE 10

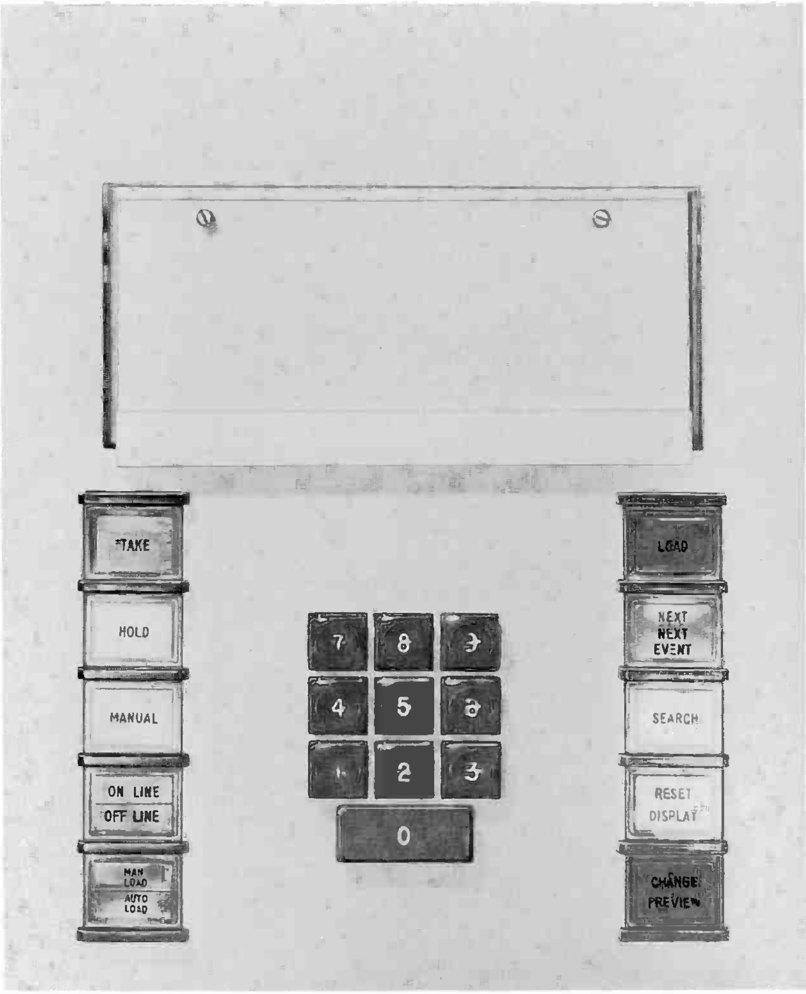
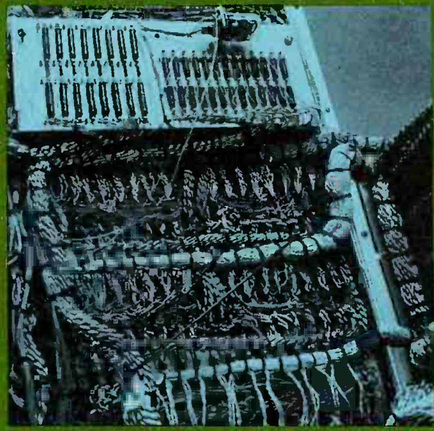


FIGURE 11





S C H U L O C K
A NEW APPROACH TO GENLOCK

A N D

TWO NEW APPROACHES TO COLOR-MONOCHROME SYSTEM INTEGRATION WITH SAME SYNC SOURCE

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S C H U L O C K
A NEW APPROACH TO GENLOCK

Nearly every television station has the need or at least the desire to time a local pulse source with some other pulse source. The customary system uses, at best, a sync stripping device followed by a device for locking the local pulse generator oscillator into time and phase coincidence.

There are several distinct disadvantages to this system. First and foremost, is the relatively large amount of time required to obtain lockup. This can be as short as a second in a well adjusted system, but usually is in the order of four or five seconds. The system is expensive although most stations have a stab. amp. or two available. Most genlocks are basically unstable, the slightest disturbance will unlock them, the 3 to 5 sec. of pulse picture which follow tend to infuriate sponsors and viewers alike. After living with these conditions for a number of years, we felt that the state of the microwave art had progressed beyond the sync loc art and most of the interuptions were momentary at most, so why not design a system which derives all its pulses directly from the incoming signal, thereby making instantaneous dropouts, just that.

The device herein described is such a device. KBTV has used this device for nearly a year now with considerable success. We supply a composite video signal to the Schulock, as we call it, from a series of selector buttons so that we can lock to a video tape, network, remote or off-the-air signal instantly. By putting the two standard sync source outputs, as well as the Schulock output on a stepping switch, we can do the tape layovers, etc. even though there may be only a second or two of stable sync immediately preceding video. The lock up time is a function of human reaction time rather than electrical phasing.

There are other uses for this gadget. It has been suggested that it could be used as a pulse source for multiple studio arrangements, thus obviating the need for four coax. lines from the sync source to each studio. It could be used as a spare sync generator. KREY in Montrose, Colorado uses it for this purpose since they receive an off-the-air signal from KREX in Grand Junction, Colorado. This makes a very inexpensive emergency pulse supply. As such, it could be used with a tuner as an emergency second sync generator on a remote. One word of caution, however, since an interuption of signal or a shift in composite signal timing will cause a corresponding loss in pulse output. Thus, we do not recommend the use of this device as a substitute for a sync generator except under the aforementioned special circumstances.

The Schulock takes composite video and separates the sync which in turn is amplified and clipped to provide a 4VPP sync output signal. The sync is delayed about .3 u secs. because of the sync separator ckt. This only means that the original non-composite video must be delayed the same amount before the sync is added in the switcher. This can be done simply by adding a length of coax. into the non-composite video input to the switcher. The amount will depend on how much delay is inherent in the system.

For the purpose of showing the method of deriving H.D., V.D. and Blanking and still maintain the proper timing with respect to the original signal, let's refer to the block diagram and waveform charts.

The separated sync is differentiated, clipped and amplified to provide a trigger signal. The first H. delay M.V. is a monostable M.V. whose output width is approximately one half TV line and because of this it ignores the 31.5 KC pulses during the vertical interval. All multivibrators in the Schulock are the monostable type and employ the same type of ckt. The second H. delay M.V. is triggered by the first and its width is variable to approximately another half TV line. The output of the second H. delay M.V. is used to trigger the H. Blanking M.V. whose width is variable in order to obtain the proper blanking width. The control in the second H. delay M.V. is used to set the front porch width. The output of the H. Blanking M.V. is fed to a blanking mixer and is also differentiated and used to trigger the H.D. M.V. The H.D. M.V. is also adjustable to provide H.D. approximately 6 u secs. wide. The H.D. is then fed to an output amplifier which provides four volt peak to peak output pulses. The separated sync is run through a standard integrator network, amplified and clipped to provide a square vertical pulse from which to trigger the first vertical delay M.V. and its output delays the timing one half TV field. The second V. delay M.V. provides another one half TV field variable delay to set the vertical front porch timing. The output of the second V. delay M.V. triggers the V.D. M.V. whose output is also variable to adjust for proper V.D. width. The V.D. M.V. output goes to an output amplifier that provides a 4VPP V.D. pulse output. The second V. delay M.V. also triggers the V. Blanking M.V. and its width is also variable. The V. blanking M.V. output goes to the blanking mixer where H. and V. blanking are combined to provide composite blanking. The blanking mixer output is amplified and clipped to provide a 4VPP blanking pulse output. The power supply is a series regulator using a 2N-301 and a 6.8 V. Zener Diode. The Schulock provides H.D., V.D., Blanking and Sync which can go to a sync changeover switch.

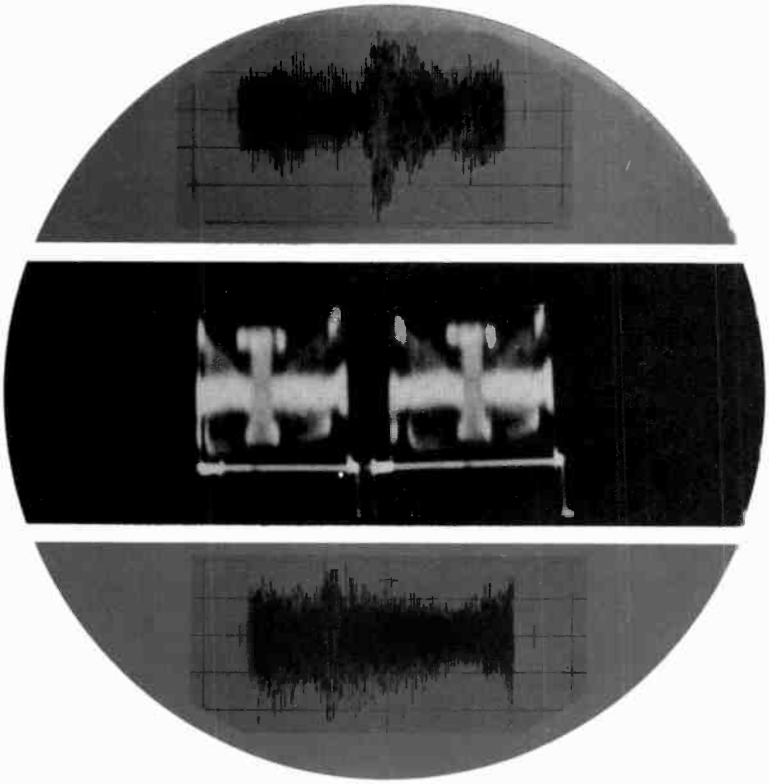
COLOR - MONOCHROME SYSTEM INTEGRATION WITH SAME SYNC SOURCE

In a system where monochrome and color equipment are integrated to use the same pulse and sync source, the problem of matching front porches when genlocked becomes complicated with extremely long delays and equalization of video cables. The inherent delays in colorplexers due to the use of a low pass filter in the luminance channel cause approximately 1.2 u sec. delay in color picture and blanking. To compensate for this delay in an integrated system the usual practice is to delay the drive pulses to the monochrome equipment, a like amount, with cable or lumped constant delay lines so the start of picture and blanking will match that of color equipment. This also requires delaying the sync pulses in the system so that the front porches are correct. Now a problem arises when genlocking; the stripped sync from the remote signal is used to time the local sync generator and a front porch phasing control is used to match the start of blanking of local cameras with the blanking of the remote signal, but when the system sync is added to the non-composite remote signal in the studio switcher the front porch is increased from a 1.7 u sec. standard to 1.7 + 1.2 or 2.9 u. sec. because of the sync delay. A solution is to delay the non-composite remote video 1.2 u sec., however, there are two other ways of solving the problem which do not require delaying the video or the necessary cable equalization that goes with long video cables.

The first of the two solutions to be discussed is - to remove all delay lines to the monochrome equipment that are normally required to match the start of monochrome blanking with that of color camera blanking. To accomplish this - electronically advance the start of drive pulses to the color cameras. We shall call this the "pulse advance system."

The unit which accomplishes this takes H. drive and V. drive pulses as inputs and converts them to H. drive and Blanking that are advanced in time 1.2 u sec. ahead of the pulses going to the monochrome equipment. The circuitry used to accomplish this is very similar to that of the Schulock except an automatic timing corrector is necessary to maintain the advance time precisely. Using this approach, the proper timing is maintained between the start of Blanking and the start of sync whether on local sync or genlocked to a remote sync source. Since a sync delay of 1.2 u secs. is not now necessary, the remote non-composite video does not require long delay lines. In other words, the pulse distribution system is simplified to the point where it resembles a "monochrome only" system for day to day operations since all delays inherent in the system are normalized.

The second solution is much simpler but more practical if a Schulock is used instead of Genlock. This solution requires only a relay to switch out the sync delay line when Schulocking, all other pulse delay lines for the mono system are left intact. The relay is operated by contacts on the sync changeover switch for the Schulock system. The reason this approach is more practical with the Schulock is that the remote stripped sync derived in the Schulock goes through the sync changeover switch and is used as system sync and the Schulock front porch control starts the Blanking ahead of it to match the remote Blanking. You can switch a line monitor from remote composite video to the output of the switcher where remote non-comsite video is added to system sync and not detect any difference in front porch widths when the front porch control is properly adjusted. A standard Genlock system maintains a fixed timing between the start of Blanking and sync and merely phases the sync. Needless to say, with a standard Genlock system, the instant the sync delay is switched out the front porch of local signals decrease from 1.7 u sec. to about 0.5 u secs. and the genlock phasing control will not change it. In fact, the front porch phasing control may not even have enough range to match Blanking start times with the delay line in the sync.



ABC ENGINEERS

ELECTRO-PHOTOGRAPHIC RECORDING

A.W. MALANG

NAB 1964

NAB - 1964

ELECTRO-PHOTOGRAPHIC RECORDING

A. W. Malang
Chief Video Facilities Engineer
ABC Engineers

Since the advent of television there has been a pressing need to record on film television programs for reasons of distribution and integration.

Historically, this function has been performed by equipment of dubious quality and reliability, and the resultant product has acquired a stigma that has resulted in the process not being used in a great many instances where it could be of great advantage.

The recent development of a process by which the scanned image of television could be converted to the discrete image storage on film stock will permit this technique to be used once again to very great advantage by Broadcasters.

Before delving into the technology of this new process, perhaps it would be well to review some of the facets of broadcasting which bear on the subject of recording.

Not too many years ago, Television recording was an art practiced by a few individuals with a tremendous problem and unlimited patience. The only avenue open to them was a process known as kine-recording, and the resultant product was in general so poor as to achieve a stigma not yet erased from the minds of many. The phrase "it looks like a kine" was the worst insult one could give a show.

In fairness, not all of the blame can be attributed to the equipment. The technology available at the time was severly limited, the exact characteristics of the process were unknown. Some of the early attempts used available hardware woefully inadequate for the task. To this day kine rooms are frequently buried away where touring guests won't see them.

The chief characteristic of the early equipment was that it coupled a TV display to a modified film camera. The display side was merely a typical monitor except that the tube phosphor was blue since the film was most sensitive to blue light. The camera modification was necessary because TV and film frame rates differ.

The first serious attempt at a professional kine recorder was made a decade ago by the General Precision Laboratories and resulted in a unit as in Figure 1A. The major features which led to the success of the unit were:

1. The development of a camera specifically designed for kine recording service (3:2 pulldown, vacuum film positioning, etc.).
2. The development of the electronic shutter so that precise shuttering of the frames was possible.
3. The use of a large diameter display tube to minimize the effects of phosphor grain and beam spot size available at the time.

In 1956, the American Broadcasting Company embarked on a large scale kinescope operation, not out of any fondness for kinescope operation and its product, but because the management had decided that TV programming would be more effective if done on a clock time basis (a given show could be viewed at the same hour in each of the time zones of continental U.S.). The only technique available when this operation was contemplated, that would repeat live programs on successive one hour delays was kine recording. The process involved recorders as in Figure 1A except equipped with 35mm cameras, rapid processing equipment of the spray type, and playback systems of monoplexed vidicons on 35mm projectors. Despite the fact that the system was operated in a manner which violated the then known "laws" of kine recording, the product was acceptable and operation was judged successful.

The following year, another technology was available for delayed broadcast. The Ampex Corporation had made available prototype versions of Television Recorders utilizing magnetic recording, and in 1957, the delayed broadcast operation by ABC was accomplished by "Videotape."

The "sages" of the industry rapidly predicted the demise of film recording, and many people laid grandiose plans to do on tape what had been attempted previously only on film. For a while TV film recording operations were almost at a standstill. For a substantial length of time the peace lasted, then lo and behold, the film recording load began to increase to where today the volume is even greater than it was before Videotape. To even the severest skeptics it was painfully obvious that instead of dying, TV film recording had merely taken a well earned rest.

A significant indication of this trend in broadcast operations was the announcement of a newly designed kine recorder, by one of the two U.S. manufacturers of broadcast Magnetic Television Recorders. The unit shown in Figure 1B is the RCA approach to fill the need.

Even this recently designed piece of equipment still uses the same basic technique of photographing the image on the face of a kinescope tube. This process is pictorially described in Figure 2, where the electrical signal input is indicated as a single camera output for simplicity. The electrical (Video) signal is then used to modulate the electron beam inside the cathode ray tube, and when the beam strikes the phosphor in the front of the tube light is created, and the modulation of the beam controls the amount of light. To the right of the figure is the camera with its film supply, a lens to relay the image from the face of the cathode ray tube to the film, and, in some units, a mechanical shutter to interrupt the light path when the film is being moved from one frame to another. The electronic shutter is used instead in some units, and accomplishes the same function of interrupting the light during film pulldown by turning off the cathode ray tube beam.

Any transducer is usually inefficient, and this process of starting with an electron beam, converting to light and imaging has an efficiency of a fraction of a per cent. Beyond the problem of efficiency, there are complications from the physical properties of the phosphor in attempting to get adequate light output to properly expose the film and simultaneously have the phosphor particles small enough so as not to degrade the resolution. Beyond these there are the expected optical problems, lens degradations and cathode ray tube faceplate degradations being the principal offenders.

Examination of the technology immediately suggests that the only two necessary items to the system are the electron beam and the film. Years of use of the electron microscope had suggested that normal silver emulsion films could be exposed by electrons just as well as by photons, and finally in the summer of 1962 the Eastman Kodak Company[1] demonstrated the feasibility of such a technique.

This new mechanism of television film recording is pictorially described in Figure 3 and the simplicity is immediately obvious, all of the optical elements are absent.

1. Photographic Data Recording by Direct Exposure with Electrons
A. A. Tarnowski and C. H. Evens

The electrical signal is used as before to modulate the electron beam, however, now the beam and the film are located in the same evacuated enclosure, and the beam traces out the image directly on the film, hence we have Electron Beam Recording. The developed negative made by the machine looks like any standard film negative.

What is probably most advantageous about this technique is its consistency. The characteristic of beam current vs. film density can be plotted for a specific development procedure, and with simple instrumentation the repeatability is very good. For operating people accustomed to video techniques the procedure is comfortingly familiar. Samples of positive enlargements from 16mm film negative frames are shown in Figures 4A and 4B. The two represent exposure for two different development procedures.

The source signal in both cases was an optical transparency viewed by a vidicon camera. The test chart is the BBC Test Pattern #52, which contains frequency and contrast scales as well picture information.

The characteristics of the film and exposure process are such that resolution far in excess of broadcast video bandwidths are readily achievable. The modulation transfer characteristic of the developed film vs. signal input is higher than any known optical exposure mechanism. The contrast range readily permits direct positive film with densities of the SMPTE Recommended Practice RP-7. Negatives of the proper range to print to RP-7 by normal processes are equally readily available.

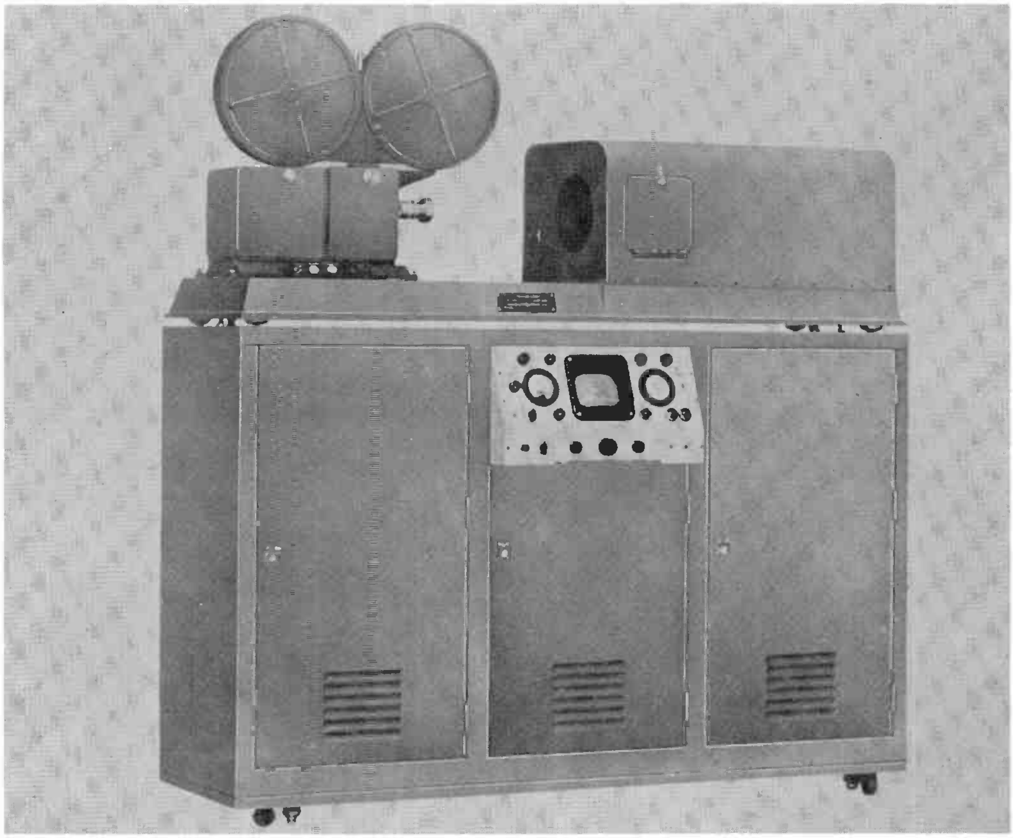
As far as can be determined to date the film output of the Electro-Photographic Recorder is superior to any other technique of Television Film Recording in use.

Such a tool will make it possible for the broadcaster to record on film video signals with excellent quality. Hence those areas of broadcasting which are best served by film can now be accommodated without the compromises presently necessary. The principal areas where this is of value are:

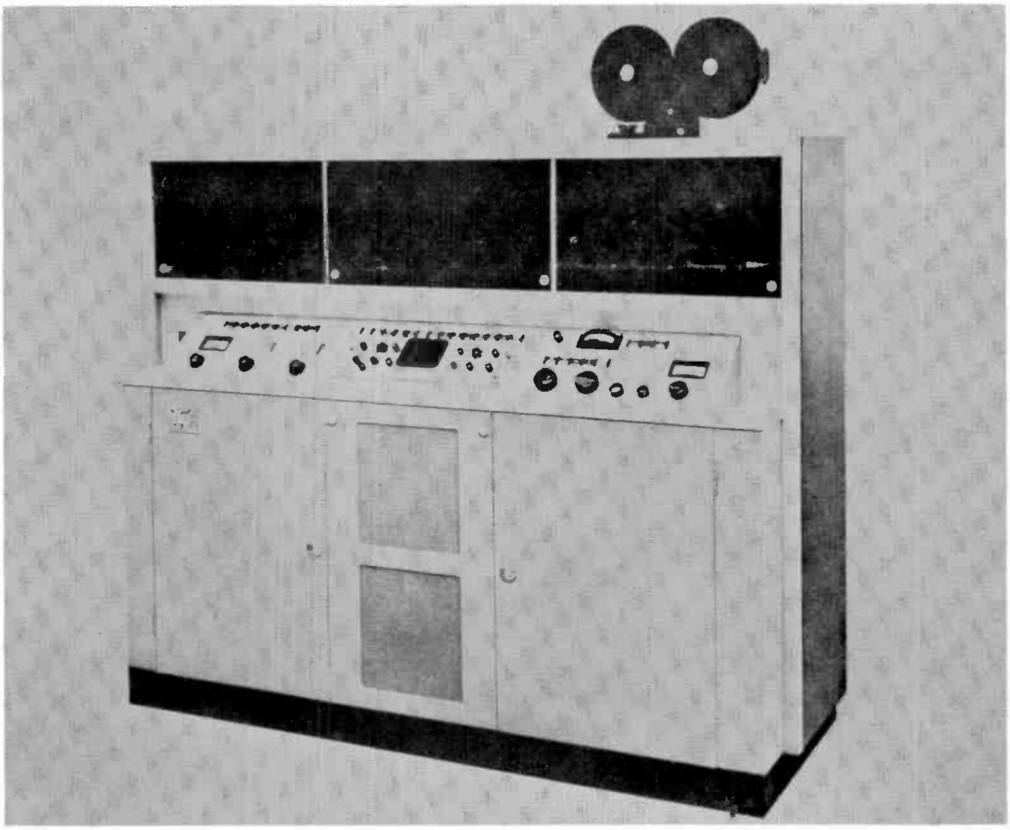
1. The repackaging of film shows.
2. Show syndication for international markets.
3. Distribution to TV stations and other users not equipped with Videotape.

Of more than passing interest is the fact that a device like this is also valuable as a standards converter between European and American TV Standards. The quality achievable by this technique is markedly superior to any known technique of such conversion. Of further interest may be possible applications for large screen display of TV.

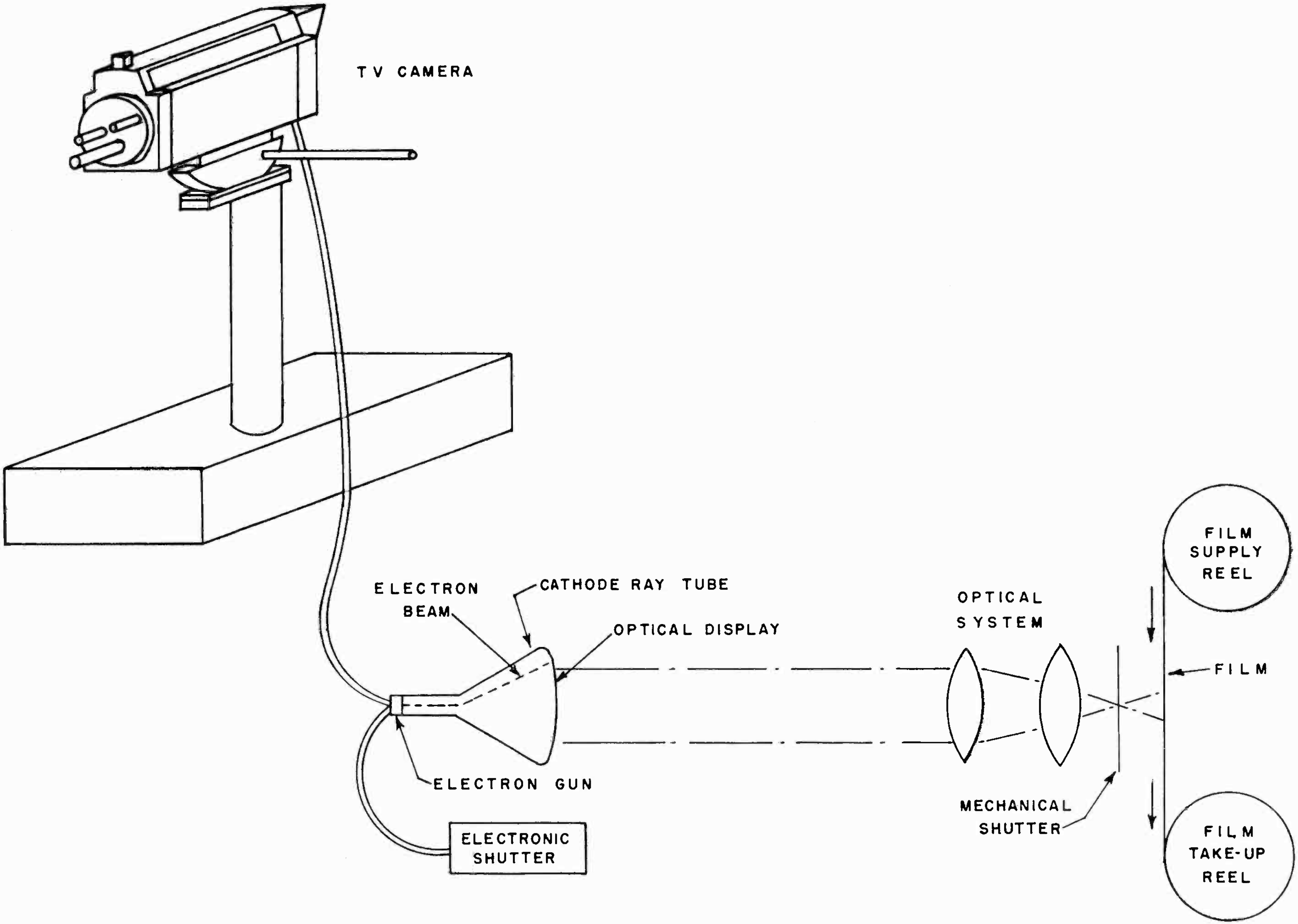
In summary the foregoing is a progress report on the work performed to demonstrate the feasibility of Electron Beam Recording to work of performing Television Film Recording. The results achieved not only establish the feasibility, but further prove that a substantial quality improvement over present art can be achieved.



Kine recorder design of a decade ago Fig. 1A



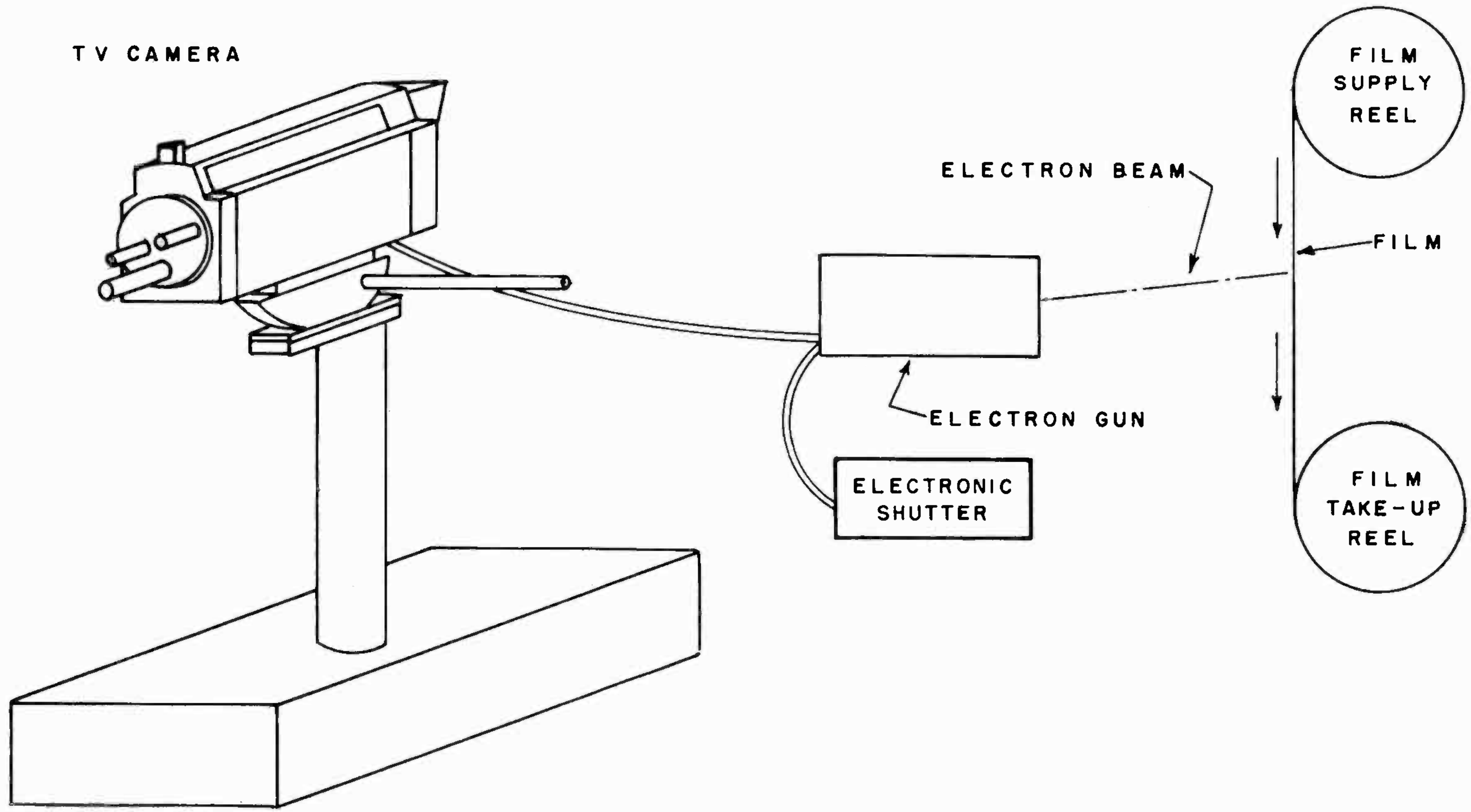
Kine recorder design of recent vintage Fig. 1B



KINESCOPE TECHNIQUE

FIGURE 2

ABC ENGINEERS



ELECTRO-PHOTOGRAPHIC TECHNIQUE

FIGURE 3

ABC ENGINEERS

Sample Frame enlargements

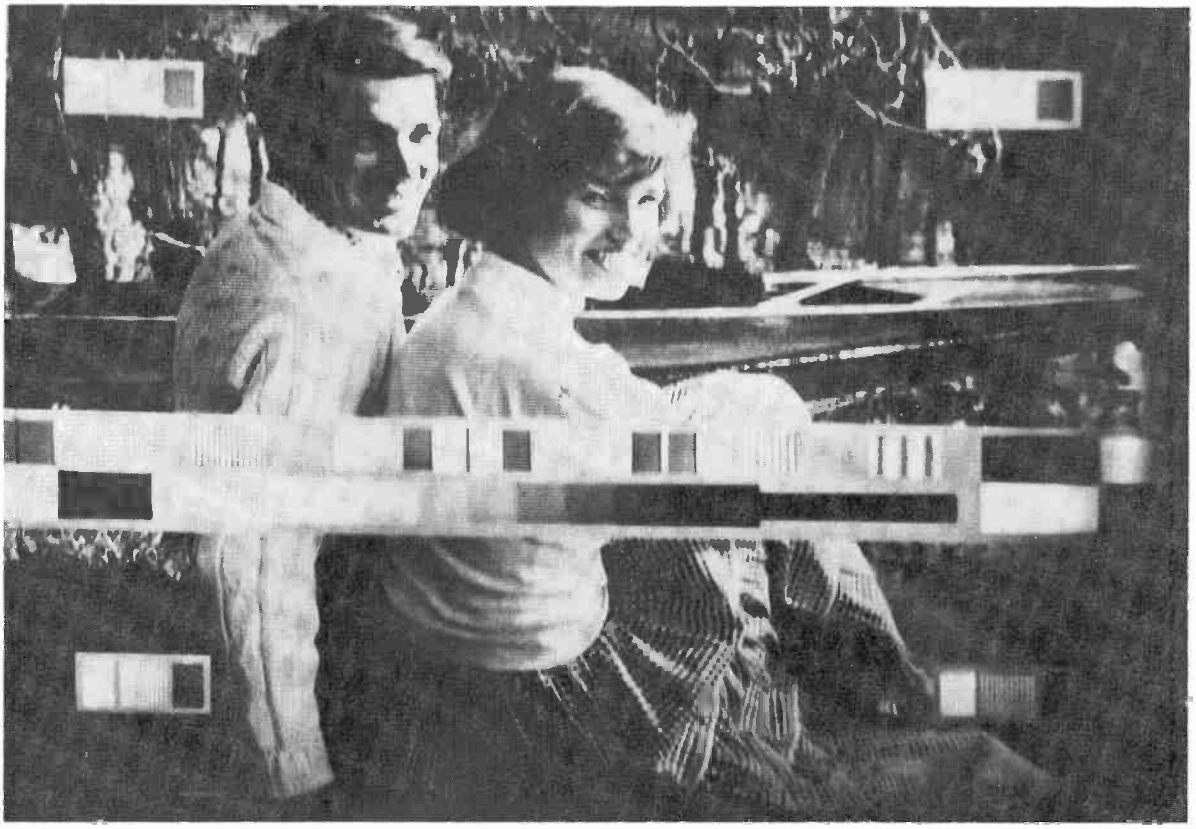


Fig. 4A

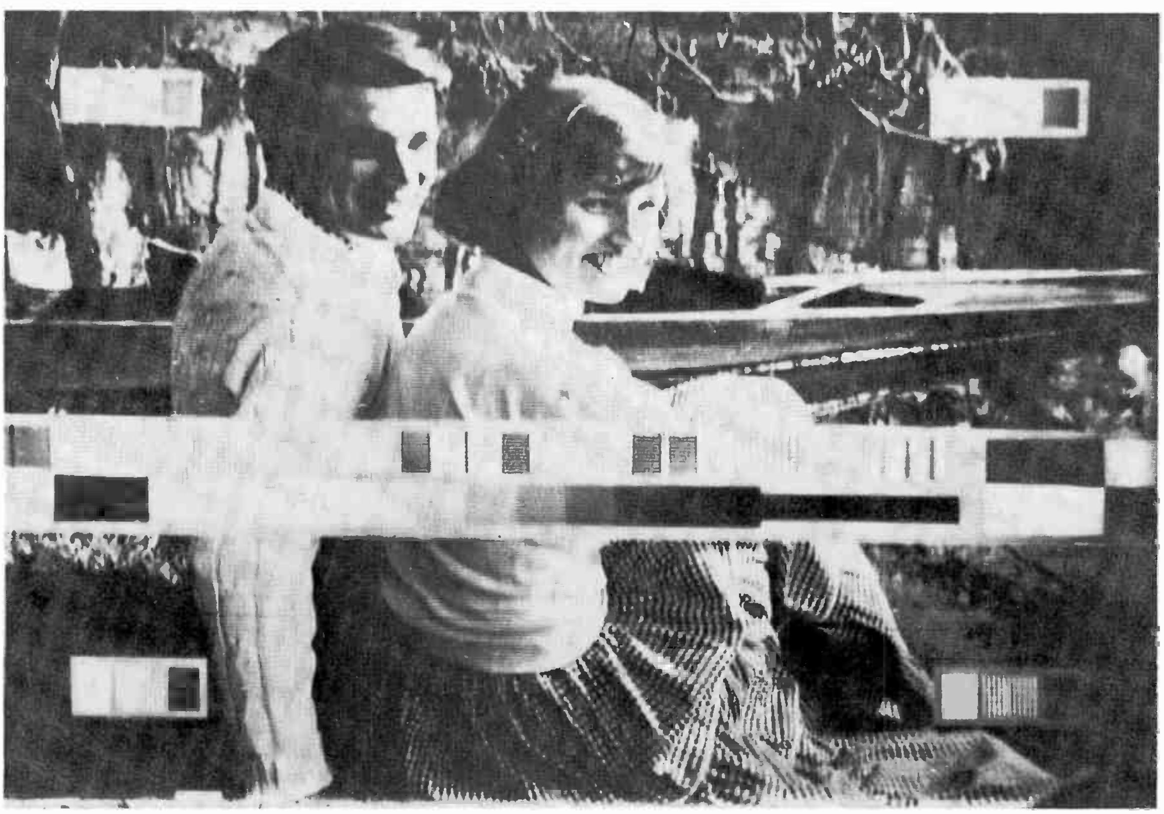


Fig. 4B

THE PLUMBICON: A CAMERA TUBE WITH A PHOTOCONDUCTIVE PbO LAYER

by

E.F. de Haan and A.G. v. Doorn

The "Plumbicon" is a small, lightweight television camera tube which utilizes the photoconductive properties of lead-monoxide (fig. 1) instead of Sb_2S_3 or Se as is normal for camera-tubes of the vidicon-type.

The photoconductive layer is applied to a transparent and conductive SnO_2-layer which is deposited on the tube face and is used as a signal electrode.

The photoconductor is an evaporated microcrystalline layer of the red, tetragonal modification of PbO, which has a bandgap of 2.0 eV. The thickness of this layer is 10-20 μm. and the crystallites are needless with dimensions of about 0.1-1 μm.

Externally a "Plumbicon" is 20 cm long (8") and 3 cm (1¼") in diameter. The useful sensitive area is 2 cm (0.8") in diameter. From these figures it can be concluded that neither the thickness of the layer nor the dimensions of the crystallites limit the resolution of this camera tube, the distance between two adjacent television lines being about 20 μm.

The principles of operation of this pick-up tube is as follows. Each picture-element represents a capacitor one plate of which is at the positive potential of the signal electrode and the other floating, that discharges as a result of leakage through the layer. The amount of charge which leaks through the layer depends on the illumination and hence there appears on the gun side of the entire layer surface a positive potential pattern composed of the various element potentials, corresponding to the pattern of light whose image is formed on the layer. When this positive potential pattern is scanned by the electron beam, electrons are deposited from the beam on the layer until the surface potential is reduced to that of the cathode of the electron gun. These charging currents of the capacities of individual picture elements constitute the video signal. Complete storage of the information present in the light beam will be achieved if the discharging time constant of the target capacity is greater than the frame period.

From this follows the requirement that the specific resistance of the photoconductor must be greater than 10^{10} cm. There are of course requirements for all the parameters of this type of camera tube which have necessarily to be fulfilled simultaneously in order to make it a useful pick-up tube in practice. The most important parameters are:

1. dark current or other spurious signals;
2. resolution;
3. sensitivity;
   a. sensitivity to incandescent light determining to a large extent the signal-to-noise ratio;
   b. spectral sensitivity;
4. speed of response.

It will be obvious that the above parameters are determined to a large extent by the physical properties of the photoconductive layer. The photoconductor of a "Plumbicon" consists in principle of three layers. The layer in the middle is almost pure lead-oxide; in other words, it is an intrinsic semiconductor. In the layer on the gun side the lead-oxide is transformed by an appropriate doping process into a p-type semiconductor, on the side of the signal electrode (SnO_2) into an n-type semiconductor. The doped area are both thin in comparison with the total thickness of the lead-oxide layer.

This means that the photoconductive layer of a "Plumbicon" is in principle, when the tube is in operation, a p-i-n-diode connected in the reverse direction. (fig. 2) The fact that the "Plumbicon" can satisfy the stringent demands of broadcast television is largely the result of this special p-i-n-diode structure of the photoconductive PbO layer.

As expected (fig. 3), the dark current of a "Plumbicon" has a diode characteristic, which means that it becomes saturated as target potential increases. The result of this very low dark current is of course that the absolute variation of the dark current will also be small, so the black level uniformity is extremely good. This becomes especially important when the "Plumbicon" is used in colour-t.v. cameras.

An ideal pick-up tube would be one in which every picture element gave a signal which was solely dependent on the light intensity projected on that particular picture element in the proper time limits and is unaffected by disturbing effects such as dark current and persistence of the photoconductor (Sb_2S_3 vidicon), dark halo and shading-signals (image orthicon). In this respect a "Plumbicon" is superior to all pick-up tubes now used in practice.

The sensitivity of a "Plumbicon" is due to the intrinsic part of the diode of the photoconductor which is situated in between the p- and n-type region. In this intrinsic region the conductivity is low and the electrical field strength high, which means that all the liberated charge carriers in this area of the lead-oxide will contribute to the photocurrent if the target potential is high enough.

If a common p-n junction had been used the sensitivity would have been low because the effective intrinsic area would have been very thin.

A high sensitivity can therefore be obtained by making the i-region as thick as possible. The optimal thickness is determined by the desired resolution especially for red light (fig. 4) (the scattered light will cover an area with a radius comparable with the thickness of the layer).

It will be clear that, like the dark current, the photocurrent will show a diode characteristic, and becomes saturated with increasing target potential (fig. 3).

It can be understood that if the tube is used at a target potential where the photocurrent saturates, beam landing errors will not introduce signal non-uniformities.

From the light transfer characteristic ($i=(L)^{\gamma}$) (fig. 5), which is the photocurrent-output as a function of the incandescent light intensity on the face plate in lux (10 lux ≈ 1 foot-candle), it can be concluded that the gamma is constant and has a value between 0.8 and 1 up to a photocurrent of 1 µA. For this reason it is possible to give in one figure the sensitivity of the tube in microamperes per lumen without specifying what light-intensity has been used. For the "Plumbicon" a sensitivity of 300 µA/L (2870°K) can easily be obtained. This means that even at light levels of 10-12 fc on the scene high quality images can be obtained at a lenssetting of f/2,8 which is comparable to image-orthicon cameras at f/5,6 for the same depth of focus. The constant gamma of the "Plumbicon" makes the tube especially suitable for colour-television, because excellent colour-rendition can be expected over a large range of varying lighting conditions.

The spectral response curve (fig. 6) is to a large extent determined by the fact that the red modification of PbO (bandgap E=2.0 eV) is used; this means that the edge wavelength of the red sensitivity is about 6400 Å. The maximum sensitivity of a "Plumbicon" is at 5000 Å. The fall-off in sensitivity in the region of shorter wavelength is due to the fact that the absorption of this type light takes place mostly in the thin n-type region which is an almost field-free area where the rate of recombination is accordingly high.

The resolution of a television camera tube is usually defined by expressing the modulation depth at 5 Mc/s (in the European 625-line system corresponding to 400 lines per picture height) as a percentage of the value at 0.5 Mc/s. (fig. 7) A modulation depth of 50% can be obtained with a "Plumbicon". This is comparable with the resolution of a standard 3" image orthicon. This can only be obtained if the cathode region of the photoconductor, despite being strongly p-type, has a very low conductivity along the surface on the gun side.

In a "Plumbicon" the persistence of the photoconductor is hardly noticeable. This can be shown by the following experimental figures obtained at a target potential such that the photocurrent is saturated. If the light intensity changes from L_I to L_{II}, the photocurrent i will attain the value $i_{II} \pm 0.1\ (i_I - i_{II})$ after 3 frames, and after 10 frames the value i_{II}, independent of light intensity. The absence of objectionable persistence is due, firstly, to the fact that the capacitance of the layer is chosen as low as possible to avoid a slow response due to the beam resistance, and secondly to the elimination of disturbing trap centres in the intrinsic region. In fig. 8 is shown that with increasing target potential the persistence of the photoconductor is decreasing and at 50 V is fully acceptable.

The life-time now achieved with tubes of the type "Plumbicon" is quite satisfactory. Most characteristics were found to remain unchanged after operation of the tube for several thousand hours. It can be concluded that a "Plumbicon" has the advantage of simple construction and operation, has a high sensitivity and a low dark current, is free of objectionable persistence and ensures an excellent final gradation of high-contrast pictures. These properties of a "Plumbicon" make this tube suitable for a large number of television-applications. Especially for colour-t.v. cameras the "Plumbicon" is almost the ideal pick-up tube.

In fact the reason why development of this tube was started a few years ago, was the urgent demand for pick-up tubes suitable for colour television.

Several three-"Plumbicon" colour-t.v. cameras have been built on a laboratory-basis. These "Plumbicon" cameras have the advantages of small size, easy operation, excellent stability good colour rendition and a high sensitivity.

With a lighting level of 100-150 fc fully saturated colour-pictures can be obtained at a lenssetting of f/2,8. In that case the signal-to-noise ratio in the Y-channel will be better than 40 db.

Eindhoven, March 1964

Philips Research Laboratories
N.V. Philips' Gloeilampenfabrieken

IB

Subscripts to the figures

fig.1a The "Plumbicon

fig. 1 The "Plumbicon"

fig. 2 The p-i-n diode structure of the "Plumbicon"

fig. 3 Photocurrent of a "Plumbicon" versus target potential (ordinate on the left) exposed to incandescent light of 2870°K (W).
Dark current versus target potential (ordinate on the right).

fig. 4 Effect of light scattering in the photoconductor on resolution.

fig. 5 Light transfer characteristic of an average "Plumbicon".

fig. 6 An equal energy relative spectral response curve of an image orthicon, a Sb_2S_3 vidicon, a "Plumbicon" and the human eye.

fig. 7 Modulation depth from a square-wave test pattern as a function of the number of lines.

fig. 8 Photocurrent of Plumbicon with varying light level as a function of time.

Target potential (a) 5V
(b) 15V
(c) 50V

fig. 9 Experimental 3-plumbicon colour camera with "zoom" lens.

Reference

E.F. de Haan, A. v.d. Drift and P.P.M. Schampers, Philips Technical Review, 25, 1963/64 no. 6/7.

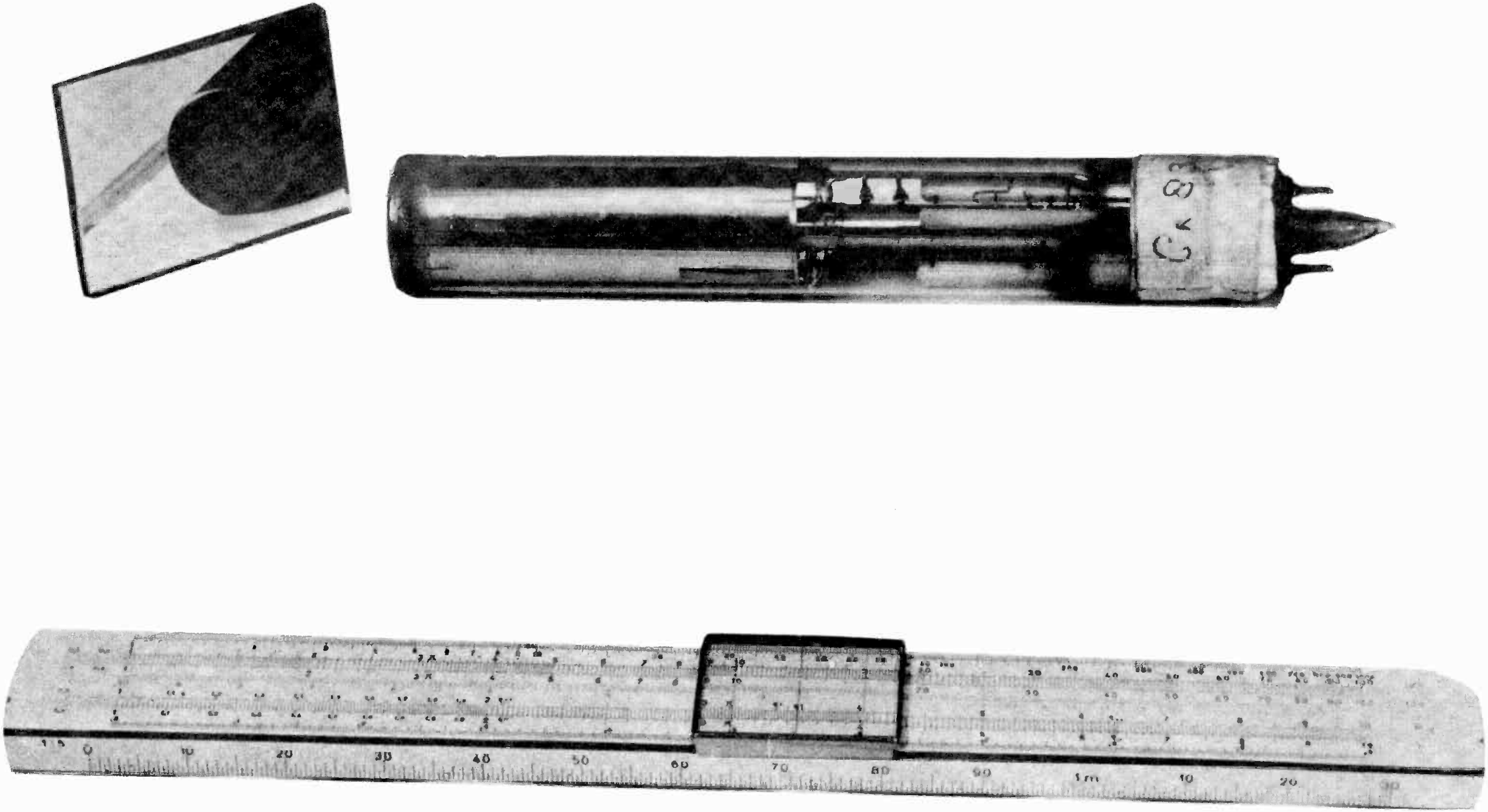


FIGURE 1A

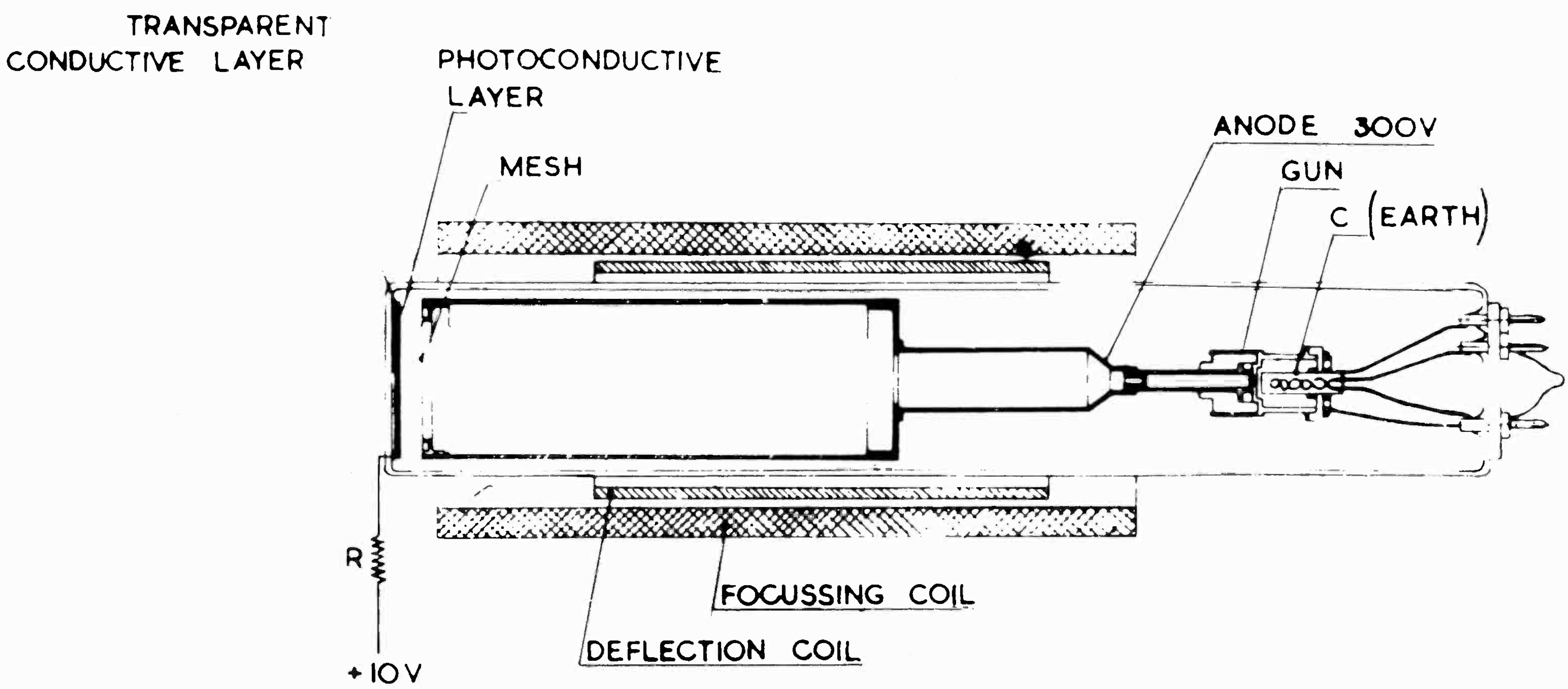

TRANSPARENT
CONDUCTIVE LAYER
PHOTOCONDUCTIVE
LAYER
MESH
ANODE 300V
GUN
C (EARTH)
R
+10V
FOCUSSING COIL
DEFLECTION COIL

FIGURE 1

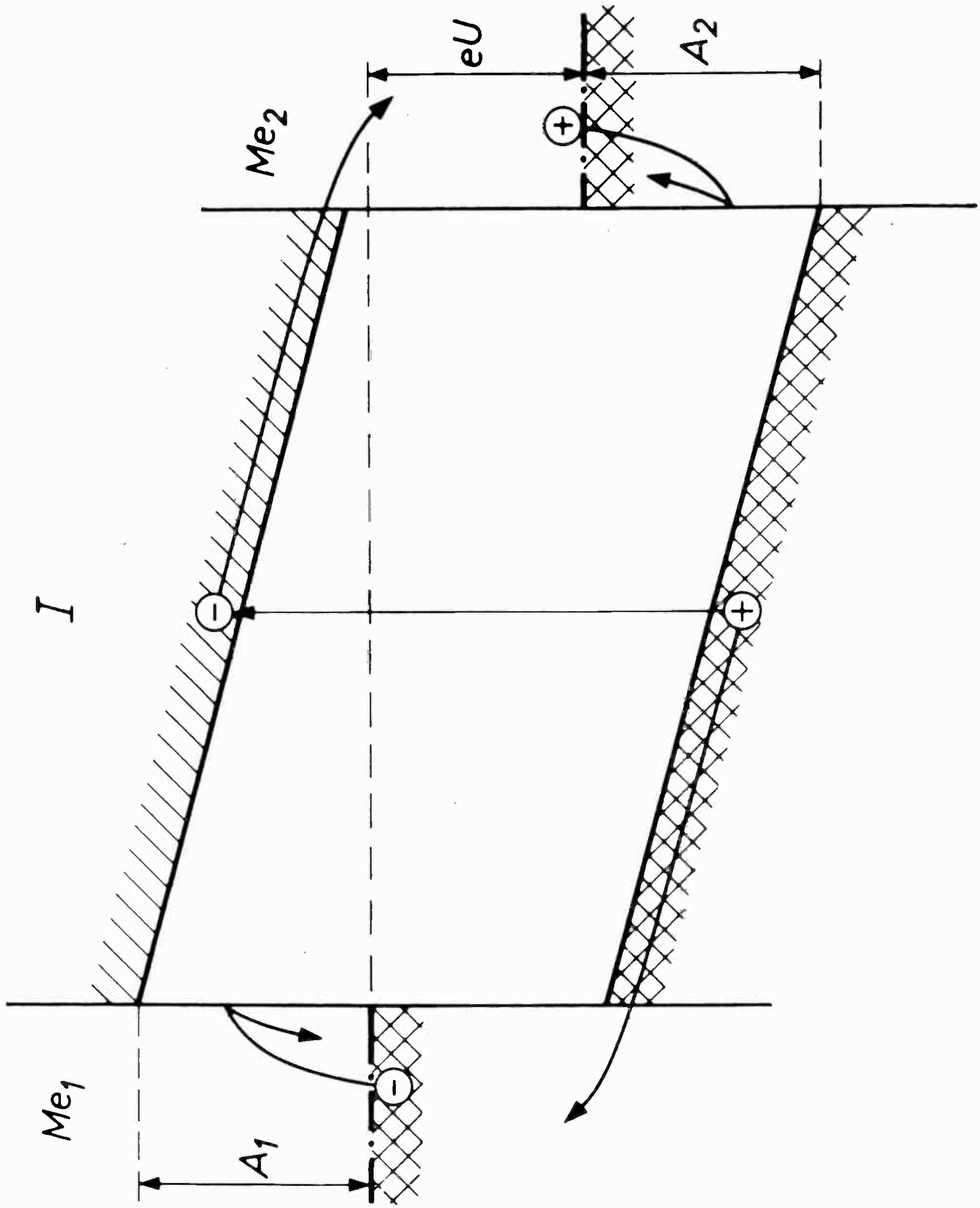
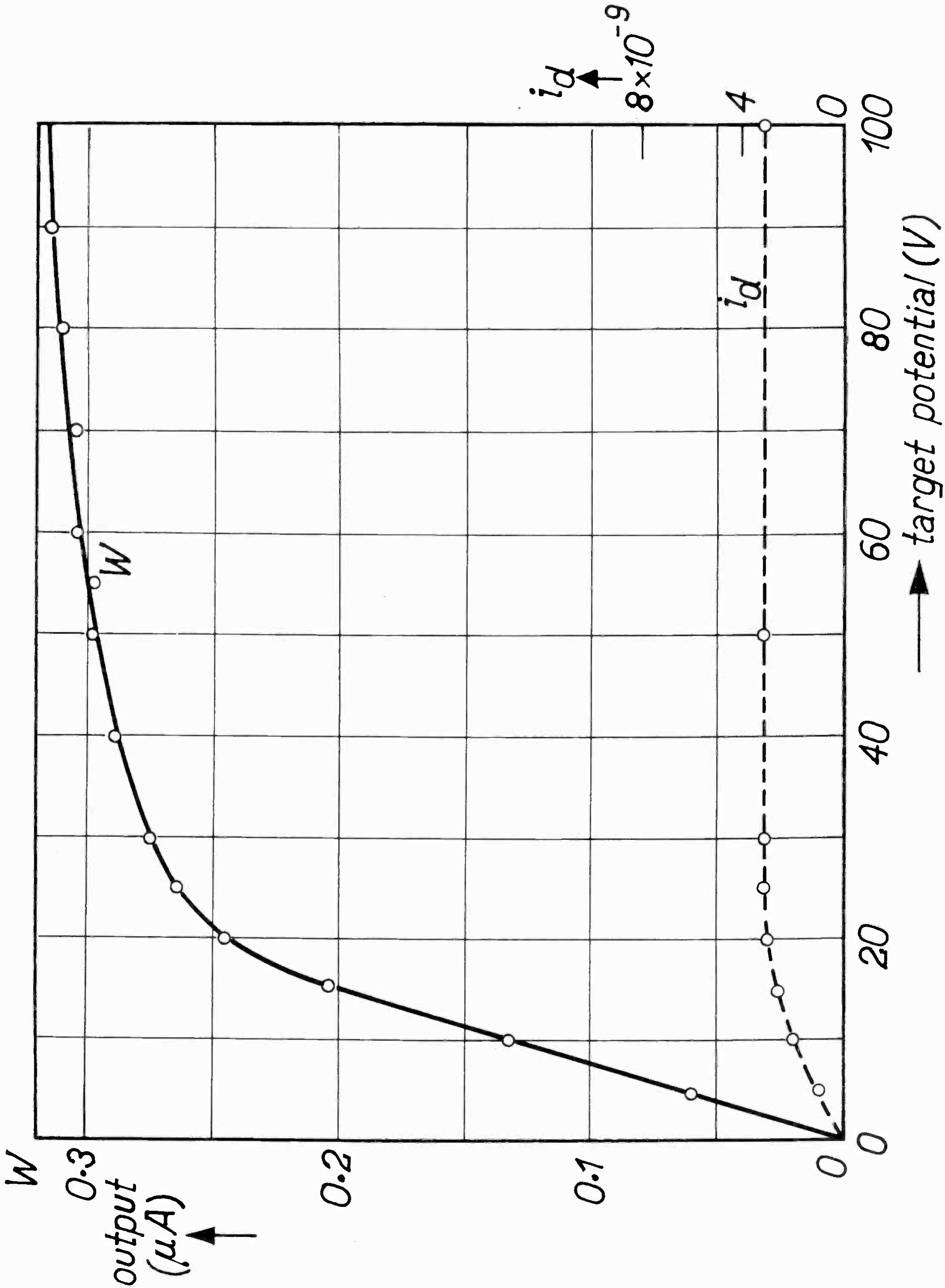


FIGURE 2



W
0·3
0·2
0·1
0
output (μA)
0
20
40
60
80
100
target potential (V)
W
i_d
i_d
8×10^{-9}
4
0

FIGURE 3

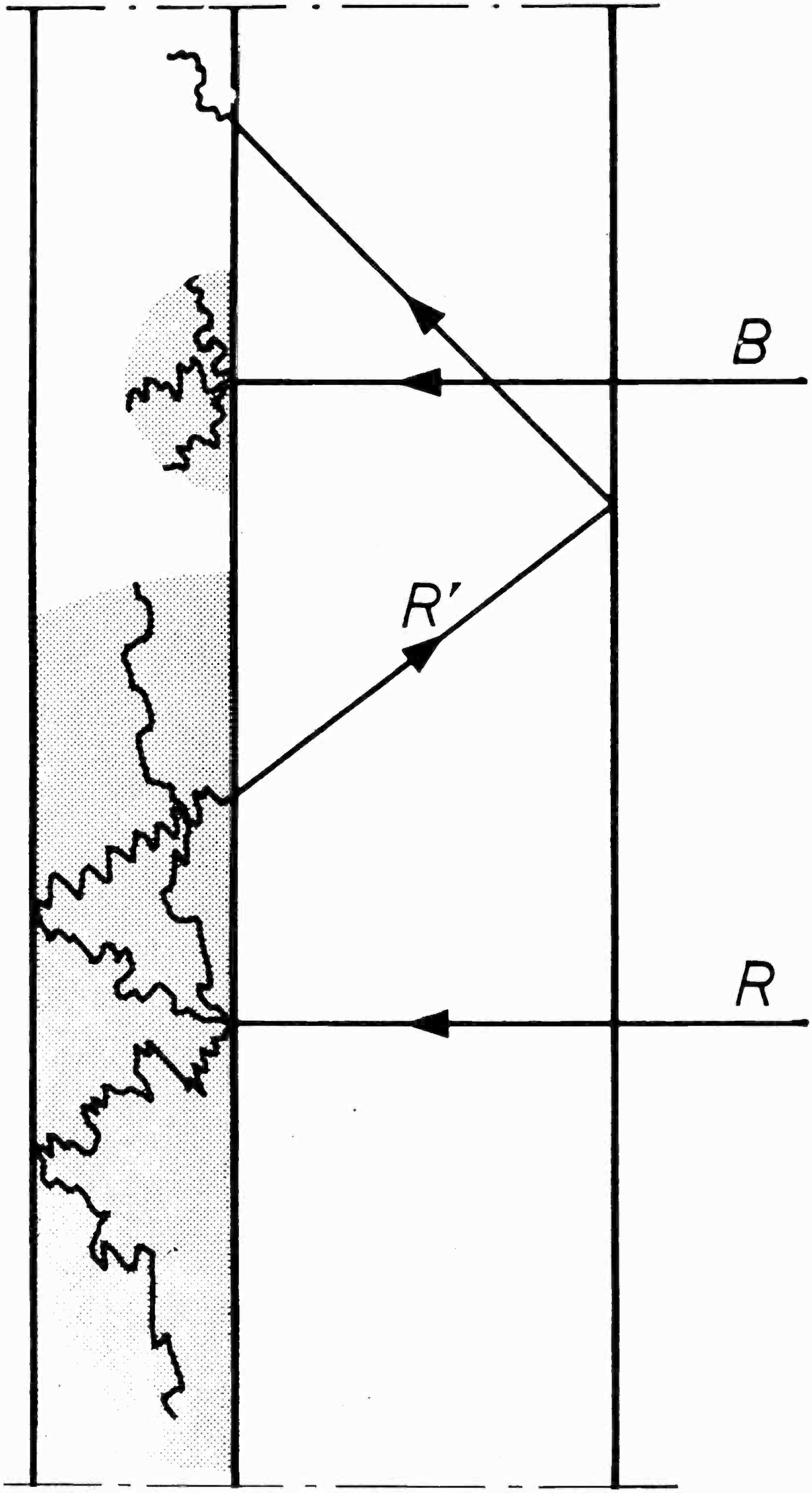
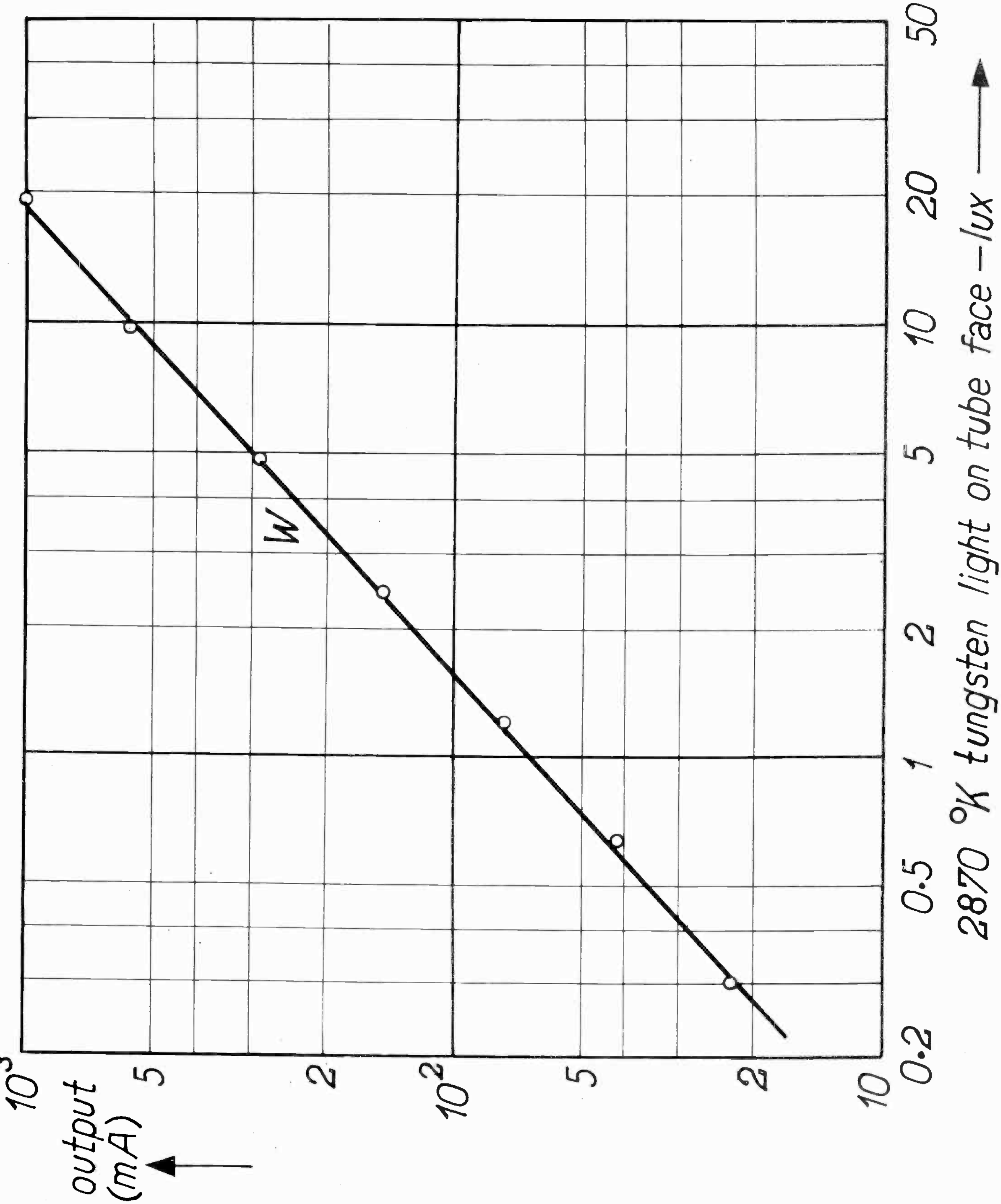


FIGURE 4



output (mA)
10^3
5
2
10^2
5
2
10
0·2
0.5
1
2
5
10
20
50
W
2870 °K tungsten light on tube face —lux

FIGURE 5

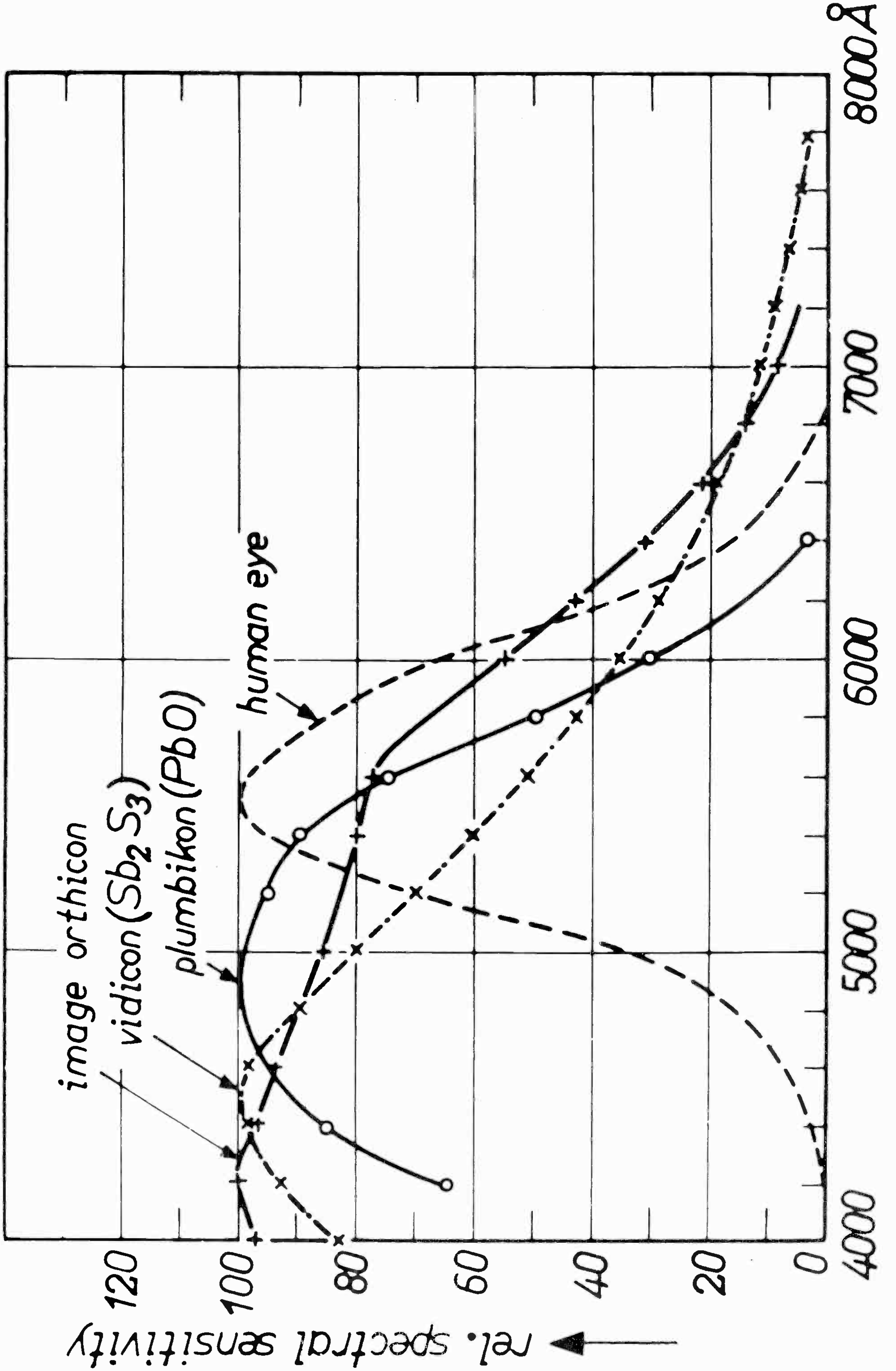


image orthicon
vidicon (Sb_2S_3)
plumbikon (PbO)
human eye
rel. spectral sensitivity
120
100
80
60
40
20
0
4000
5000
6000
7000
8000 Å

FIGURE 6

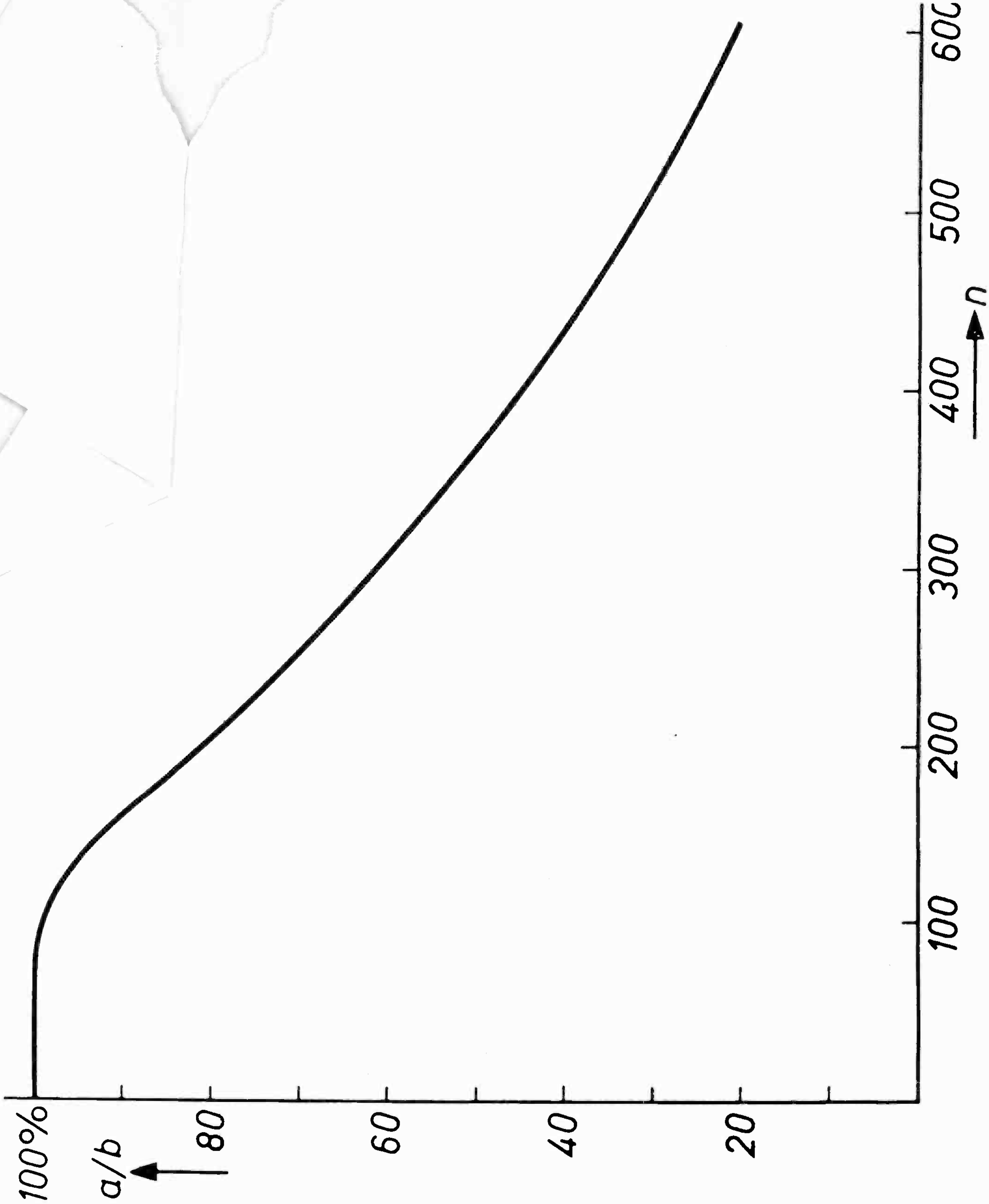


FIGURE 7

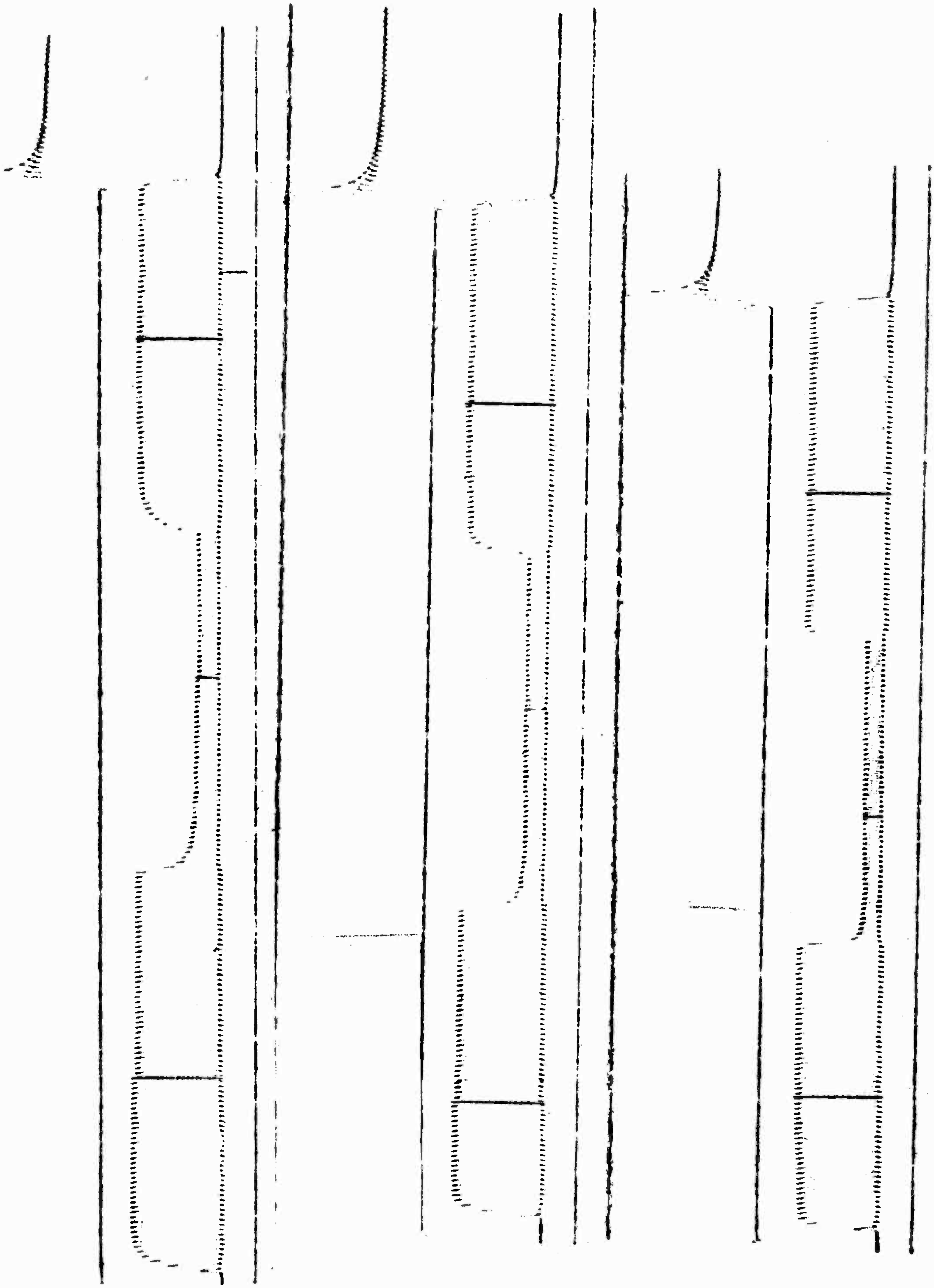


FIGURE 8

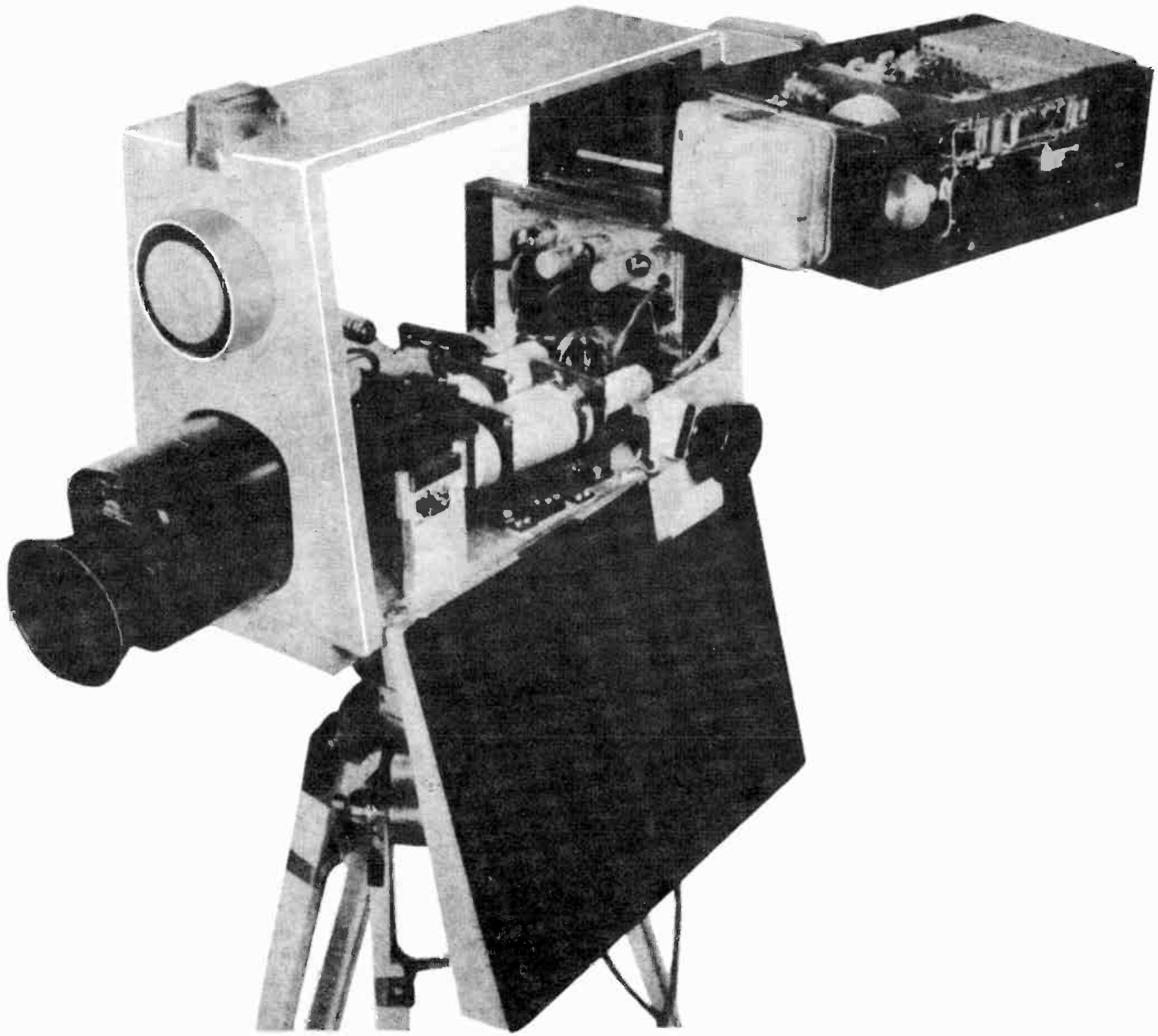


FIGURE 9

A Report on Color TV Camera Developments

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Radio Corporation of America, Camden, New Jersey

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

These early color cameras had the drift and instability problems of three monochrome cameras compounded into a single operating unit. Experience and practice showed that, given a sufficiently long warm-up interval, the cameras would stabilize to a point where satisfactory results could be produced. However, a "sufficiently long interval" meant three or more hours, which, to the Broadcaster, meant that his preparation time often exceeded the actual length of the color TV program.

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

The importance of getting this misregistry under practical control was recognized and resulted in many efforts along parallel paths. Some were aimed at the development of color cameras based on novel concepts, and others on stabilization of the circuits and components in the three-tube camera.

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

So far the successful three-tube approaches in color have used image orthicons for live studio pickup and vidicons for reproduction of color film.

Nevertheless, the intriguing possibility of making a radical and fundamental advance in color cameras has continued to engage our interest and efforts.

It is useful to define the goal, before discussing the various possibilities. The features to be desired of a new color camera are:

A. Best possible monochrome picture

B. No sacrifice in color performance

C. Competitive sensitivity

D. Latitude in operating conditions

E. Ease of operation

F. Economy in pick-up tube life

The wide acceptance of high-performance monochrome cameras during the last few years virtually dictates that no degradation in monochrome quality of a color picture can be tolerated purely for the case of color. The monochrome viewer should be unaware that the program is in color, while the viewer at the color receiver enjoys it fully.

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

Many approaches have been investigated with varying degrees of success and even failure. These range from two-tube systems involving storage of color information, three-tube systems in which the "missing" color is obtained by subtraction of two color signals from the luminance channel signal, and finally, four-tube systems in which the luminance signal is generated by a single high-definition tube, with the red, green and blue components of the chroma signal almost completely divorced from the luminance channel, being produced by three independent tubes.

Our first developmental model of the luminance channel camera was shown at NAB in Chicago in April, 1962.

This camera used a 4 1/2" image orthicon for the luminance channel and three electrostatic-focus and deflection vidicons for the chroma information. The optical system was based on the use of the Rank-Taylor Hobson Varotal III Lens, having a focal length range of 1.6" to 40" when used with an auxiliary wide angle adaptor element. The back-focal distance of 290mm or 11.6" made it possible to locate all beam-splitting and color dichroic elements in this available space. The electronic circuitry was a hybrid of solid-state devices and vacuum tubes, determined by the state of the art, and by performance goals.

The performance of this camera both at NAB and experimentally under actual broadcasting studio conditions generated both interest and enthusiasm for the results obtained. These tests also showed us where additional effort was required for improvements and where a fresh point of view might be rewarding. Thus reoriented, we continued development and refinement for two more years.

Historically, the luminance channel concept for color cameras is quite old. In fact a patent filed on October 12, 1944 by Dr. A. N. Goldsmith makes him legally the Columbus of the new world of luminance channel color cameras. The four tubes shown in the patent description are Iconoscopes, probably because the image orthicon was still a classified military device. It is frightening to consider the light intensity required on the scene. Many of us can remember that the monochrome Iconoscope started to show interest in a scene at 1000 foot-candles incident.

It seems that most engineers deliberately veered from this suggested direction into paths which offered the possibility of a degree of simplification by cutting down the number of pick-up tubes required. Study has shown that practical problems are introduced which tend to complicate the design or limit the operating performance of the device when we try to cut down the number of tubes.

A critical re-examination of the four tube approach to a luminance channel camera indicates to us that the use of three separate vidicons to obtain direct R, G, B chroma information keeps the color circuits clean and the operational flexibility high. Other advantages are apparent.

The version of camera shown at the 1964 NAB Exhibition is based on an image orthicon for luminance signal and three electrostatic focus, magnetic deflection vidicons for the chroma channel.

The optical system is now centrally placed so that image orthicon and vidicons are located on each side of the main lens. This allows the use, experimentally, of either the 3" or 4 1/2" image orthicon assembly for the luminance channel.

The three electrostatically-focused, magnetic-deflection vidicons used in the camera are easy to drive, and with precision yokes, easy to register.

Certain annoying registry problems associated with charging of the deflection plates of the early electrostatic focus and deflection vidicons are now completely eliminated with the new electrostatic focus magnetic-deflection vidicon tubes.

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

The use of standard-size plug-in modules for the electronic circuits holds a potential for high reliability, and ease of maintenance and operation. All of the known precision registry and stabilizing techniques and circuits have been incorporated in this development model. The goal of an inherently stable camera requiring only minor trimming adjustments over long periods of time has been achieved.

Following the philosophy developed in monochrome camera design, the circuits and controls provided in the camera head allow the camera to be registered and aligned using the transistorized viewfinder as a monitor. Stabilization circuits and stable components assure that the alignment will be maintained for long periods of time. Paralleled registry controls at the control position allow for precision registry checks using a color picture display if this is desired. Beam current adjustment for the image orthicon is also provided to obtain optimum signal-to-noise, even under difficult or unusual lighting conditions.

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

Critical tests of colorimetry using calibrated Munsell Charts, and the new color swatches developed in England show that the color fidelity is at least equal to the fidelity of the TK-41 three-image orthicon camera now in general use. It is possible, by simple switching techniques to compare the colorimetry of the four-tube camera with that of the 3-Vidicon section alone. The colorimetric performance from the two signal sources can be made identical.

Our experience with this experimental camera both in set-up and operation makes us very optimistic about the future reception of the luminance channel concept in broadcast color pick-up. This concept represents a large step forward in providing a color camera which is easy to handle, produces an excellent monochrome picture, and equally excellent color picture, and provides a welcome increase in the ability to handle dramatically illuminated scenes.

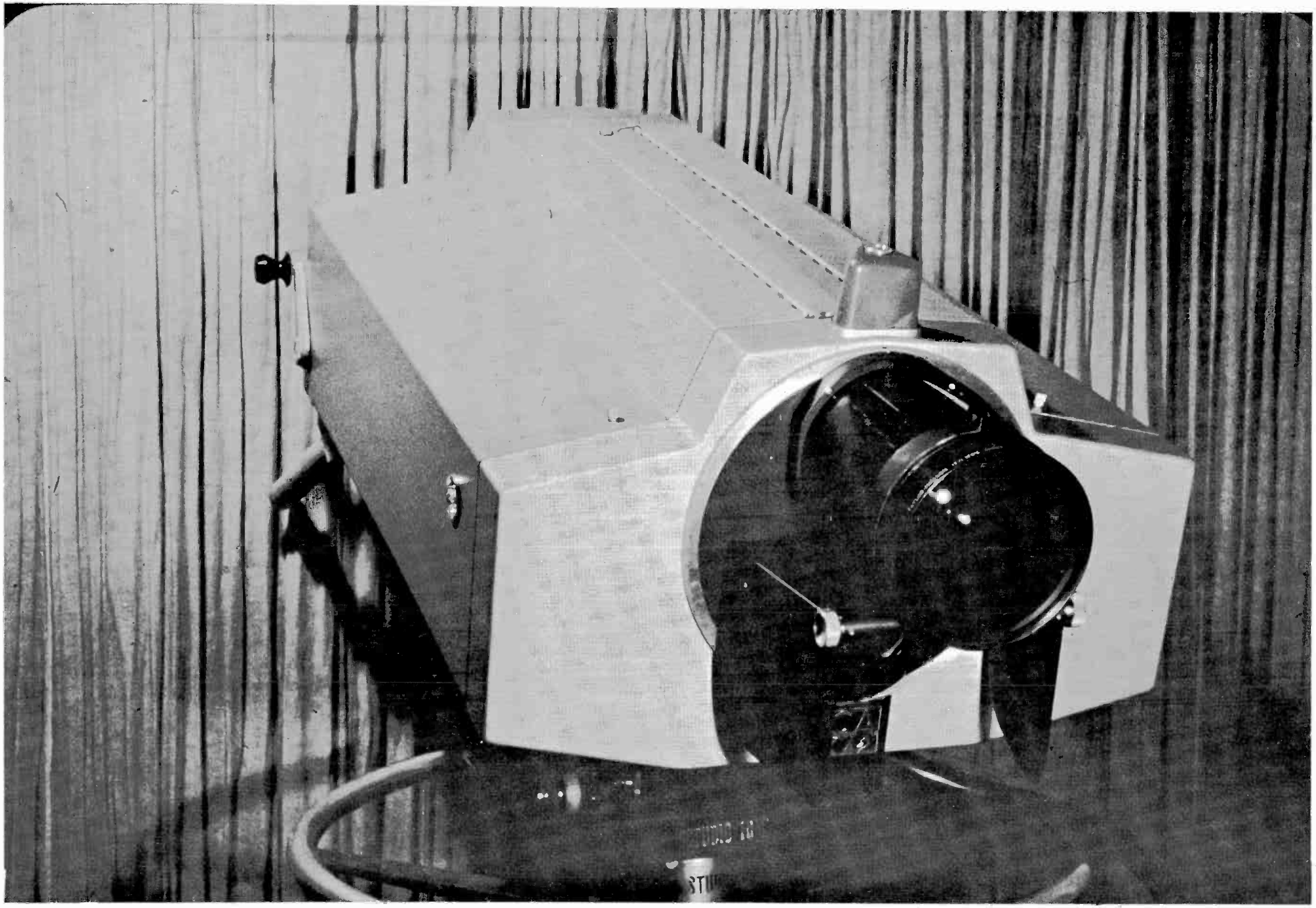


Figure 1. View of front of camera showing lens turret, zoom handle, and general profile

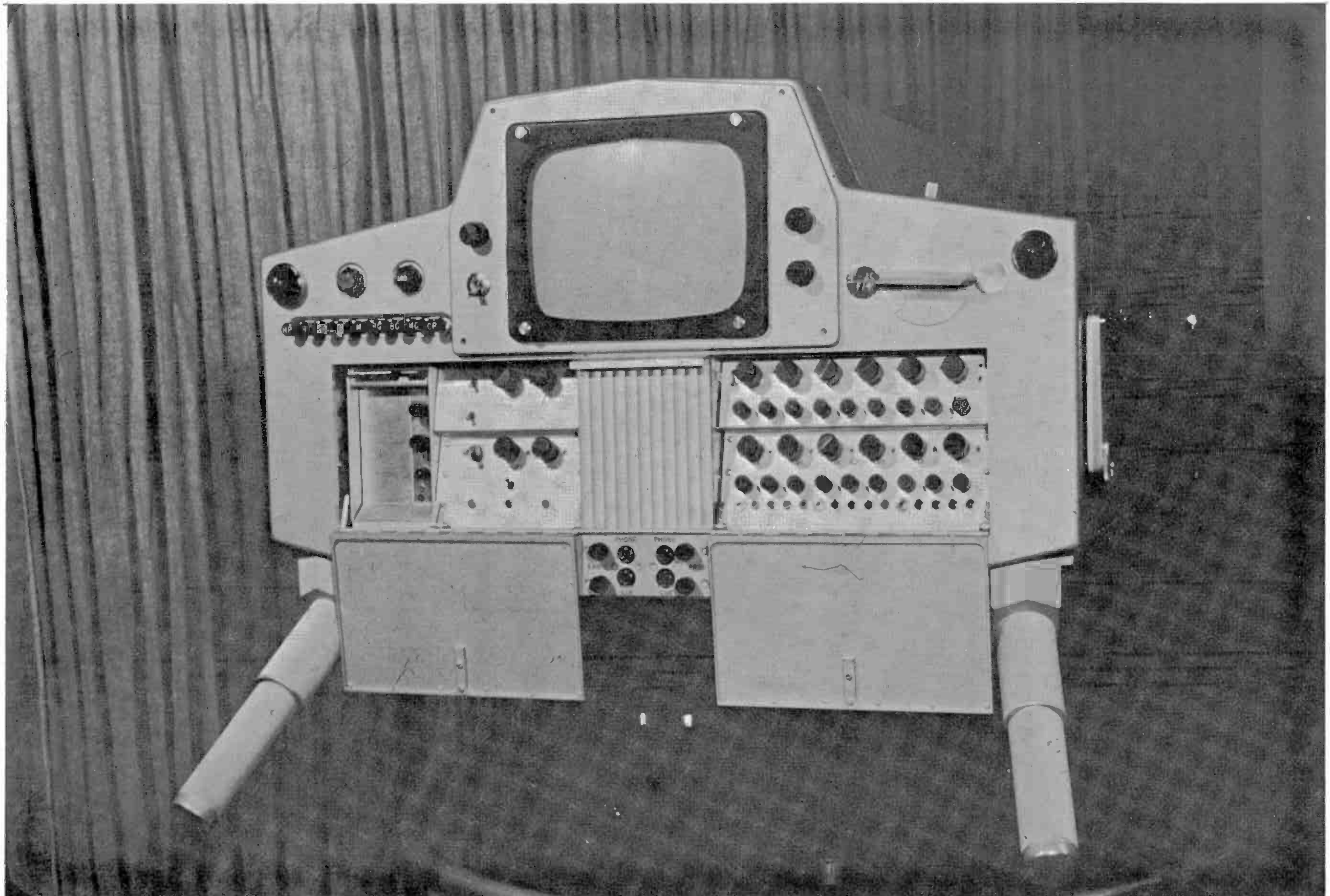


Figure 2. View of rear of camera showing set-up controls, zoom range selector, viewfinder and controls

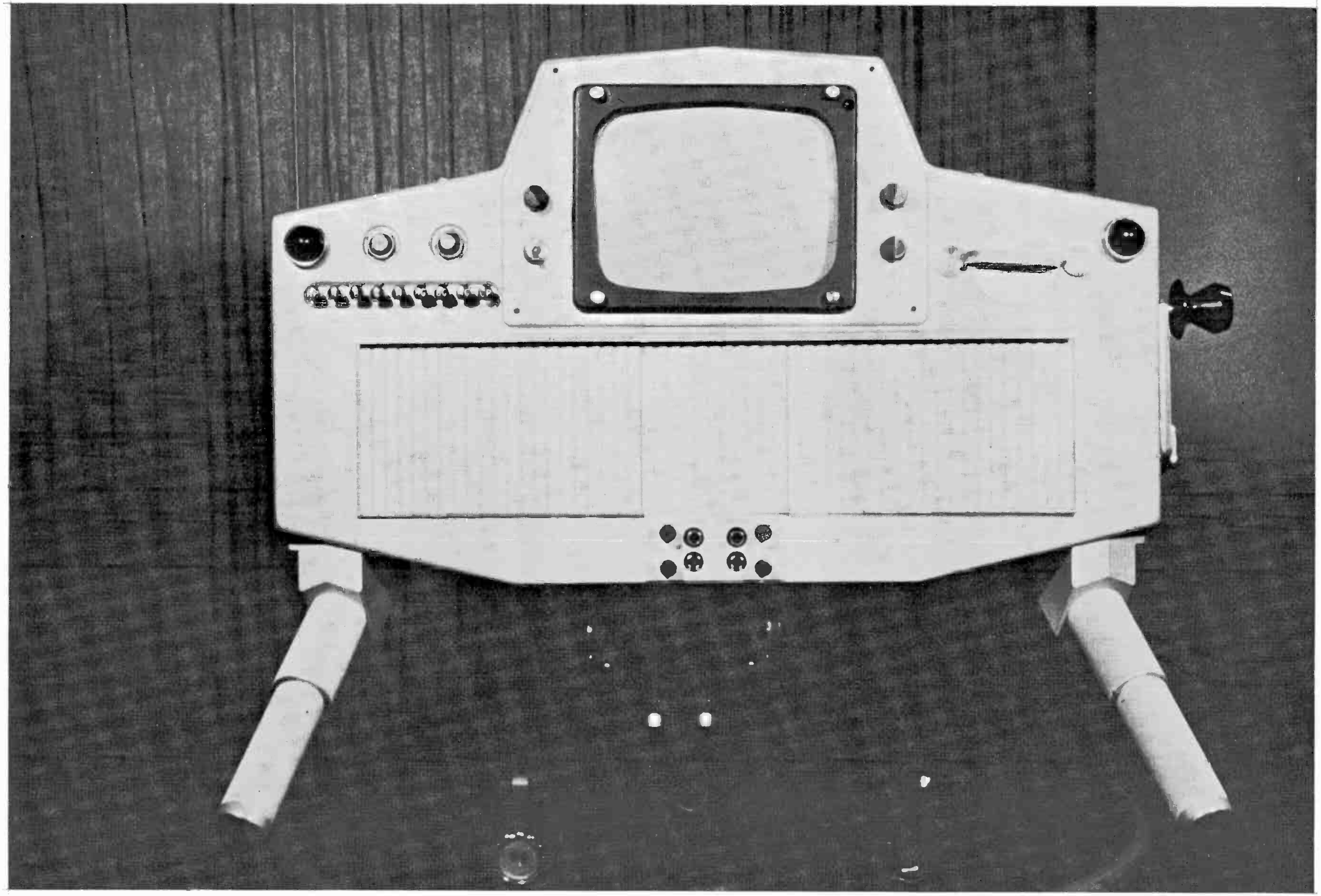


Figure 3. Rear of camera with doors closed

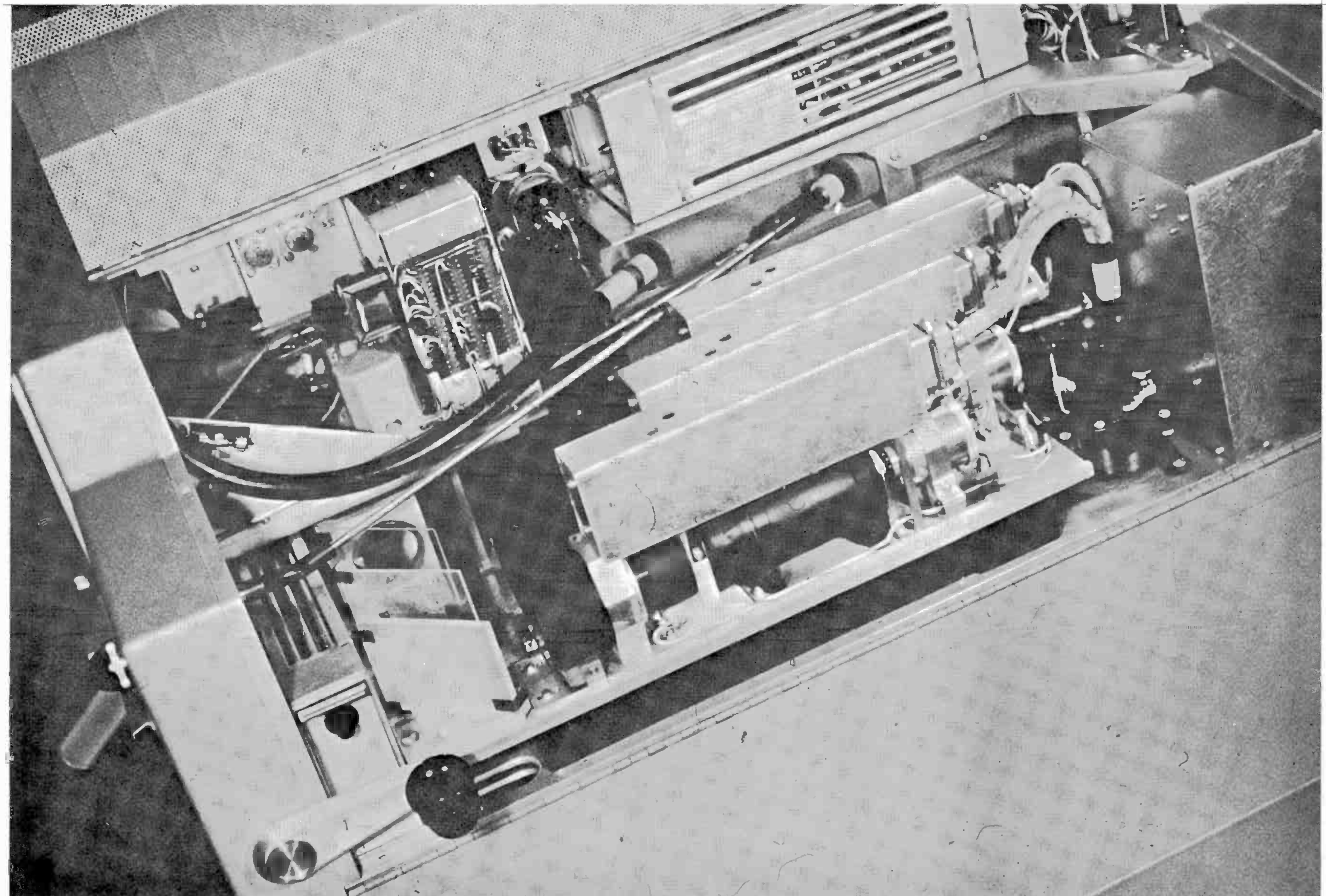


Figure 4. Top view of camera showing optical arrangements

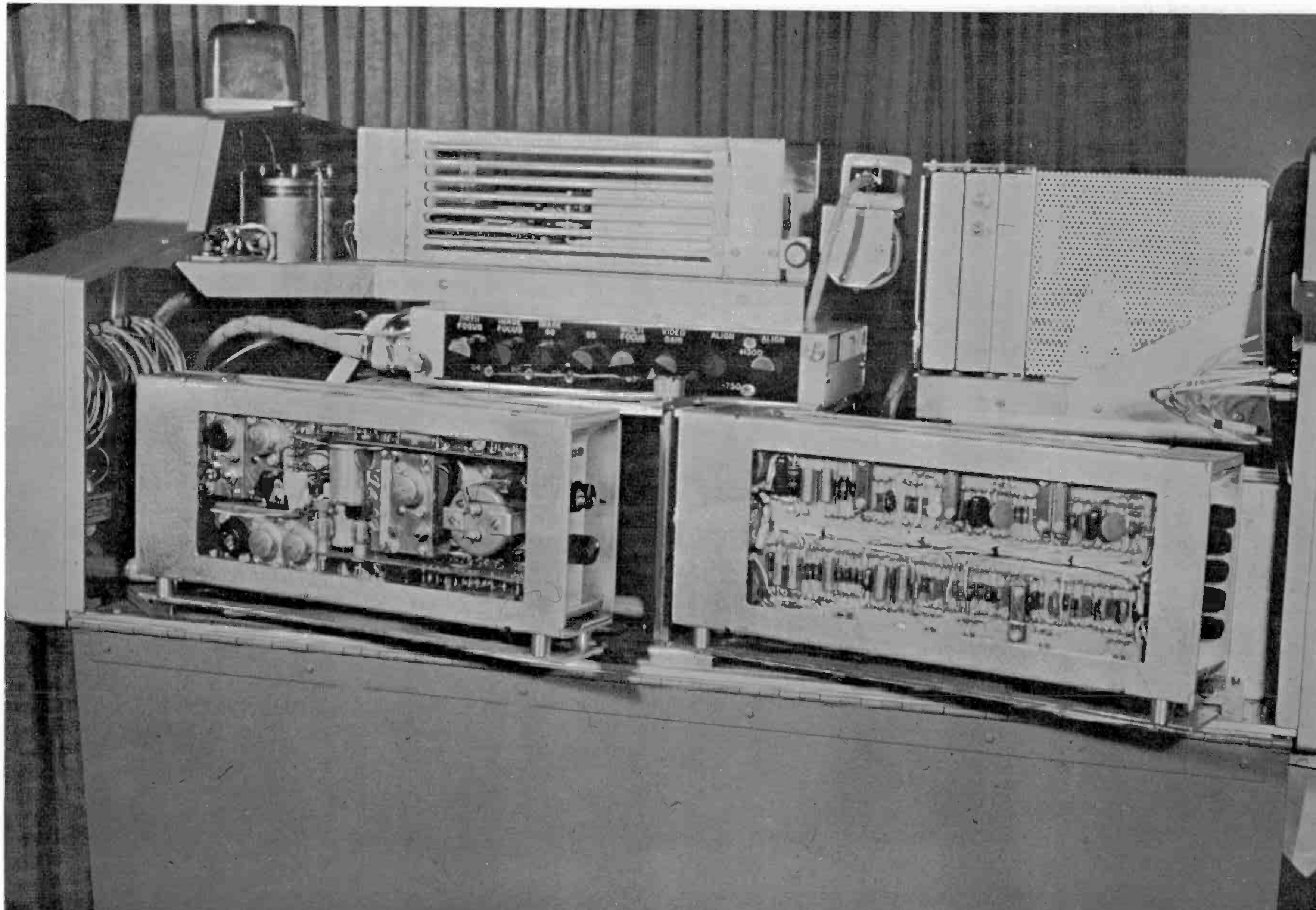


Figure 5. Details of image orthicon and control panel

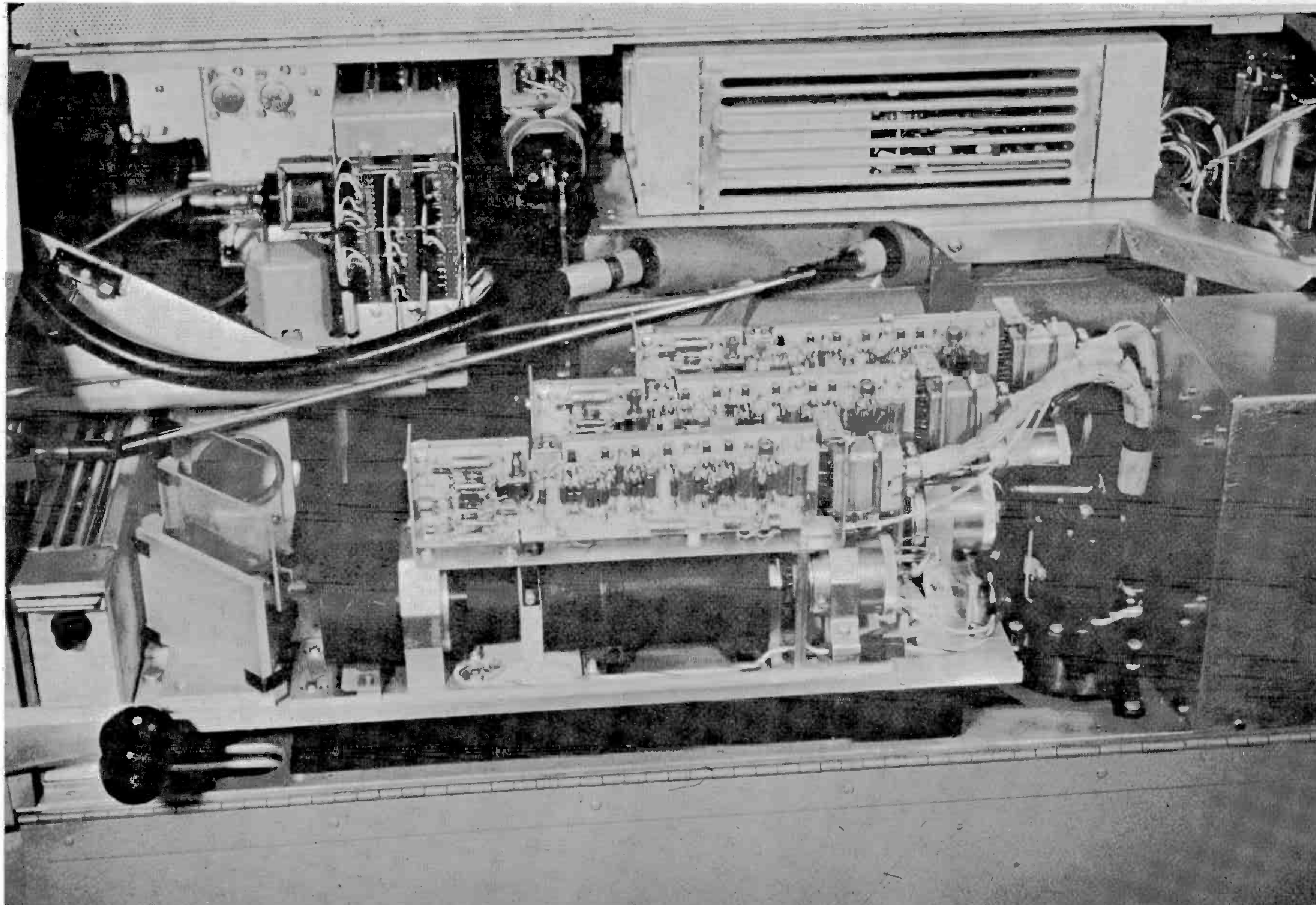


Figure 6. Details of vidicon assembly

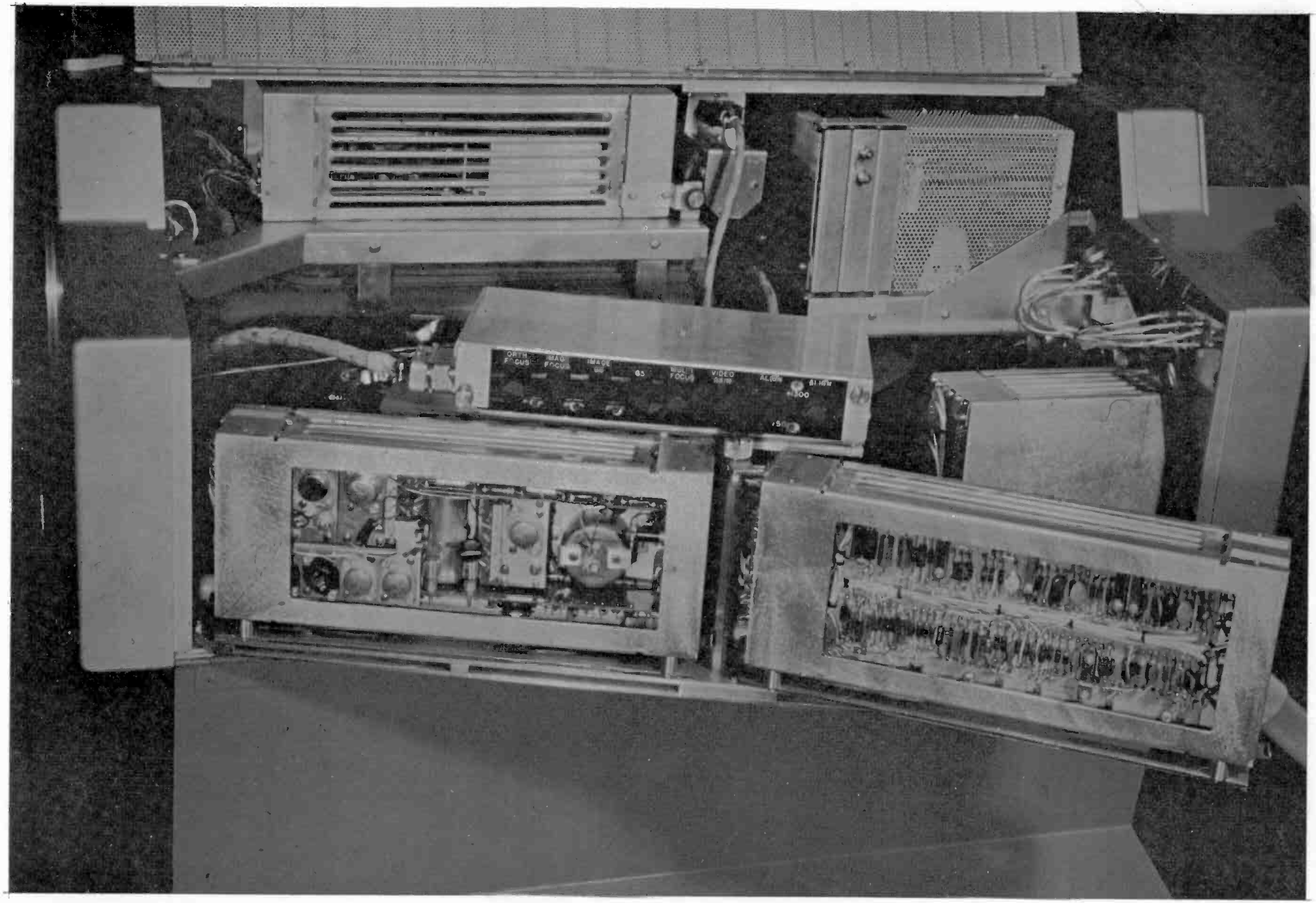


Figure 7. Details of horizontal and vertical deflection modules

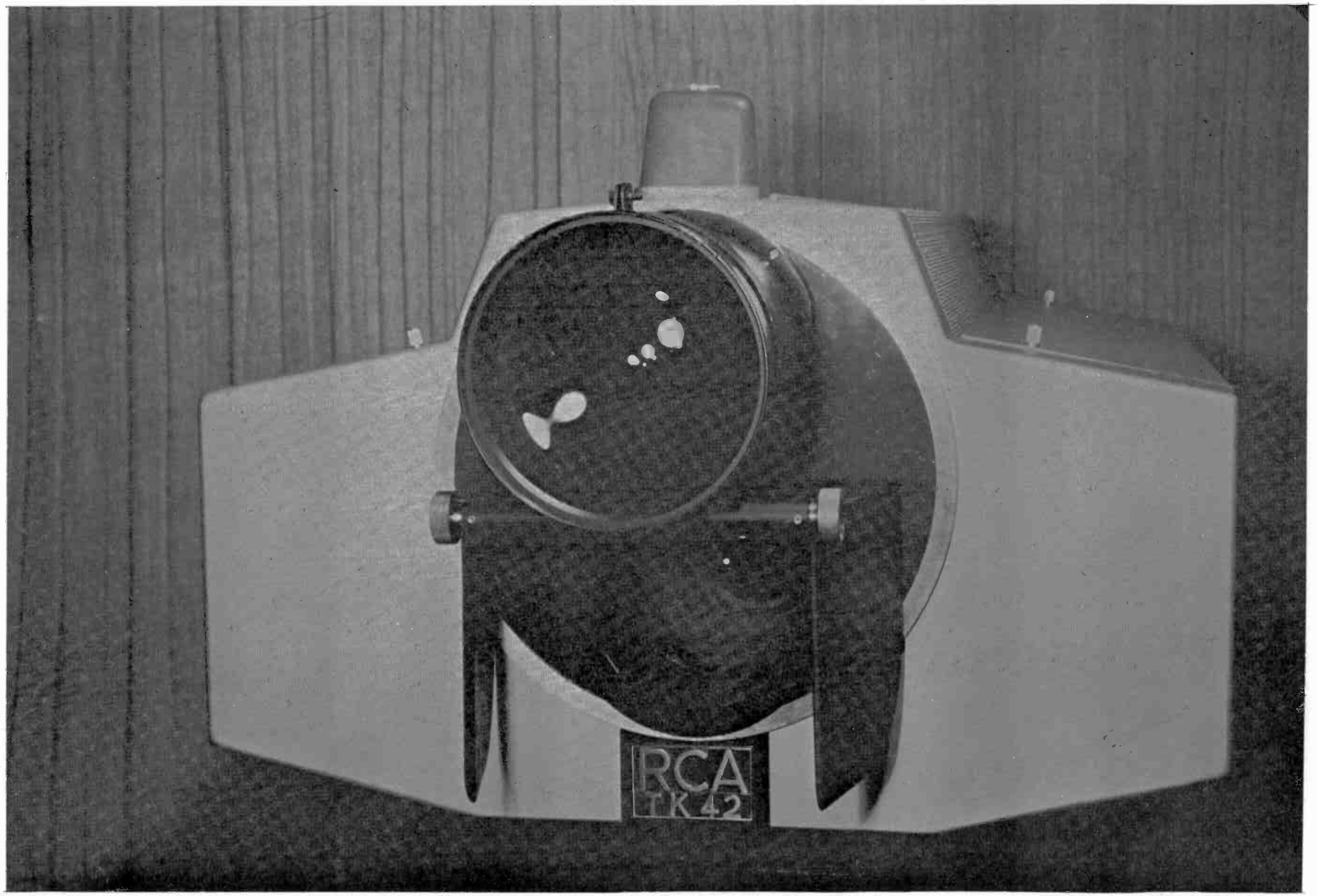
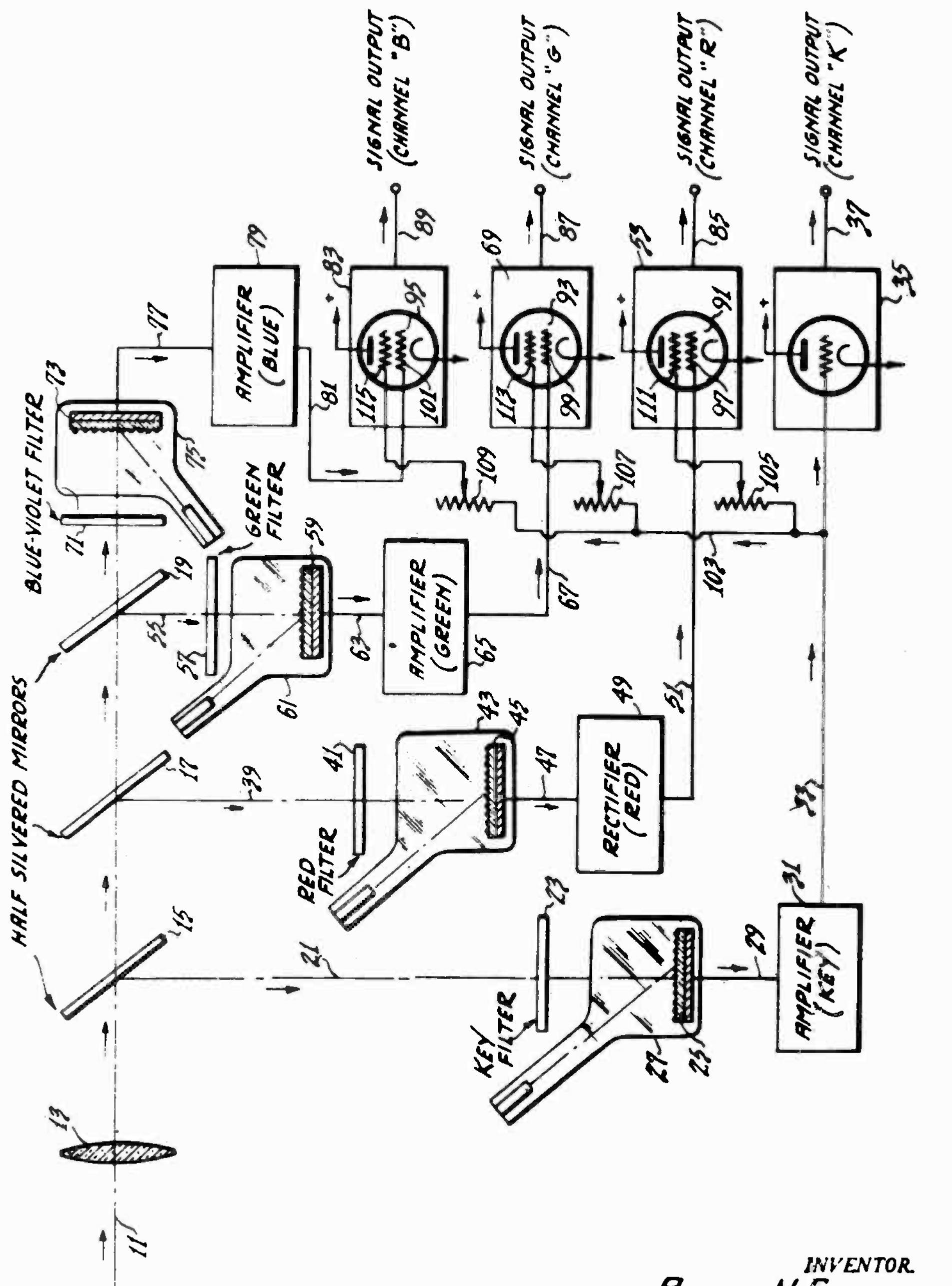


Figure 8 Details of wide angle lens adaptor turret

May 23, 1950 A. N. GOLDSMITH 2,509,038

TELEVISION SYSTEM

Filed Oct. 12, 1944



INVENTOR.
ALFRED N. GOLDSMITH
BY H. S. Grover.
ATTORNEY

Figure 9. Goldsmith patent on luminance channel color cameras.

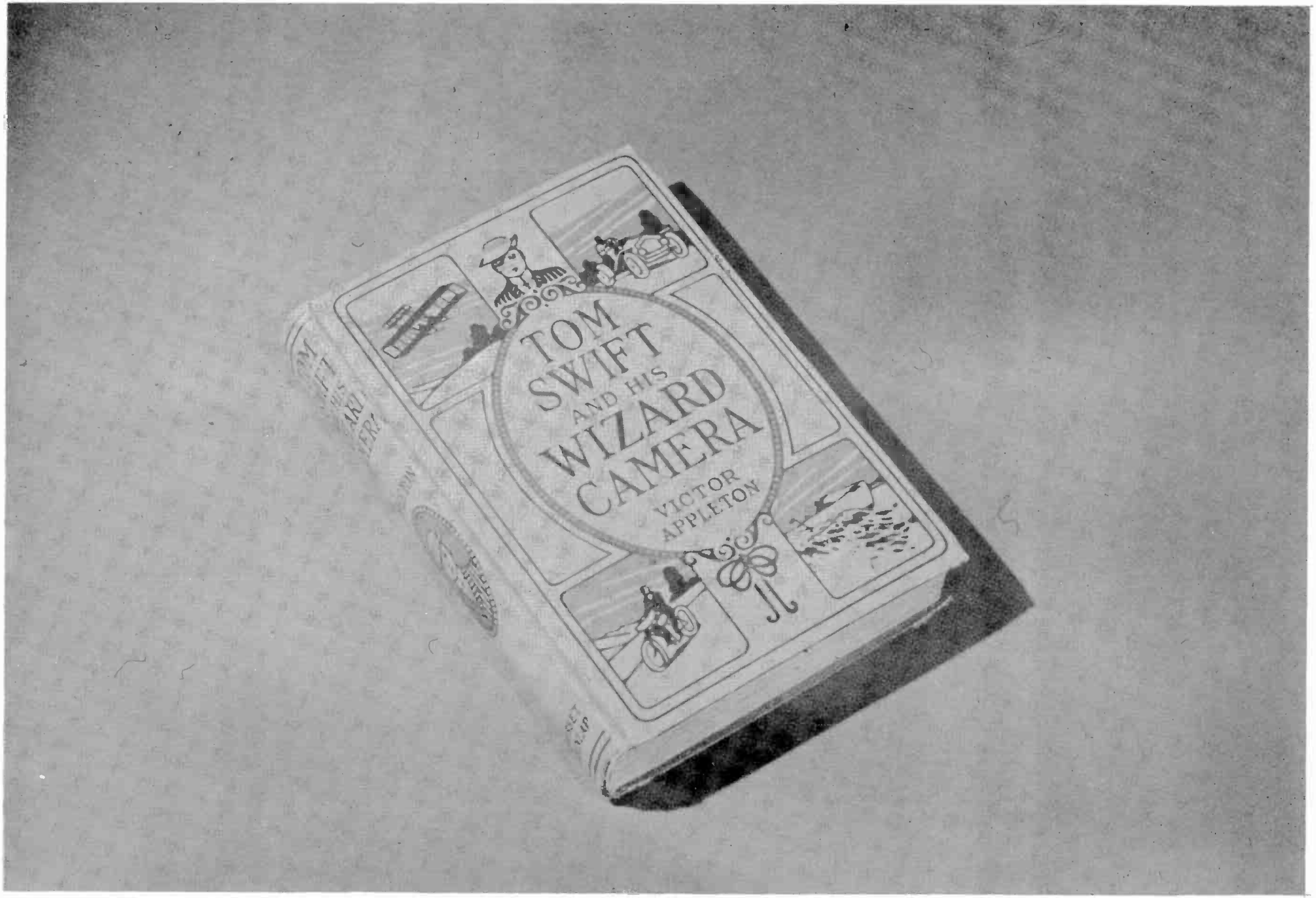


Figure 10. Our inspiration - Tom Swift

FCC TECHNICAL PANEL PRESENTATION

QUESTIONS AND ANSWERS

Moderator:

Frank Marx, President, ABC Engineers,
American Broadcasting Company

FCC Panelists:

Otis T. Hanson, Chief, Existing Facilities Branch

Wallace E. Johnson, Assistant Chief, Broadcast Bureau

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18th NAB BROADCAST ENGINEERING CONFERENCE
Chicago, Illinois
Wednesday, April 8, 1964
(9:30 - 10:30 a.m.)

FCC TECHNICAL PANEL

NAB Broadcast Engineering Conference
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Questions and Answers

Mr. Marx: What are the most frequently violated rules and regulations that you gentlemen are faced with?

Mr. Kratokvil: In the last twelve months, there were a total of about 1,500 broadcast service citations issued.

The most commonly violated rule in the AM broadcast service was Section 73.39..."The remote antenna ammeter not within 2 per cent of calibration of the regular meter." Also, "Failure to calibrate the remote antenna ammeter weekly."

The next biggest violation was Program Logs, with 141 there as against 174 for the other.

Also, 120 items were noted where various technical violations were noted, such as spurious emissions, poor installation practices, tuning house not protected against the public, and so on.

The next biggest was over- and undermodulation.

The next, general log requirements.

The next, following closely, was failure to have available equipment performance measurements that are required at yearly intervals.

The next was over- and under-powered.

Next, maintenance log requirements. We instituted a maintenance log some time ago and this is a common violation.

Failure to have a properly operating EBS receiver.

"Modulation monitor not working properly," is one of the minor infractions, along with "Failure to have an operator of the proper class."

In FM, the most common violation is modulation, over and under, followed by failure to have an operator of the required class. That is followed by equipment performance measurements - simply failure to have them available. There is a sprinkling of others. Logs brings up a poor fifth. The number of violations in FM noncommercial is quite insignificant.

In television, I have an old and a new listing. The old listing indicates that percentage of modulation seems to be a big factor, along with logs and operating power. All the broadcast services together join in developing forty-seven items of violation, failure to have a properly operating EBS receiver, and failure to test the emergency action notification system.

Out of seventeen stations jointly monitored, no violations were issued for frequency deviation either of the video carrier or the aural carrier. The typical infraction you will find will be logs and improper setup of the television picture, which, of course, can be shown on the station's own monitor also.

Question from the Audience: Section 73.47 requires equipment performance tests every year. In the last few years, of course, it has been the habit in AM broadcasting to have 24-hour-a-day programming on Class I channels. Section 73.10 requires us not to interfere with other stations carrying on a regular program service.

Which of these two Sections would you gentlemen prefer us to violate?

Mr. Kassens: You must run these equipment performance measurements every year. You are not supposed to run them into a dummy load, because the transmitter should be operating when you run the measurement into its normal load. If you have this situation, I am sure we could work out an arrangement to let you do it by dummy load, but I think your easy way to do it is to find out when these stations do their maintenance period, and run yours at the same time.

Mr. John H. DeWitt, Jr., WSM, Inc., Nashville, Tennessee:

Frank Kratokvil said that the most common violation was the calibration between the remote antenna ammeter and the one in the tuning house. We ran into something on this subject recently that might be of general interest and I want to ask the Commission what the answer might be.

We found pretty good variations between winter and summer between the antenna ammeter in the tuning house and the remote meter. We found the remote meter was correct. Then we found that in the Western Catalog for thermocouple meters it says that the temperature coefficient is 1.6 per cent per 10° C.

Our tuning house changes from 20° F in the winter to 100° F in the summer, and this figures out to be 44° C range which would cause the antenna ammeter to vary in percentage by 7.04 per cent, which is 14 per cent in power.

I would like to know if the Commission has taken this into account. If they haven't, we would like to be authorized to have a curve in the tuning house with a thermometer so that we can correct the readings to make them fit the remote meter.

Mr. Hanson: We realize this is a problem. I don't know whether anyone has done any active work on it.

Mr. Kassens: Several consultants have mentioned this to me. Frankly, I don't know where the problem is. Our rules say that the base current meter should have an accuracy of 2 per cent. These rules were written a good many years ago, and I don't know why these RF meters should be getting worse with time. We didn't have this problem before the war. Consulting engineers are concerned because when they go out to run a proof they find that you buy four or five meters and none of them will agree. So, I think it is a little deeper problem, and apparently it goes back to the meter itself.

Mr. DeWitt: I am going entirely by the statement in the Western Catalog, which says that it is 1.6 per cent per 10° C. We have a letter from Westinghouse which says theirs is 2.5 per cent per 10° C. So, this is another factor over and above the accuracy, because the accuracy is stated as 1 or 2 per cent of whatever it is at 25 per cent degrees Centigrade.

Mr. Marx: In line with the Commission's recent relaxation on non-directional stations, when will the FCC relax operator requirements at 500-watt, 2-tower directional daytime stations?

Mr. Johnson: Every time we get into this problem of relaxing our operator requirements depending on what type of installation we have, citations increase tremendously.

One of the things that worries us is that with the data we have on the maintenance of directional antennas and the performance of directional antennas, each one becomes a pretty unique situation. So, before we get to the point of actually relaxing that first-class operator requirement for directional, I think we are going to take a mighty hard and fast look at the performance of directional antennas, and possibly try to work out some criteria as to what type of antenna systems we would permit a relaxation of first in the operators. We are very leery of relaxing requirements, especially for directional antennas, and it is going to be a long time before we are convinced that it might be done.

Mr. Kratokvil: About two years ago we made a survey of directional antenna system stations. It included two-, three- and four-tower jobs, and 40 per cent of them were found to be out of tolerance.

Unfortunately, I don't have more exact information, but in preparation for this conference, I went out and made an inspection of a 2-hour array, and I was amazed how close it was to the licensed power. There were two inspectors at the site. The meters agreed with the Commission's meter, and it looked like a good job. So there seems to be some justification on the other side, too.

Mr. Marx: How much time is acceptable on the hour and half-hour readings? Can the readings be taken, say, at 20 and 50 minutes past the hour?

Mr. Hanson: The rule says that if you can't possibly make it, a minute or two either way won't make much difference. I would be a little leery of that, unless extreme circumstances are encountered. Ten minutes out of the way is outside the rule.

Mr. Marx: Does that necessarily mean they have to be taken straight up and at six, or is the spread the important thing?

Mr. Hanson: The spread is the important thing.

Mr. Marx: Has the FCC specified a procedure for a station to obtain TV aural power reduction authority?

Mr. Kelley: The Commission has recently changed its rules regarding VHF-TV aural-to-visual power ratio. Previously, it was 70 to 50 per cent, the minimum is now 10 per cent.

In applying for a reduction in aural power, we follow the normal procedure of filing an application to make a change in power. Use Application Form 301. Depending upon the type of change you are making - that is, how you are going to achieve the change in power - it would be treated as a modification of a license, or you would be issued a CP to make the change.

The thing that determines which category it falls into is whether you have undertaken construction or possibly destruction, as you might refer to it, in order to achieve your new operating power.

Mr. Johnson: We have had a lot of questions asked about the two documents that came out last Wednesday. One is the document Mr. Kelley was referring to, actually permitting a reduction from 10 to 70 per cent. Then there was another proposed rule making that came out, bringing it down to the ratio from 10 to 20 per cent. So, there are two things that were done last Wednesday that are completely separate, one of them permitting 10 to 70 and the other proposing 10 to 20.

Mr. Marx: Please explain the differences between the Emergency Action Notification System and the Emergency Broadcast System, and which term properly applies to the non-NDEA participating radio station.

Comr. Bartley: Perhaps I had better rephrase it so we are clear on what the question is.

The Emergency Action Notification is the APUPI system of notification of an emergency. The control point for this is at NORAD and at a classified location near Washington. It can be instituted by the Office of Civil Defense for higher authority, which in that case means the President.

The stations which are not members of the EBS System will find in this booklet the announcement that they make before they go off the air. At this point, I might point out that all of the existing NDEA licenses expire June 30. Between now and then those stations which qualify and request the EBS or NDEA authorizations will be issued them prior to that time.

Mr. Marx: Is it against FCC rules for unlicensed personnel to turn the radiation switch on on an STL microwave transmitter? Is the fact that there is a first-class licensed man on duty at the receiving end of an STL sufficient to meet FCC regulations so that an unlicensed man at the transmitter end could activate the STL?

In other words, we would like to use an unlicensed man to open the studios each morning, and not require a first-class man until about two hours later. In the event of improper operation of the STL transmitter, the first-class man at the receiving end could direct the steps to be taken by the unlicensed man to either obtain proper operation or shut off the emission of the STL, not by remote control but by directing the unlicensed man by radio or by telephone circuits.

Mr. Kelley: In STLs we have three modes of operation - We have the direct control; the unattended operation; and remote control. This proposal, as I understand it, would not fit any of those categories.

I think this question would come nearer fitting the unattended operation. I would suggest that anyone who would care to do what this gentlemen would like to do should write us and give us in detail exactly how he proposes to operate, and ask if there are any objections to his operating in that manner. We will advise him whether there are.

I think this would probably be satisfactory, but it would be well to get this on the record both at the Commission and in your own offices so that in the event an inspector ever visited you and questioned this mode of operation, you could show him that you have been so authorized by the Commission. However, I would not attempt this, if I were you, without getting some concurrence from us.

Mr. Marx: Is it true that there is some experimentation with using black and white paint on television towers?

Mr. Kelley: I believe WHAS at Louisville conducted some experimentation with black and white paint in cooperation with FAA. That is the only case I remember.

Mr. Marx: How long will it be until the Citizens Band regulations are changed so that a business will be free from interference with the ham-type conversations and restrict some channels to use between stations of the same calls only?

Mr. Kratokvil: The citizens radio problem is a very, very tough one, and I might say that probably right at this moment there are people who are framing and reframing the rules. There was a set of proposed rules which the Commission gave some consideration to but they have been referred back to a staff committee.

You might be interested in knowing that my particular Bureau is doing its part. We are issuing between 400 and 1,000 violation notices a month on citizens radio. There are 530,000 authorizations so you can see it is rather engulfing us.

Mr. Marx: When measuring field intensity, should the maximum signal be recorded or the value measured on the true azimuth toward the station?

Mr. Hanson: We prefer, of course, to have you make your measurements in your proof along the true azimuth; but sometimes nature doesn't help. We prefer to have it at the azimuth line. If you find out that you get a stronger signal from somewhere else and there is nothing there to account for it, please tell us. We prefer the measurement along the azimuth line, for obvious reasons. That is the true signal and not a reflected signal.

Mr. Kratokvil: In our procedure we have instructed our man to move as much as 50 feet either way from the chosen monitoring point, to see if he can get an agreement with the station's measurement, so it is plus or minus 50 feet. If there is a variation within the area where the azimuth would be off quite a bit, we would suspect buried pipes or copper, or something like that.

Mr. Marx: The increasing number of notices that are being handed out for overmodulation of FM stations....What is the problem as you see it, and how is that going to be slowed down or resolved?

Mr. Kassens: There are several aspects to this problem. One of them, of course, is the Commission's concern about loud commercials. I think there is a lot of confusion. The rule says that you should modulate between 85 and 100 per cent on peaks of frequent recurrence. There is a flasher on the monitor, and it is put there for a purpose. It has a better activity characteristic than the meter, and is probably more accurate. This flasher should not be flashing all the time, obviously. In the days of compressors and limiters, the tendency is to try to ride to as close to 100 per cent as you can. I think this is probably one of the difficulties.

A station tries to keep right up close to 100. Occasionally there are citations for undermodulation, but in this case the inspector is supposed to watch the modulation over a long period of time. FM operators, of course, being interested usually in a more classical type of music, recognize the fact that there are low passages. There is nothing in the Rule that says a low passage has to be boosted up to 85 per cent, but over a fairly long period of time certainly the average modulation should be riding somewhere between 85 and 100%.

So, you can set it too low and you can also set it too high. Probably the thing to do is to get the level set right in the first place, so that you aren't overmodulating too often.

There has been a complaint and there have been citations of stations overmodulating and saying, "The monitor is only reading 100 per cent." When the field truck pulls up they use a spectrum analyzer which is much more accurate. The operator says, "What should the station do? You have type-approved this monitor."

We have a rule that says you can't overmodulate. I think the point is that the level isn't really adjusted in the first place.

Mr. Marx: I wonder whether the placement of the limiter before pre-emphasis or after pre-emphasis would make a great deal of different. I think there are FM stations operating in the United States today that have the limiters on both sides. I am not sure there is a standard. I know there is still some discussion about it. As a matter offact, I wonder whether we can have discussion from the floor on this subject.

Question from the Floor: If this problem of modulation in FM as contrasted to AM isn't brought about by the fact that the percentage of modulation is a function of two things, not only amplitude but frequency due to the pre-emphasis, and if you set the gain controls along the system for a particular frequency, and then the program content has a great deal of hiss in it, this is when the overmodulation occurs. I would like to hear some comment on that.

Mr. Marx: Would anyone like to discuss this point?

Mr. Richard L. Kaye, WCRB, Boston, Massachusetts: This is a problem we run into all the time. Pre-emphasis serves a good purpose. It is supposed to improve signal-to-noise ratio. After all, you have listeners, some of them with hi-fi sets, some with lo-fi things with 4-inch speakers. There is a great variety of receiving equipment on the market. Also, we have operators on the board. There is a big problem because the operator on the board has both meters and a loudspeaker, and sometimes these things are contradicting each other.

After all, he is trying to get the program level to be fairly steady from one selection to another. His meter tells him it isn't so. A perfect example is a Mercury record. Take a John Philip Sousa march on a Mercury record: You can't modulate the thing on FM as far as the receiver is concerned, as far as the audio is concerned, because the meter is pegging all over the place because it has so much pre-emphasis on the record which is adding on top of the pre-emphasis we are required to have. If you play that record and then follow it with a record of strings, for instance, you can't comply with the rules and keep the audio level balanced.

This is part of the problem you are talking about with loud commercials, too. It is a question of the high-frequency content. What is your solution? What is important? Do we follow the modulation monitor or do we try to give the listener a good sound?

Mr. Kassens: I think perhaps one part of the problem is "Where do you put the limiter?" If you want to be reasonably sure of protecting against overmodulation, then you put the limiter later. If you put the limiter first, you take advantage of the pre-emphasis.

If anybody is suggesting that maybe we should do away with pre-emphasis, I would say: Why destroy a good thing? It has a very beneficial effect. It was put in there in the first place to pick this advantage. We should not destroy it by doing away with pre-emphasis or reducing it.

The Europeans, of course, use only 50 microseconds. I am not sure they have any particular problems with overmodulation. They play the records we play.

Voice from Audience: I don't want to belabor this, but this is something I have been bothered with since 1941. I would like to go back to this pre-emphasis. If my memory is correct, if a system is set up for a reference, let's say, at 15,000 cycles, and we modulate the FM transmitter 100 per cent and then leave all the controls alone and just change the level, if we go down to normal speech frequencies, the modulation of the transmitter will drop down about 15 db; is that correct?

Let's say we change the tone down to 400 or 300 cycles. As I recall it, the modulation of the transmitter will drop down 15 db. It seems to me over the years this has been the greatest problem of maintaining this 85 to 100 per cent modulation of an FM transmitter.

On the other hand, if you take the speech frequencies and set your gain for average speech frequencies, and you have an announcer on the air giving news, for instance, and you are modulating between 85 and 100 per cent, and then somebody comes along and plays a hi-fi tape or record with a lot of hi-fi frequencies, unless you take your gain way down as indicated on the VU on the studio console, the modulation is going to go crazy.

2nd Voice from Audience: There is an answer to that, with an instrument called the Conex, a frequency-sensitive limiter which we have used and which is very satisfactory. It has an inverse characteristic. The higher the frequency, the more it cuts down the gain.

First Voice: Then isn't that counteracting your pre-emphasis?

Second Voice: No. It takes a very trained listener to tell that you are doing anything, and it helps. If somebody suddenly toots a flute, for example, this takes care of it.

Mr. Marx: Our station has never carried color programs, so our application for license did not have to include measurements to show color performance. What FCC authority would be required now if we wished to start transmitting color programs?

Mr. Kelley: None, with one condition, that your equipment is designed or has been modified to accommodate the color transmission standards. It would ordinarily imply that you would run a color proof of performance and determine this; and if you are satisfied that you meet all the requirements, then you may proceed.

I would suggest, however, that you advise the Commission informally by letter that you are now equipped and will henceforth carry some color programs, just to make your file complete. Once a station is licensed, no further authority is required to meet the color transmission standards.

Mr. Marx: Stations with directional antennas are generally required to check monitoring points weekly. Is it required that such a station have in its possession a field strength meter?

Mr. Kratokvil: No, if you have a good friend from whom you can borrow one quickly, it's all right. It simply must be available. I suppose the inspector would wait 10, 15 or 30 minutes for you to get the thing.

Mr. Marx: Why should monitoring point field intensities be measured at least 2 hours after sunrise and 2 hours before sunset?

Mr. Hanson: Because your proof is made during daylight hours, and the true readings are obtained this way. Skywave effect is the most obvious reason.

Mr. Kassens: We would rather not have people measuring monitoring points at night if they can avoid it. If you have a DA at night and want to check the monitoring points, all you have to do is to write a letter to the Commission and request authority to operate daytime with your directional pattern long enough to check your monitoring points.

We would prefer in the letter that you specify some time, say Tuesday morning or Thursday afternoon, when you want to operate directionally, and we will send a letter back telling you this is all right. You should hang onto the letter when the inspector walks in.

Mr. Marx: Has the Commission waived the rule requiring daily inspection of transmitters operated by remote control?

Mr. Hanson: We have in a few cases, under delegated authority, waived this requirement. But the delegation of authority to the staff to waive its rules is rather limited, and it is in extreme weather conditions that we say no, you don't have to make your measurements once a day for five days. But we do say yes, you have to make them at least once during that week. We let you make the measurements once during the week, and you must notify the inspector and the Commission that the snow is 10 feet deep and your man broke a leg and can't get up there to make the measurements. That is the extent to which we have waived that requirement at present.

There are a couple of petitions in the Commission to waive this rule, which we are in the process of writing a reply to in their particular instance. But feel free to write us and request a waiver. State your conditions and, depending upon what they are, we will give you some sort of reply.

Mr. Kassens: Let me emphasize that this is only in emergencies. This has only been in effect for about a year. The intent was to upgrade the technical quality of broadcast stations, and it appears to be doing a good job. We recognize the fact that there always will be occasions when it is difficult to get to the transmitter once a day, and we want to be reasonable, but we don't want to forego all the good that the rule is doing.

Mr. Hanson: In most cases, if I remember correctly, the waivers have been for FM stations that are on top of mountains, and so on.

Mr. Marx: Is a construction permit required for the addition of a dipole or other type of receiving and transmitting antenna on a standard broadcast tower? In this case the added antenna will not extend above the top of the existing tower?

Mr. Hanson: In this case, no construction permit is required, but you must advise the Commission that the construction is taking place, and request authority to determine power by the indirect method. When the construction has been completed, of course, you must make a determination of your antenna resistance. If it has changed, then you file FCC Form 302 for request to determine power by the direct method.

No construction permit is required as far as the broadcast station is concerned. You would have to have an FM construction permit. If it is a citizens' band, the Commission will give you a construction permit to put that on. If you receive a construction permit to put an antenna on a standard broadcast station, that will be a condition on your CP. Then you file your application for license or application to determine power by direct measurement. I can say your $30 fee is not required with that particular application because it is a condition of the construction permit from the other service.

Mr. DeWitt: Is there any possibility that a diurnal curve will be adopted to permit more sensible calculation of skywave interference near to sunrise?

Mr. Johnson: I think what you are asking is pre-sunrise operation of daytime stations. We are in quite a controversial state as far as permitting daytime stations to operate pre-sunrise and we have a rule making going on trying to come up with some device whereby we can have some procedure for licensing or at least permitting stations under certain circumstances to extend their early morning hours of operation.

These diurnal curves are one of the things we have been considering. We have had some questions raised about the accuracy of these curves, but I think the main problem we have in using diurnal curves is that very few daytimers can extend their pre-sunrise hours of operation by using them. So we are probably going to have to shy away from such an exact method for determining actual interference conditions. This again is rule making. I am just talking off the top of my head with the rule-making procedure going on, but this is covered in the rule-making procedure.

Mr. George Hagerty, Westinghouse Broadcasting Co., Inc.:

Most of the discussion this morning has been concerned with violations of the Commission's rules. Occasionally, the inspectors find a station operating in direct compliance. Has the Commission given any consideration to a letter of commendation, this letter being included in the station's files?

Mr. Kratokvil: Some years ago, ex-Commissioner Sterling thought of something like that, but it never got off the ground. I will tell you that on every inspection record - even though you receive a citation - you can still get a "Very Good" rating from the inspection. So it isn't necessarily a fact that when you get a ticket you are a "bad" station. On every inspection record there is a place where the inspector gives his opinion of the over-all situation. This information is then forwarded to the Broadcast Bureau.

Mr. Kassens: We do have a procedure we go through. I guess you would call it a letter of commendation. It happens once every three years and it is called a renewal.

Comr. Bartley: I would like to contribute the thought that this is a case of "Silence is consent".

Mr. Davidson M. Vorhes, CBS Radio, New York City:

The Commission has rules that call for proof of performance from the microphone outlet to the antenna system, and we have seen in the exhibit halls all this wonderful equipment that is available - extended frequency range, low distortion, low noise, and yet it comes to my attention that some broadcasters are tinkering with the fidelity of their systems quite extensively, by using various types of limiters that have all sorts of frequency discrimination and filtration in their circuits so that the listener is confused by the multiplicity of sounds that emanate from the broadcast stations.

Has there ever been any ruling on this matter, or is there any feeling on the matter?

Mr. Kassens: To start with, remember that the rules we have were written long before the war. As you say, the specs say you make equipment performance measurements once a year from microphone input to transmitter output. We have no control over everything preceding the microphone input. The network runs this sort of thing. I presume it is an area we really ought to go into.

When you run your equipment performance measurements, you should really take out the limiters and compressors, naturally, yet immediately after these measurements you put them right back in.

That is a very good question, and I think it comes up to some degree in connection with this question of loud commercials, which is presently pending.

Mr. Marx: That concludes the time we have for this session. Thank you Commissioner...Gentlemen of the panel...and thank you all for your kind attention.

XXX

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The next biggest violation was Program Logs, with 141 there as against 174 for the other.

Also, 120 items were noted where various technical violations were noted, such as spurious emissions, poor installation practices, tuning house not protected against the public, and so on.

The next biggest was over- and undermodulation.

The next, general log requirements.

The next, following closely, was failure to have available equipment performance measurements that are required at yearly intervals.

The next was over- and under-powered.

Next, maintenance log requirements. We instituted a maintenance log some time ago and this is a common violation.

Failure to have a properly operating EBS receiver.

"Modulation monitor not working properly," is one of the minor infractions, along with "Failure to have an operator of the proper class."

In FM, the most common violation is modulation, over and under, followed by failure to have an operator of the required class. That is followed by equipment performance measurements - simply failure to have them available. There is a sprinkling of others. Logs brings up a poor fifth. The number of violations in FM noncommercial is quite insignificant.

In television, I have an old and a new listing. The old listing indicates that percentage of modulation seems to be a big factor, along with logs and operating power. All the broadcast services together join in developing forty-seven items of violation, failure to have a properly operating EBS receiver, and failure to test the emergency action notification system.

Out of seventeen stations jointly monitored, no violations were issued for frequency deviation either of the video carrier or the aural carrier. The typical infraction you will find will be logs and improper setup of the television picture, which, of course, can be shown on the station's own monitor also.

Question from the Audience: Section 73.47 requires equipment performance tests every year. In the last few years, of course, it has been the habit in AM broadcasting to have 24-hour-a-day programming on Class I channels. Section 73.10 requires us not to interfere with other stations carrying on a regular program service.

Which of these two Sections would you gentlemen prefer us to violate?

Mr. Kassens: You must run these equipment performance measurements every year. You are not supposed to run them into a dummy load, because the transmitter should be operating when you run the measurement into its normal load. If you have this situation, I am sure we could work out an arrangement to let you do it by dummy load, but I think your easy way to do it is to find out when these stations do their maintenance period, and run yours at the same time.

Mr. John H. DeWitt, Jr., WSM, Inc., Nashville, Tennessee:

Frank Kratokvil said that the most common violation was the calibration between the remote antenna ammeter and the one in the tuning house. We ran into something on this subject recently that might be of general interest and I want to ask the Commission what the answer might be.

We found pretty good variations between winter and summer between the antenna ammeter in the tuning house and the remote meter. We found the remote meter was correct. Then we found that in the Western Catalog for thermocouple meters it says that the temperature coefficient is 1.6 per cent per 10° C.

Our tuning house changes from 20° F in the winter to 100° F in the summer, and this figures out to be 44° C range which would cause the antenna ammeter to vary in percentage by 7.04 per cent, which is 14 per cent in power.

I would like to know if the Commission has taken this into account. If they haven't, we would like to be authorized to have a curve in the tuning house with a thermometer so that we can correct the readings to make them fit the remote meter.

Mr. Hanson: We realize this is a problem. I don't know whether anyone has done any active work on it.

Mr. Kassens: Several consultants have mentioned this to me. Frankly, I don't know where the problem is. Our rules say that the base current meter should have an accuracy of 2 per cent. These rules were written a good many years ago, and I don't know why these RF meters should be getting worse with time. We didn't have this problem before the war. Consulting engineers are concerned because when they go out to run a proof they find that you buy four or five meters and none of them will agree. So, I think it is a little deeper problem, and apparently it goes back to the meter itself.

Mr. DeWitt: I am going entirely by the statement in the Western Catalog, which says that it is 1.6 per cent per 10° C. We have a letter from Westinghouse which says theirs is 2.5 per cent per 10° C. So, this is another factor over and above the accuracy, because the accuracy is stated as 1 or 2 per cent of whatever it is at 25 per cent degrees Centigrade.

Mr. Marx: In line with the Commission's recent relaxation on non-directional stations, when will the FCC relax operator requirements at 500-watt, 2-tower directional daytime stations?

Mr. Johnson: Every time we get into this problem of relaxing our operator requirements depending on what type of installation we have, citations increase tremendously.

One of the things that worries us is that with the data we have on the maintenance of directional antennas and the performance of directional antennas, each one becomes a pretty unique situation. So, before we get to the point of actually relaxing that first-class operator requirement for directional, I think we are going to take a mighty hard and fast look at the performance of directional antennas, and possibly try to work out some criteria as to what type of antenna systems we would permit a relaxation of first in the operators. We are very leery of relaxing requirements, especially for directional antennas, and it is going to be a long time before we are convinced that it might be done.

Mr. Kratokvil: About two years ago we made a survey of directional antenna system stations. It included two-, three- and four-tower jobs, and 40 per cent of them were found to be out of tolerance.

Unfortunately, I don't have more exact information, but in preparation for this conference, I went out and made an inspection of a 2-hour array, and I was amazed how close it was to the licensed power. There were two inspectors at the site. The meters agreed with the Commission's meter, and it looked like a good job. So there seems to be some justification on the other side, too.

Mr. Marx: How much time is acceptable on the hour and half-hour readings? Can the readings be taken, say, at 20 and 50 minutes past the hour?

Mr. Hanson: The rule says that if you can't possibly make it, a minute or two either way won't make much difference. I would be a little leery of that, unless extreme circumstances are encountered. Ten minutes out of the way is outside the rule.

Mr. Marx: Does that necessarily mean they have to be taken straight up and at six, or is the spread the important thing?

Mr. Hanson: The spread is the important thing.

Mr. Marx: Has the FCC specified a procedure for a station to obtain TV aural power reduction authority?

Mr. Kelley: The Commission has recently changed its rules regarding VHF-TV aural-to-visual power ratio. Previously, it was 70 to 50 per cent, the minimum is now 10 per cent.

In applying for a reduction in aural power, we follow the normal procedure of filing an application to make a change in power. Use Application Form 301. Depending upon the type of change you are making - that is, how you are going to achieve the change in power - it would be treated as a modification of a license, or you would be issued a CP to make the change.

The thing that determines which category it falls into is whether you have undertaken construction or possibly destruction, as you might refer to it, in order to achieve your new operating power.

Mr. Johnson: We have had a lot of questions asked about the two documents that came out last Wednesday. One is the document Mr. Kelley was referring to, actually permitting a reduction from 10 to 70 per cent. Then there was another proposed rule making that came out, bringing it down to the ratio from 10 to 20 per cent. So, there are two things that were done last Wednesday that are completely separate, one of them permitting 10 to 70 and the other proposing 10 to 20.

Mr. Marx: Please explain the differences between the Emergency Action Notification System and the Emergency Broadcast System, and which term properly applies to the non-NDEA participating radio station.

Comr. Bartley: Perhaps I had better rephrase it so we are clear on what the question is.

The Emergency Action Notification is the APUPI system of notification of an emergency. The control point for this is at NORAD and at a classified location near Washington. It can be instituted by the Office of Civil Defense for higher authority, which in that case means the President.

The stations which are not members of the EBS System will find in this booklet the announcement that they make before they go off the air. At this point, I might point out that all of the existing NDEA licenses expire June 30. Between now and then those stations which qualify and request the EBS or NDEA authorizations will be issued them prior to that time.

Mr. Marx: Is it against FCC rules for unlicensed personnel to turn the radiation switch on on an STL microwave transmitter? Is the fact that there is a first-class licensed man on duty at the receiving end of an STL sufficient to meet FCC regulations so that an unlicensed man at the transmitter end could activate the STL?

In other words, we would like to use an unlicensed man to open the studios each morning, and not require a first-class man until about two hours later. In the event of improper operation of the STL transmitter, the first-class man at the receiving end could direct the steps to be taken by the unlicensed man to either obtain proper operation or shut off the emission of the STL, not by remote control but by directing the unlicensed man by radio or by telephone circuits.

Mr. Kelley: In STLs we have three modes of operation - We have the direct control; the unattended operation; and remote control. This proposal, as I understand it, would not fit any of those categories.

I think this question would come nearer fitting the unattended operation. I would suggest that anyone who would care to do what this gentlemen would like to do should write us and give us in detail exactly how he proposes to operate, and ask if there are any objections to his operating in that manner. We will advise him whether there are.

I think this would probably be satisfactory, but it would be well to get this on the record both at the Commission and in your own offices so that in the event an inspector ever visited you and questioned this mode of operation, you could show him that you have been so authorized by the Commission. However, I would not attempt this, if I were you, without getting some concurrence from us.

Mr. Marx: Is it true that there is some experimentation with using black and white paint on television towers?

Mr. Kelley: I believe WHAS at Louisville conducted some experimentation with black and white paint in cooperation with FAA. That is the only case I remember.

Mr. Marx: How long will it be until the Citizens Band regulations are changed so that a business will be free from interference with the ham-type conversations and restrict some channels to use between stations of the same calls only?

Mr. Kratokvil: The citizens radio problem is a very, very tough one, and I might say that probably right at this moment there are people who are framing and reframing the rules. There was a set of proposed rules which the Commission gave some consideration to but they have been referred back to a staff committee.

You might be interested in knowing that my particular Bureau is doing its part. We are issuing between 400 and 1,000 violation notices a month on citizens radio. There are 530,000 authorizations so you can see it is rather engulfing us.

Mr. Marx: When measuring field intensity, should the maximum signal be recorded or the value measured on the true azimuth toward the station?

Mr. Hanson: We prefer, of course, to have you make your measurements in your proof along the true azimuth; but sometimes nature doesn't help. We prefer to have it at the azimuth line. If you find out that you get a stronger signal from somewhere else and there is nothing there to account for it, please tell us. We prefer the measurement along the azimuth line, for obvious reasons. That is the true signal and not a reflected signal.

Mr. Kratokvil: In our procedure we have instructed our man to move as much as 50 feet either way from the chosen monitoring point, to see if he can get an agreement with the station's measurement, so it is plus or minus 50 feet. If there is a variation within the area where the azimuth would be off quite a bit, we would suspect buried pipes or copper, or something like that.

Mr. Marx: The increasing number of notices that are being handed out for overmodulation of FM stations....What is the problem as you see it, and how is that going to be slowed down or resolved?

Mr. Kassens: There are several aspects to this problem. One of them, of course, is the Commission's concern about loud commercials. I think there is a lot of confusion. The rule says that you should modulate between 85 and 100 per cent on peaks of frequent recurrence. There is a flasher on the monitor, and it is put there for a purpose. It has a better activity characteristic than the meter, and is probably more accurate. This flasher should not be flashing all the time, obviously. In the days of compressors and limiters, the tendency is to try to ride to as close to 100 per cent as you can. I think this is probably one of the difficulties.

A station tries to keep right up close to 100. Occasionally there are citations for undermodulation, but in this case the inspector is supposed to watch the modulation over a long period of time. FM operators, of course, being interested usually in a more classical type of music, recognize the fact that there are low passages. There is nothing in the Rule that says a low passage has to be boosted up to 85 per cent, but over a fairly long period of time certainly the average modulation should be riding somewhere between 85 and 100%.

So, you can set it too low and you can also set it too high. Probably the thing to do is to get the level set right in the first place, so that you aren't overmodulating too often.

There has been a complaint and there have been citations of stations overmodulating and saying, "The monitor is only reading 100 per cent." When the field truck pulls up they use a spectrum analyzer which is much more accurate. The operator says, "What should the station do? You have type-approved this monitor."

We have a rule that says you can't overmodulate. I think the point is that the level isn't really adjusted in the first place.

Mr. Marx: I wonder whether the placement of the limiter before pre-emphasis or after pre-emphasis would make a great deal of different. I think there are FM stations operating in the United States today that have the limiters on both sides. I am not sure there is a standard. I know there is still some discussion about it. As a matter offact, I wonder whether we can have discussion from the floor on this subject.

Question from the Floor: If this problem of modulation in FM as contrasted to AM isn't brought about by the fact that the percentage of modulation is a function of two things, not only amplitude but frequency due to the pre-emphasis, and if you set the gain controls along the system for a particular frequency, and then the program content has a great deal of hiss in it, this is when the overmodulation occurs. I would like to hear some comment on that.

Mr. Marx: Would anyone like to discuss this point?

Mr. Richard L. Kaye, WCRB, Boston, Massachusetts: This is a problem we run into all the time. Pre-emphasis serves a good purpose. It is supposed to improve signal-to-noise ratio. After all, you have listeners, some of them with hi-fi sets, some with lo-fi things with 4-inch speakers. There is a great variety of receiving equipment on the market. Also, we have operators on the board. There is a big problem because the operator on the board has both meters and a loudspeaker, and sometimes these things are contradicting each other.

After all, he is trying to get the program level to be fairly steady from one selection to another. His meter tells him it isn't so. A perfect example is a Mercury record. Take a John Philip Sousa march on a Mercury record: You can't modulate the thing on FM as far as the receiver is concerned, as far as the audio is concerned, because the meter is pegging all over the place because it has so much pre-emphasis on the record which is adding on top of the pre-emphasis we are required to have. If you play that record and then follow it with a record of strings, for instance, you can't comply with the rules and keep the audio level balanced.

This is part of the problem you are talking about with loud commercials, too. It is a question of the high-frequency content. What is your solution? What is important? Do we follow the modulation monitor or do we try to give the listener a good sound?

Mr. Kassens: I think perhaps one part of the problem is "Where do you put the limiter?" If you want to be reasonably sure of protecting against overmodulation, then you put the limiter later. If you put the limiter first, you take advantage of the pre-emphasis.

If anybody is suggesting that maybe we should do away with pre-emphasis, I would say: Why destroy a good thing? It has a very beneficial effect. It was put in there in the first place to pick this advantage. We should not destroy it by doing away with pre-emphasis or reducing it.

The Europeans, of course, use only 50 microseconds. I am not sure they have any particular problems with overmodulation. They play the records we play.

Voice from Audience: I don't want to belabor this, but this is something I have been bothered with since 1941. I would like to go back to this pre-emphasis. If my memory is correct, if a system is set up for a reference, let's say, at 15,000 cycles, and we modulate the FM transmitter 100 per cent and then leave all the controls alone and just change the level, if we go down to normal speech frequencies, the modulation of the transmitter will drop down about 15 db; is that correct?

Let's say we change the tone down to 400 or 300 cycles. As I recall it, the modulation of the transmitter will drop down 15 db. It seems to me over the years this has been the greatest problem of maintaining this 85 to 100 per cent modulation of an FM transmitter.

On the other hand, if you take the speech frequencies and set your gain for average speech frequencies, and you have an announcer on the air giving news, for instance, and you are modulating between 85 and 100 per cent, and then somebody comes along and plays a hi-fi tape or record with a lot of hi-fi frequencies, unless you take your gain way down as indicated on the VU on the studio console, the modulation is going to go crazy.

2nd Voice from Audience: There is an answer to that, with an instrument called the Conex, a frequency-sensitive limiter which we have used and which is very satisfactory. It has an inverse characteristic. The higher the frequency, the more it cuts down the gain.

First Voice: Then isn't that counteracting your pre-emphasis?

Second Voice: No. It takes a very trained listener to tell that you are doing anything, and it helps. If somebody suddenly toots a flute, for example, this takes care of it.

Mr. Marx: Our station has never carried color programs, so our application for license did not have to include measurements to show color performance. What FCC authority would be required now if we wished to start transmitting color programs?

Mr. Kelley: None, with one condition, that your equipment is designed or has been modified to accommodate the color transmission standards. It would ordinarily imply that you would run a color proof of performance and determine this; and if you are satisfied that you meet all the requirements, then you may proceed.

I would suggest, however, that you advise the Commission informally by letter that you are now equipped and will henceforth carry some color programs, just to make your file complete. Once a station is licensed, no further authority is required to meet the color transmission standards.

Mr. Marx: Stations with directional antennas are generally required to check monitoring points weekly. Is it required that such a station have in its possession a field strength meter?

Mr. Kratokvil: No, if you have a good friend from whom you can borrow one quickly, it's all right. It simply must be available. I suppose the inspector would wait 10, 15 or 30 minutes for you to get the thing.

Mr. Marx: Why should monitoring point field intensities be measured at least 2 hours after sunrise and 2 hours before sunset?

Mr. Hanson: Because your proof is made during daylight hours, and the true readings are obtained this way. Skywave effect is the most obvious reason.

Mr. Kassens: We would rather not have people measuring monitoring points at night if they can avoid it. If you have a DA at night and want to check the monitoring points, all you have to do is to write a letter to the Commission and request authority to operate daytime with your directional pattern long enough to check your monitoring points.

We would prefer in the letter that you specify some time, say Tuesday morning or Thursday afternoon, when you want to operate directionally, and we will send a letter back telling you this is all right. You should hang onto the letter when the inspector walks in.

Mr. Marx: Has the Commission waived the rule requiring daily inspection of transmitters operated by remote control?

Mr. Hanson: We have in a few cases, under delegated authority, waived this requirement. But the delegation of authority to the staff to waive its rules is rather limited, and it is in extreme weather conditions that we say no, you don't have to make your measurements once a day for five days. But we do say yes, you have to make them at least once during that week. We let you make the measurements once during the week, and you must notify the inspector and the Commission that the snow is 10 feet deep and your man broke a leg and can't get up there to make the measurements. That is the extent to which we have waived that requirement at present.

There are a couple of petitions in the Commission to waive this rule, which we are in the process of writing a reply to in their particular instance. But feel free to write us and request a waiver. State your conditions and, depending upon what they are, we will give you some sort of reply.

Mr. Kassens: Let me emphasize that this is only in emergencies. This has only been in effect for about a year. The intent was to upgrade the technical quality of broadcast stations, and it appears to be doing a good job. We recognize the fact that there always will be occasions when it is difficult to get to the transmitter once a day, and we want to be reasonable, but we don't want to forego all the good that the rule is doing.

Mr. Hanson: In most cases, if I remember correctly, the waivers have been for FM stations that are on top of mountains, and so on.

Mr. Marx: Is a construction permit required for the addition of a dipole or other type of receiving and transmitting antenna on a standard broadcast tower? In this case the added antenna will not extend above the top of the existing tower?

Mr. Hanson: In this case, no construction permit is required, but you must advise the Commission that the construction is taking place, and request authority to determine power by the indirect method. When the construction has been completed, of course, you must make a determination of your antenna resistance. If it has changed, then you file FCC Form 302 for request to determine power by the direct method.

No construction permit is required as far as the broadcast station is concerned. You would have to have an FM construction permit. If it is a citizens' band, the Commission will give you a construction permit to put that on. If you receive a construction permit to put an antenna on a standard broadcast station, that will be a condition on your CP. Then you file your application for license or application to determine power by direct measurement. I can say your $30 fee is not required with that particular application because it is a condition of the construction permit from the other service.

Mr. DeWitt: Is there any possibility that a diurnal curve will be adopted to permit more sensible calculation of skywave interference near to sunrise?

Mr. Johnson: I think what you are asking is pre-sunrise operation of daytime stations. We are in quite a controversial state as far as permitting daytime stations to operate pre-sunrise and we have a rule making going on trying to come up with some device whereby we can have some procedure for licensing or at least permitting stations under certain circumstances to extend their early morning hours of operation.

These diurnal curves are one of the things we have been considering. We have had some questions raised about the accuracy of these curves, but I think the main problem we have in using diurnal curves is that very few daytimers can extend their pre-sunrise hours of operation by using them. So we are probably going to have to shy away from such an exact method for determining actual interference conditions. This again is rule making. I am just talking off the top of my head with the rule-making procedure going on, but this is covered in the rule-making procedure.

Mr. George Hagerty, Westinghouse Broadcasting Co., Inc.:

Most of the discussion this morning has been concerned with violations of the Commission's rules. Occasionally, the inspectors find a station operating in direct compliance. Has the Commission given any consideration to a letter of commendation, this letter being included in the station's files?

Mr. Kratokvil: Some years ago, ex-Commissioner Sterling thought of something like that, but it never got off the ground. I will tell you that on every inspection record - even though you receive a citation - you can still get a "Very Good" rating from the inspection. So it isn't necessarily a fact that when you get a ticket you are a "bad" station. On every inspection record there is a place where the inspector gives his opinion of the over-all situation. This information is then forwarded to the Broadcast Bureau.

Mr. Kassens: We do have a procedure we go through. I guess you would call it a letter of commendation. It happens once every three years and it is called a renewal.

Comr. Bartley: I would like to contribute the thought that this is a case of "Silence is consent".

Mr. Davidson M. Vorhes, CBS Radio, New York City:

The Commission has rules that call for proof of performance from the microphone outlet to the antenna system, and we have seen in the exhibit halls all this wonderful equipment that is available - extended frequency range, low distortion, low noise, and yet it comes to my attention that some broadcasters are tinkering with the fidelity of their systems quite extensively, by using various types of limiters that have all sorts of frequency discrimination and filtration in their circuits so that the listener is confused by the multiplicity of sounds that emanate from the broadcast stations.

Has there ever been any ruling on this matter, or is there any feeling on the matter?

Mr. Kassens: To start with, remember that the rules we have were written long before the war. As you say, the specs say you make equipment performance measurements once a year from microphone input to transmitter output. We have no control over everything preceding the microphone input. The network runs this sort of thing. I presume it is an area we really ought to go into.

When you run your equipment performance measurements, you should really take out the limiters and compressors, naturally, yet immediately after these measurements you put them right back in.

That is a very good question, and I think it comes up to some degree in connection with this question of loud commercials, which is presently pending.

Mr. Marx: That concludes the time we have for this session. Thank you Commissioner...Gentlemen of the panel...and thank you all for your kind attention.

XXX

Cartridge Tape Design to Meet

NAB Recording and Reproducing Standards

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Cartridge Tape Design to Meet

NAB Recording and Reproducing Standards

Introduction

This paper is concerned with the design of a cartridge tape recorder to meet proposed NAB standards. It discusses specific engineering areas in which special care was needed. These are the areas of tape speed, flutter, tape tracking, frequency response, and head characteristics. Brief mention is also made of other parts of the proposed standard. These other parts presented no special problem.

The Proposed Standard

For the last year or so, engineering committees of NAB have been actively writing a standard for cartridge tape recorders. At the present time, one subcommittee has issued its report in the form of a proposed standard. This proposal is currently under study and review by higher committees, and thus it has not yet been officially adopted. It is expected to be approved by the NAB board in June, with only minor revisions. However, it is a useful indication of what design requirements may be placed on a machine, even though it is at present only proposed.

Tape Speed

The proposed standard specifies a tape speed of 7 1/2 inches per second. For programming purposes this means exactly that speed; an error of only 1% would amount to 18 seconds in half an hour. Such an error would be a disaster.

At first thought, one might think that the perfect solution would be to use a synchronous direct drive motor, whose shaft was ground to a diameter that had a surface speed of exactly 7 1/2 ips. This is wrong. If such a machine were made, the tape would run fast. The reason can be seen through fig. 1. Here we see a tape wrapped around a capstan. Imagine a number of lines drawn through a cross section of the tape, such as a series of butt splices. As these lines move past the capstan, the distance between them at the outer edge of the tape will stretch. The distances at the inner edge will shrink. After the tape leaves the capstan, the distances return to normal. Note that there is one place in the tape where it is not warped. This is called the neutral axis.

Now if the inner edge of the tape were driven by the capstan at exactly 7 1/2 ips, as this edge moved past the capstan the line distances would stretch back to normal, and this would make the tape run a little fast.

In order to make the tape run at the right speed, we must try to drive that part of it which isn't stretched apart or squeezed together. Fig. 2 shows the same tape, but with the neutral axis added to the drawing. To a first approximation, the neutral axis runs down about the middle of the tape. The effective radius of the capstan is its actual radius plus half the tape thickness. This means that the shaft diameter (not radius) must be ground smaller (by the tape thickness) than was originally computed.

At first thought, it may seem like this is a very small effect; too small to worry about. However, for the typical shaft diameter found in cartridge machines it amounts to over 10 seconds in half an hour. The proposed standard allows about 7 seconds.

Although a direct drive capstan would seem to be ideal from a tape speed accuracy standpoint, it has a serious potential drawback from a flutter standpoint. This will be discussed later on. An indirect drive was used in the design of this machine. Experience with thousands of earlier machines in the field has proven that, with careful design, they can achieve excellent uniformity of tape speed. Most of the tape speed problems that I have encountered were caused either by using a motor that wasn't synchronous, or involved design errors that ignored the tape thickness effect just described.

Wow and Flutter

We are all familiar with the effects of wow on piano music and on chimes. Even a very small amount makes most music sound "sour". Wow usually involves rates up to about 7 cps. Higher rates are usually called flutter; however, the term flutter often includes both meanings. This is rather unfortunate, for flutter rates above about 10 cps cause a different effect; flutter usually makes a tone sound harsh or noisy, while wow sounds "sour".

At first thought, one might think that all that is needed to eliminate all wow and flutter from a tape transport is to have perfect machining. This is only half true, although good machining certainly is necessary. Even with perfect machining, there can be a fair amount of flutter left, and sometimes some wow, too. Here's an example: Earlier I said that we did not use a direct drive motor as a capstan. Our experience with such motors shows that they have a tendency to "hunt", that is, slowly oscillate around their average speed. This produces wow while the motor is "hunting". After a time, the hunting stops...provided that there is no change in load. Thus in a reel-to-reel machine, direct drive is practical, because the tape pays off the supply reel comparatively evenly, and the hunting dies out. But in a cartridge machine the picture is different. Here the tape is literally pulled from the center of the reel, and the back tension becomes rather jerky. This jerkiness, often occurring once each revolution of the platter, would aggrevate hunting and wow. So here is a case where precision machining still cannot eliminate wow.

The use of an indirect drive can reduce hunting to practical proportions. In this case the motor is coupled to a massive flywheel by means of a rubber O ring. The capstan is the shaft of the flywheel. It turns out that the springiness of the O ring and the mass of the flywheel are successful in filtering out the motor hunting. Listening tests (which are often more useful than a flutter measurement) verify this conclusion.

One design aid that has been helpful is a "spectrum analysis" of the flutter rates. This involves connecting a wave analyzer to the flutter meter output. If a curve is plotted of the various flutter rates, one can see what each shaft and bearing contributes to the overall flutter. For example, suppose one makes an overall flutter measurement. The meter reads 0.2%. What can be done to lower it? The usual procedure is pretty much of a guess and test operation: you try replacing the pressure roller; you clean the heads;

you try another cartridge; you lubricate the capstan, motor and flywheel bearings, and so on. This procedure may or may not be successful. But a spectrum analysis lets you see exactly what each shaft and bearing contributes to the overall measurement.

Figure 3 shows such an analysis. The bottom curve shows the flutter rates of a tape recorded on a reel-to-reel machine (an RT-21 B) which has low flutter... only 0.03%. This tape was then loaded into a cartridge, and played in the cartridge recorder. Flutter measurements were made at both of the head positions: these are curves A and B. Note that there is a peak around 3.2 cps. This is the pressure roller speed. Note another peak around 6 cps. This one is the belt rate, that is, it is caused by the once around speed of the rubber O ring in the drive assembly. Another peak at about 11 cps is caused by the capstan. These three peaks are small, amounting to only a few hundredths of a per cent. But as we go higher in frequency, it becomes more difficult to explain the source of flutter. The large peak at 150 cps occurs at a speed much faster than any shaft (including the motor) rotates. Preliminary calculations suggest that the 150 cps rate is the result of a resonance involving the tape (it acts like a spring) and the tape and platter in the cartridge (which acts as a mass).

In this case the overall flutter in the A head position is only 0.10%, and in the B position 0.12%. The proposed standard allows 0.2%. Further improvement would be expensive, and rather difficult, for a more precise motor shaft wouldn't help the principal offender (the 150 cps peak) at all. To improve that, changes in the cartridge would be needed.

So far, we have discussed moving the tape at the right speed, and doing it uniformly. Now let's consider the path the tape takes.

Tape Tracking

The path the tape takes across the heads is called the track of the tape, and of course, it is desirable that it not vary from one machine to another, or from one cartridge to another. This path is shown in fig. 4. Note that the tape motion is from left to right. The tape is pulled around the cartridge post, which acts as a guide, across the B head (this is the record head), through a guide mounted on the deck, across the A (or playback) head, and between the capstan and pressure roller. If the tape path is straight for some machines and cartridges, but bent or crooked for others, there will be azimuth errors.

A common source of error that is not well known is caused by the capstan and pressure roller. Normally we assume that they merely pull the tape in the direction we want it to go. However, there are two types of shaft misalignment that tend to push the tape up or down from the deck.

The first type is shown in fig. 5. This view is the same as the previous one, that is, the tape moves from left to right. In the figure, there is a shaft misalignment of angle A. A little thought will show that the capstan is trying to move the tape horizontally, but the pressure roller wants to move it down and to the right. How far down it moves depends on the back tension of the tape.

The second type of misalignment is shown in fig. 6. This view is 90 degrees from the previous one, that is, the tape is moving away from us. In this case, the capstan and pressure roller surfaces aren't parallel because their shafts are misaligned.

Although these two alignment errors are rather obvious, what isn't obvious is the precision needed for good tracking. Tests show that these errors must be about 1/4 degree at the most. This is a very tight tolerance for a machine of this type.

Frequency Response

There are, of course, many factors that affect the overall frequency response of a machine. The design of the recording and playback amplifiers has been discussed elsewhere before, and won't be repeated now. In the design of this machine the factor that affected response the most turned out to be another tracking problem. Back in fig. 4 we saw that the cartridge post acted as a tape guide. If different cartridges have guide heights other than 0.562 inches, then these cartridges will have different azimuths at the record head. The azimuth at the play head will tend to remain the same, however. What this means is that different cartridges will have different overall responses, unless azimuth is adjusted for each cartridge. This, of course, is impractical. An example of post errors is shown in fig. 7. This is the response of a machine measured by six different cartridges.

In an effort to improve this response, the post heights of these cartridges, which were off by as much as 10 mils, were hand adjusted to within 1/2 mil. Another response run was taken, and is shown in fig. 8. There are still serious variations. At this point we noticed that the covers of the cartridges fit very tightly, and could warp the cartridges. After adjusting the covers for proper fit, we obtained fig. 9. Notice that there is one cartridge still in trouble. This was traced down to too tight a loop in the cartridge (due to improper loading). After the loop was loosened, we obtained an overall response as shown in fig. 10. The variations between cartridges is only $\pm$ 1 db at 15 kc. This might have been caused by pressure pad variations.

While on the subject of pressure pads, it is worthwhile to point out that there is a tendency to blame them for just about every fault one runs into. (This is probably because they are the only element that is visually wrong.) As a matter of fact, they aren't responsible for as much trouble as it appears. That this is true is shown by that last response curve. I suspect that in the past, the process of bending the pads into weird shapes to correct response problems simply put another error into the system that partially corrected for something else, such as post height errors.

The response problems were discussed with the cartridge manufacturer. He has supplied redesigned cartridges which perform very well indeed; the typical variation at 15 kc is now about $\pm$ 1 db.

Magnetic Heads

Another factor that affects response are the magnetic heads, particularly the playback head. There are many important head characteristics, but the only one we have time to consider is the gap in playback head. Our friends in the "hi-fi" field often imply that their slow speed supposedly wide response tape systems were achieved by using narrow gap heads (such as 50 microinches) and that we ought to do the same. Of course, this is only part of the story.

As a matter of fact, there is no great problem these days in making a narrow gap. The gap spacer material can be purchased as a stock item down to about 90 microinches. The problem is that of head assembly. The gap must be straight-edged, if interchangibility is to be obtained.

In the process of evaluating magnetic heads, it is our practice at RCA to measure the gap with a toolmaker's microscope. We often take photomicrographs for our records. Some of these are displayed as fig. 11. In fig. 11a, the edges are definitely not straight. Incidentally, a graticule was photographed each time, and the space between the smallest divisions is 84 microinches (that's about 4 wavelengths of light). Fig. 11a is supposed to be a 250 microinch gap. Fig. 11b shows another type of error; the gap spacer is straight, but the two cores are not pressed tightly together, and the actual gap is about 150% of the spacer! This is supposed to be a 200 microinch gap. Still another type is shown in fig. 11c. Here the material is smeared across the gap so badly that it is hard to recognize it at all, although this is supposed to be a 170 microinch gap. Finally, in fig. 11d, we have a 100 microinch gap that is very good for an audio recorder. The edges are reasonably straight and parallel. Performance tests with tape verify that this is true.

Miscellaneous Requirements

The proposed standard specifies that the basic cue tone (at the very beginning of a message) be a 1000 cps tone at about program level. The "end cue" is called out as a 150 cps tone, about 6 db above program level. The random use cue (for operating slide projectors, etc.) is an 8 kc tone, about 10 db below program level. There was no particular design problem in achieving these frequencies or levels, although the 150 cps tone is approaching tape saturation.

One area of the proposed standard that requires a little explanation is the signal to noise requirement. The old standard was actually a distortion (2%) to noise requirement. The proposed standard specifies noise as 45 db below program level, and distortion as a 3% maximum measured 6 db above program level. On the basis of the old standard, this would amount to a little less than 51 db. However, the old standard was intended for full track equipment; cartridge equipment has a narrower track of about 1/3 the width; this represents a theoretical loss of 5 db. With this 5 db track width effect in mind, the two standards are about the same.

The same argument holds true for stereo, except that another 3 db is lost due to its track width, which is only 43 mils.

Summary

Once we did our engineering "homework" in the five areas of tape speed, flutter, tracking, response, and head characteristics, we were able to proceed with the design of a cartridge recorder that has very good performance and meets the proposed NAB standard.

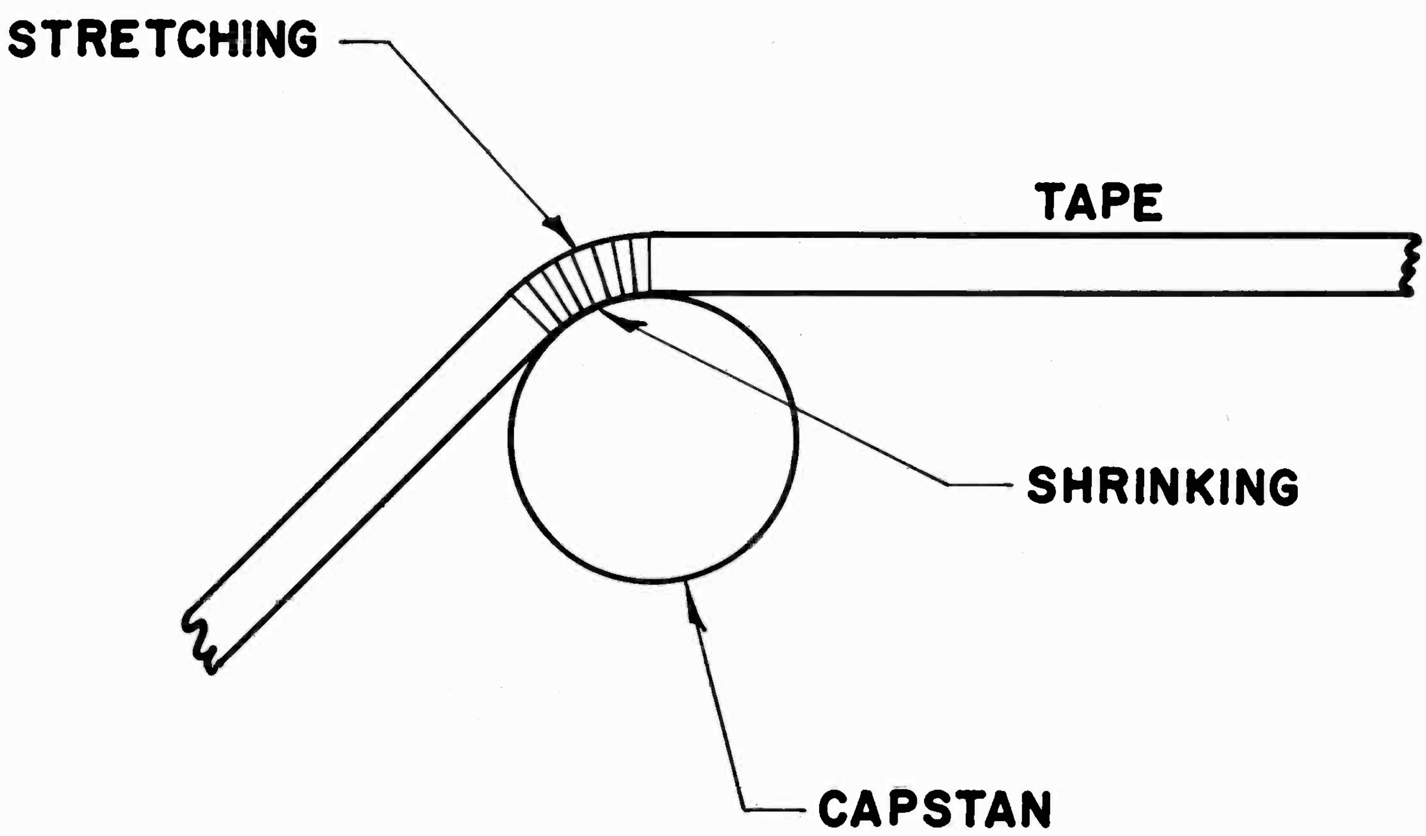
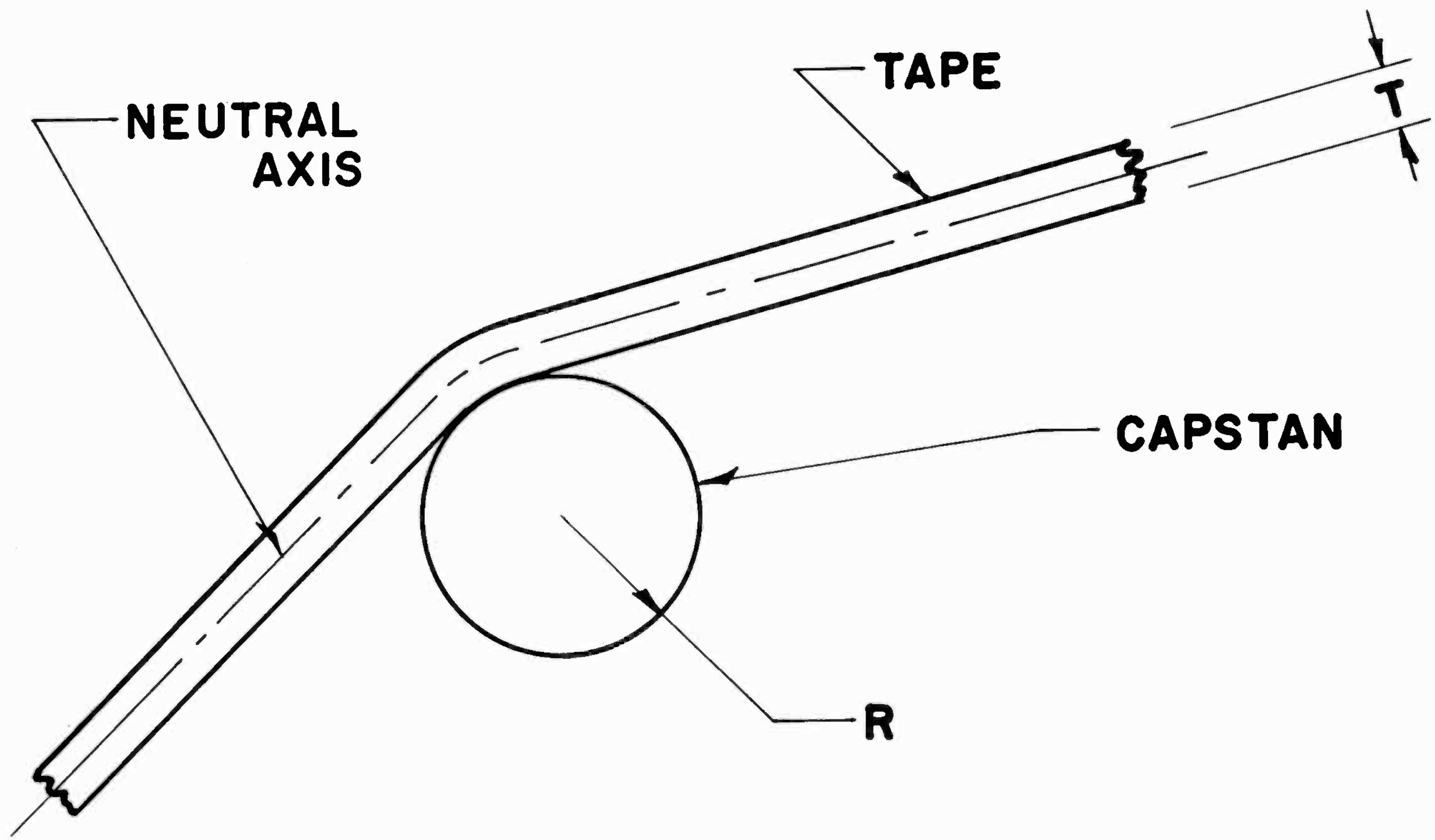


Figure 1 Tape Wrap around Capstan Showing Stretching and Shrinking



$$\text{EFFECTIVE RADIUS} = R + \frac{1}{2} T$$

$$\text{TAPE SPEED} = \pi N \left(R + \frac{1}{2} T \right)$$

Figure 2 Tape Wrap around Capstan Showing the Neutral Plane and its Effect on Tape Speed

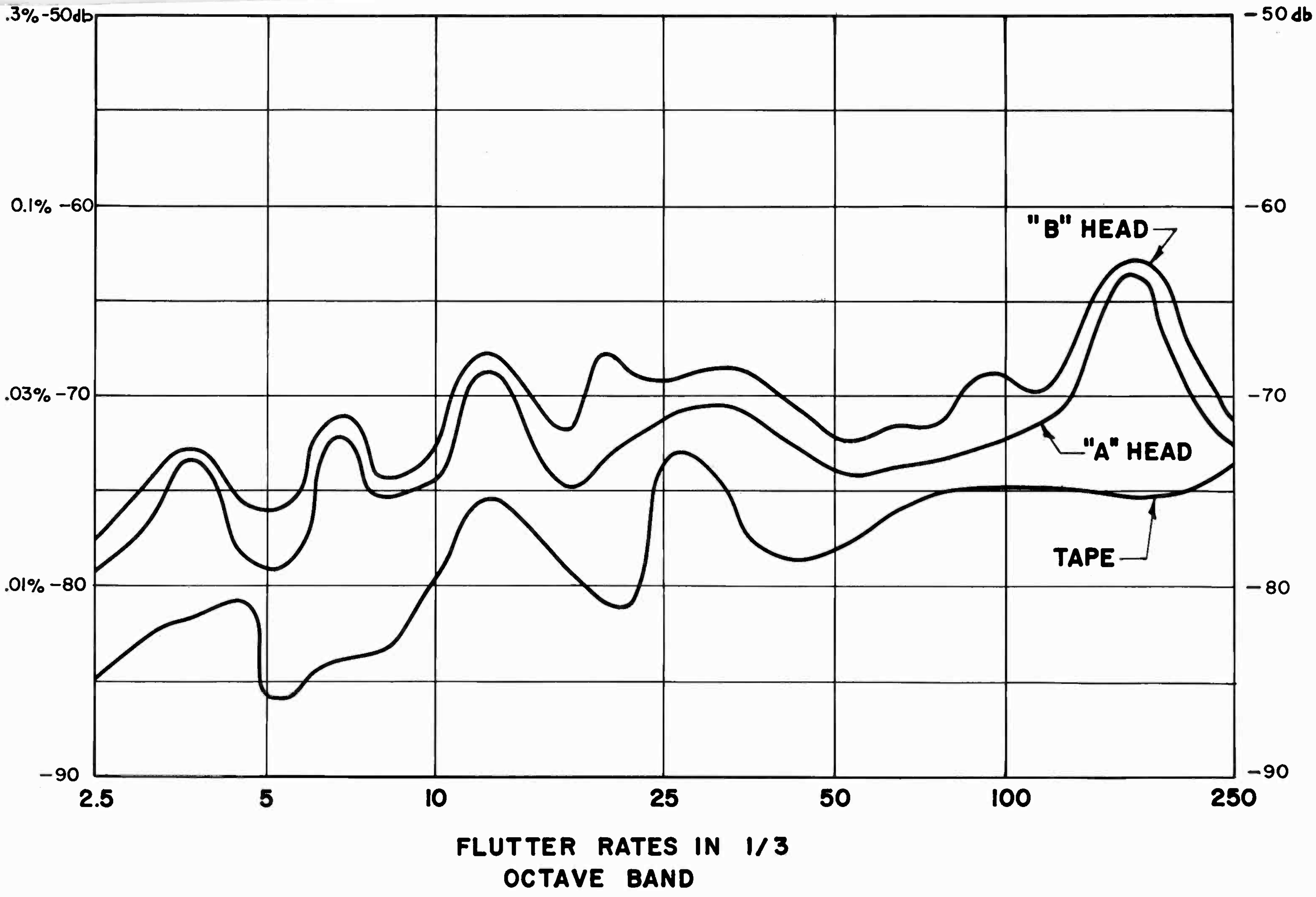


Figure 3 Flutter Content at Various Flutter Rates

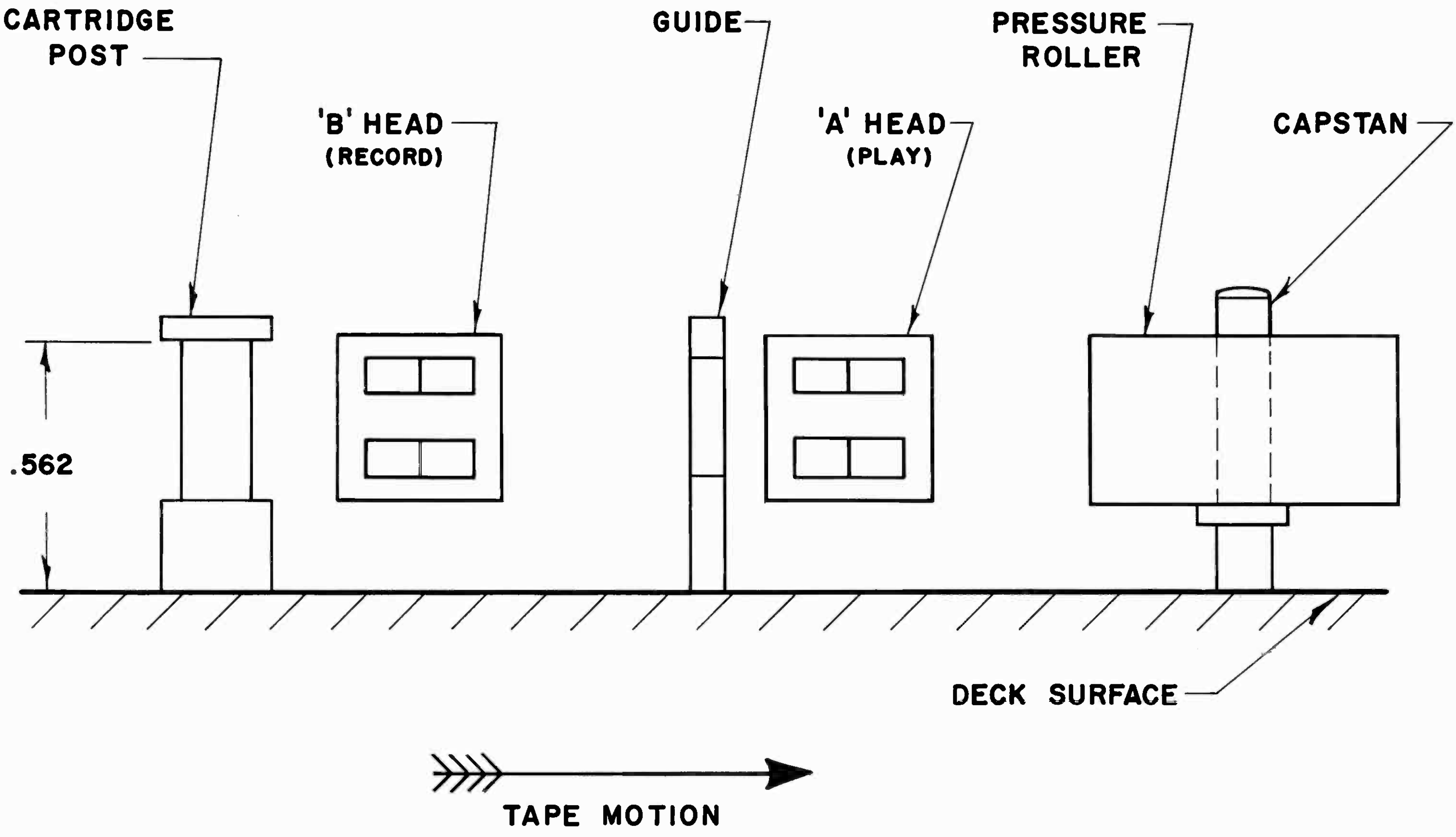


Figure 4 Tape Path in a Cartridge Recorder

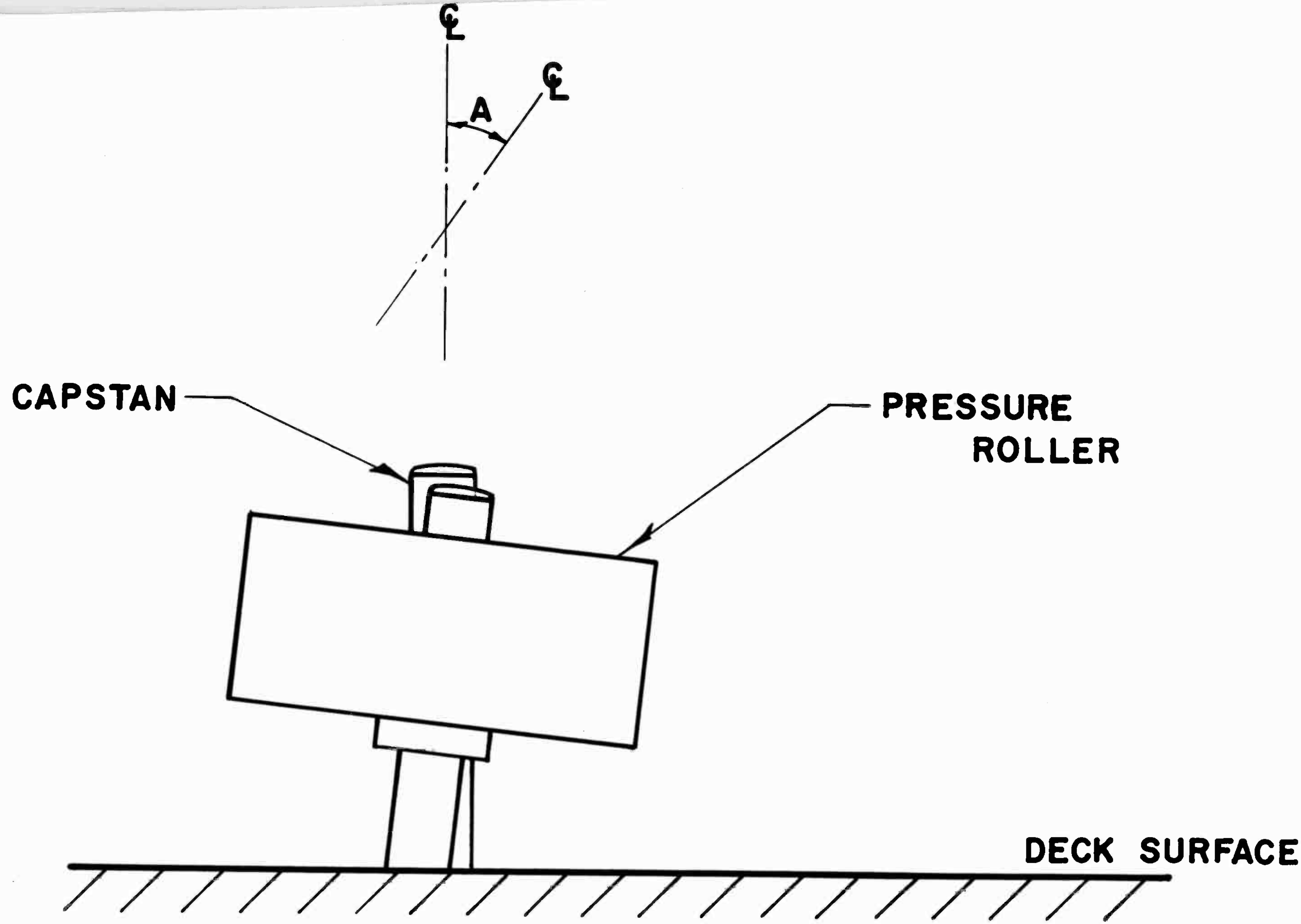


Figure 5 Shaft Misalignment in the Tape Plane

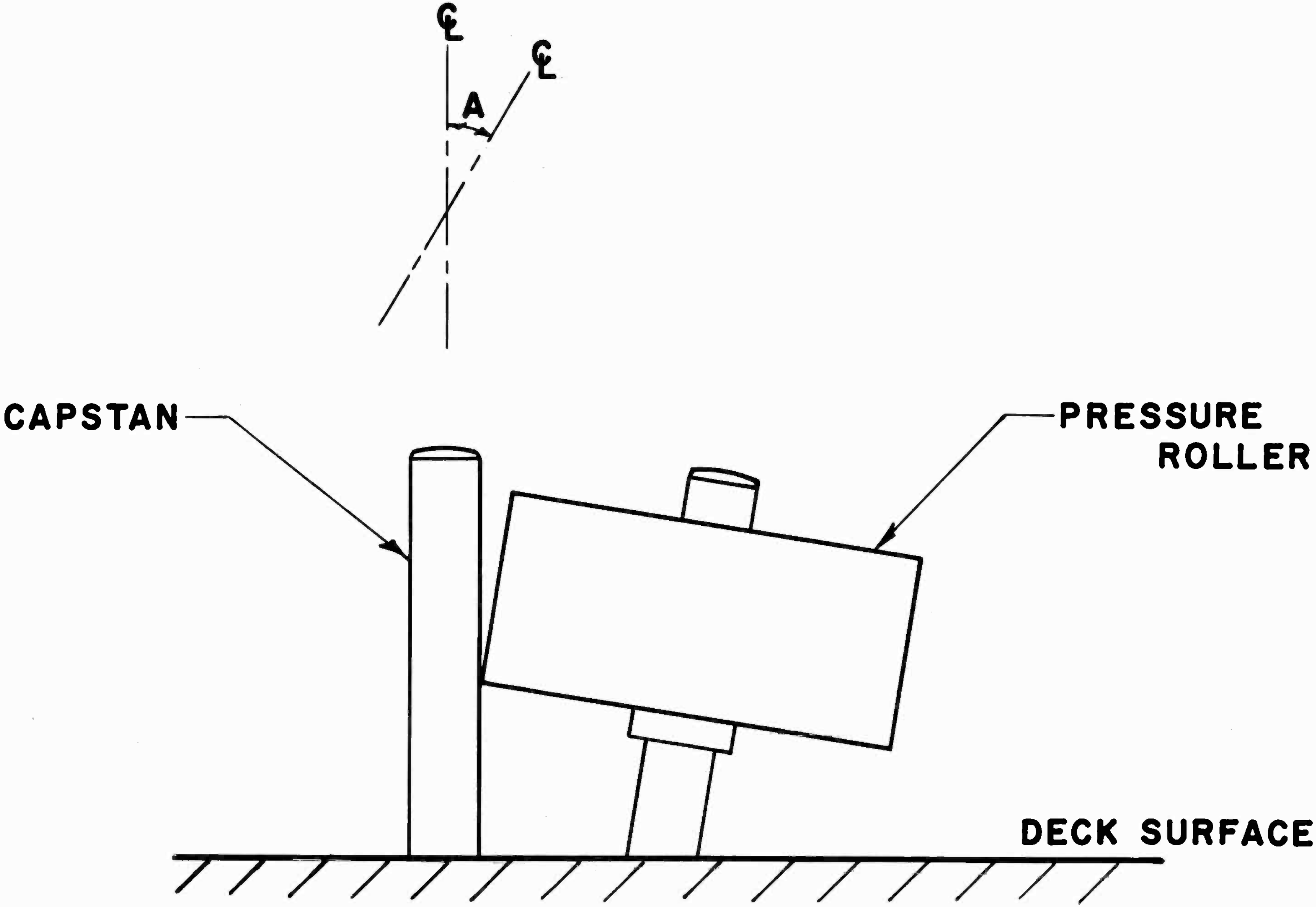


Figure 6 Shaft Misalignment Normal to the Tape Plane

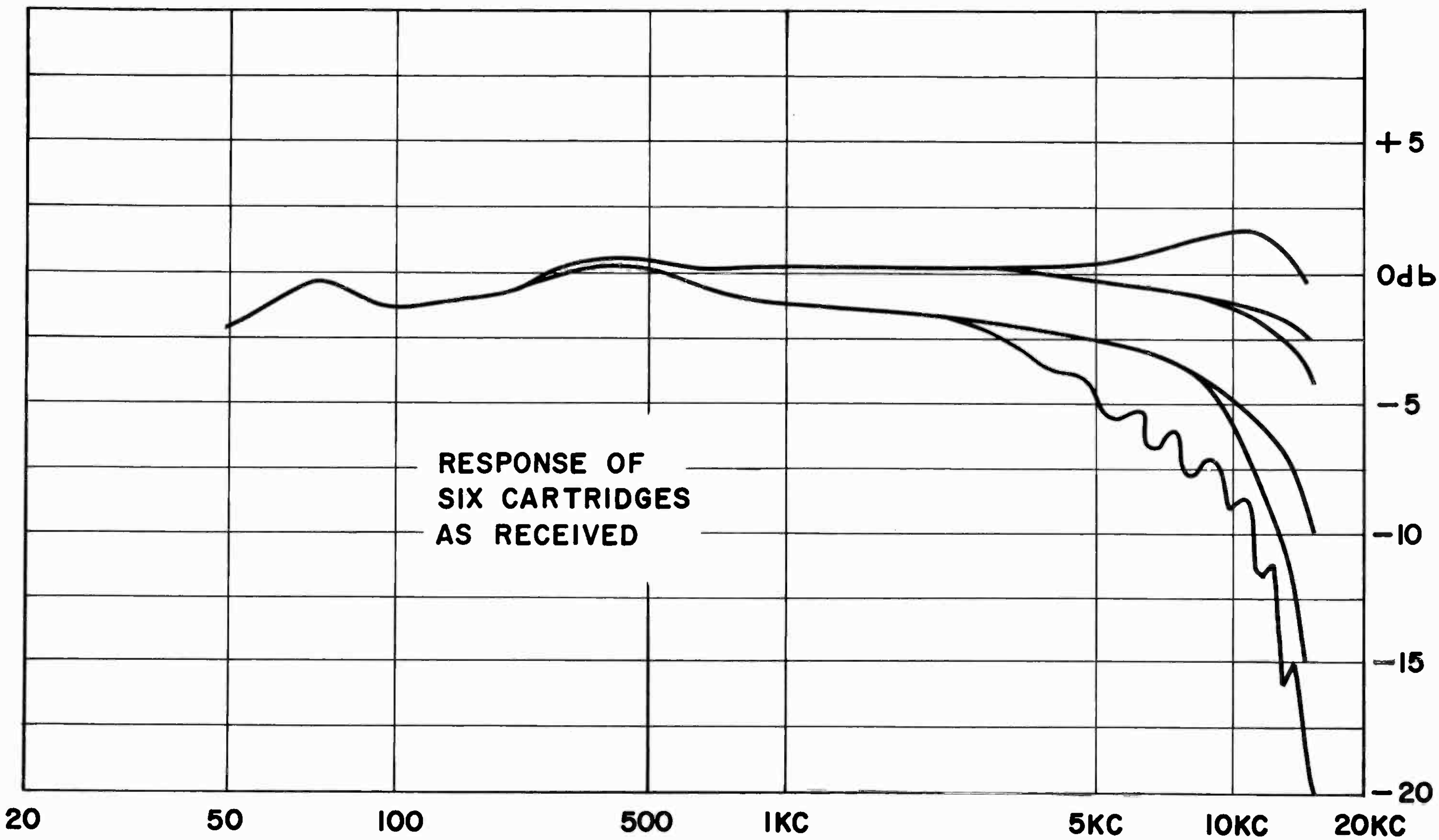


Figure 7 Frequency Response of Six Cartridges as Received

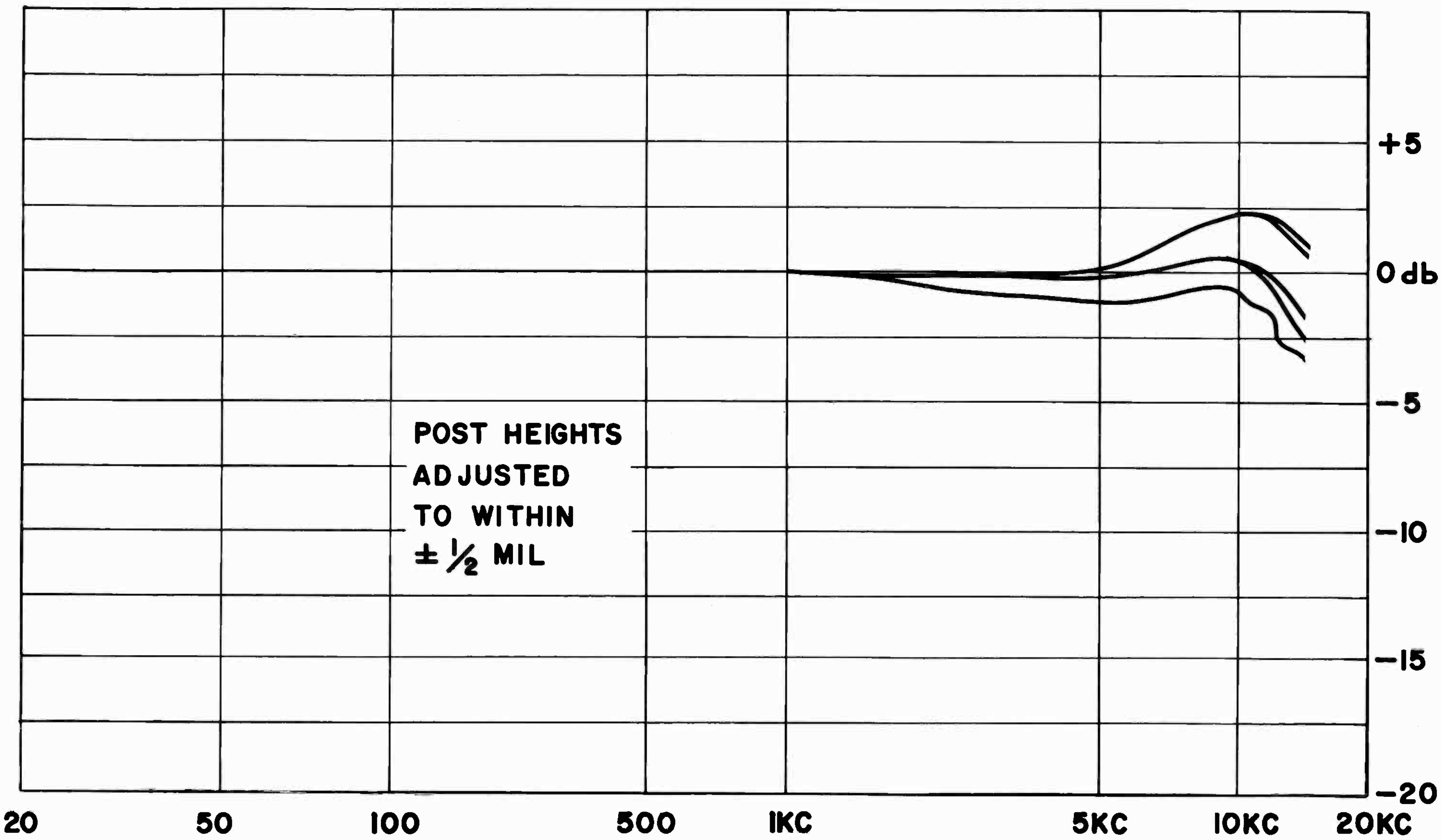


Figure 8 Frequency Response after Adjusting Post Heights

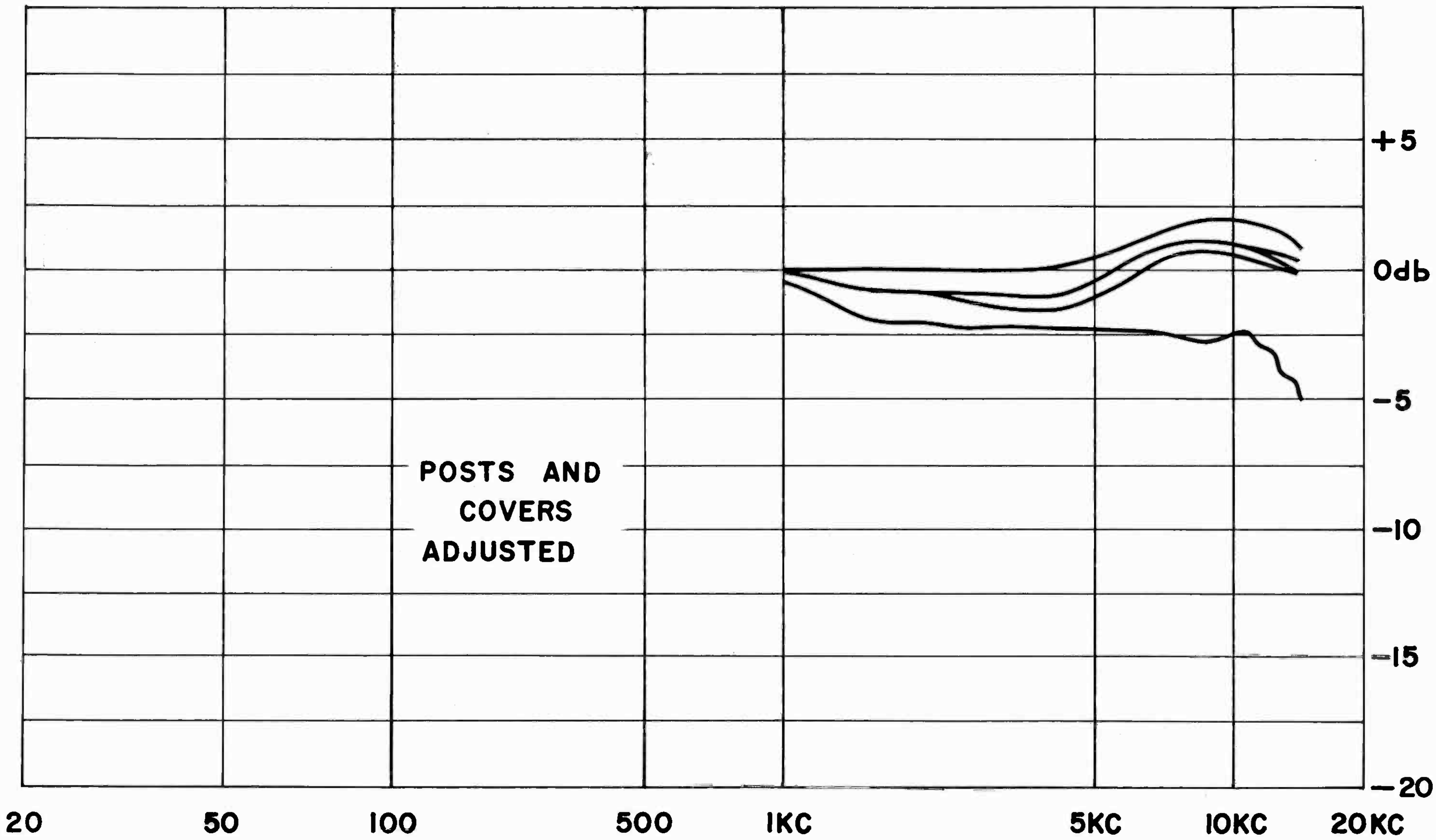


Figure 9 Frequency Response after Adjusting Posts and Covers

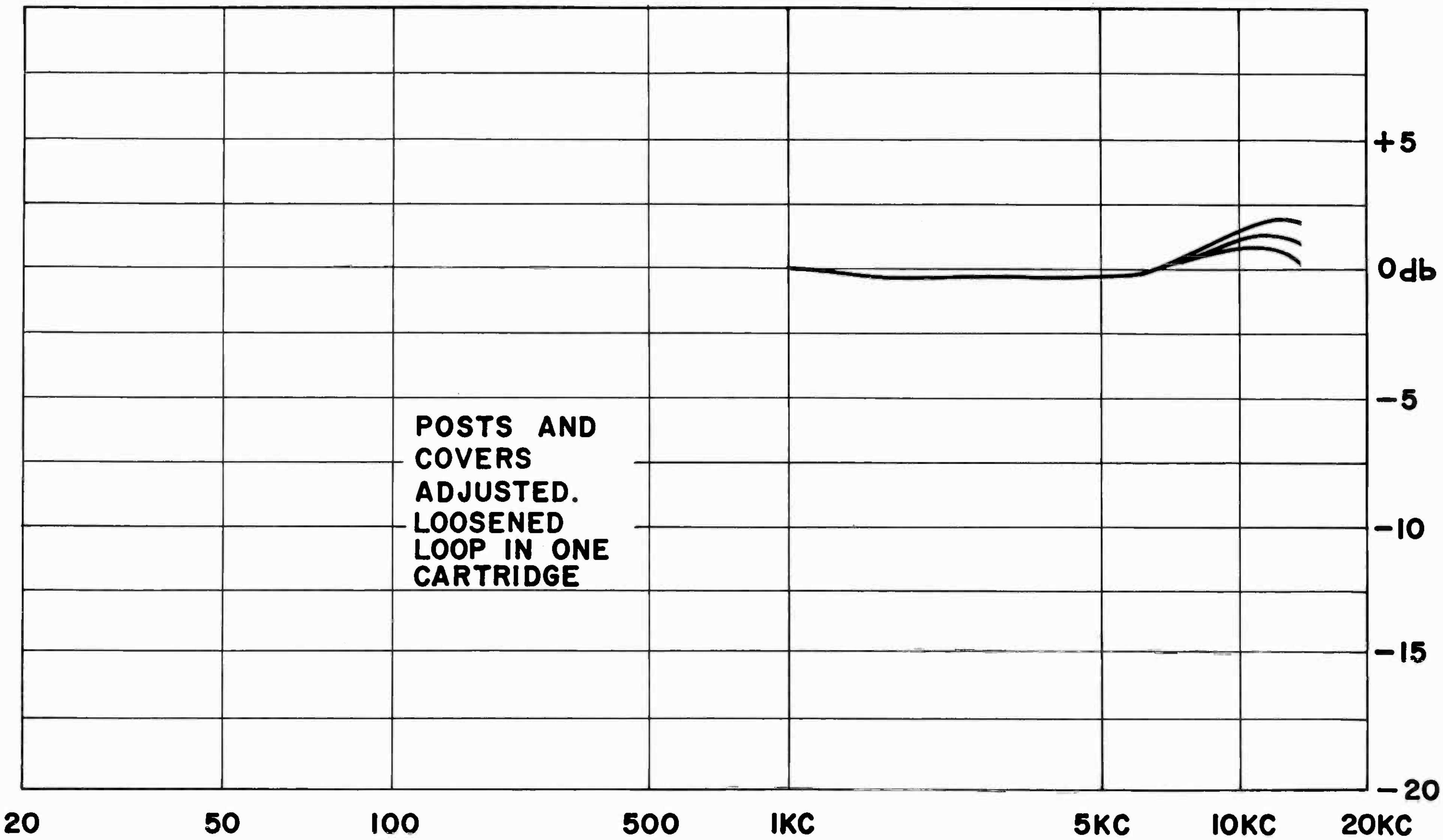
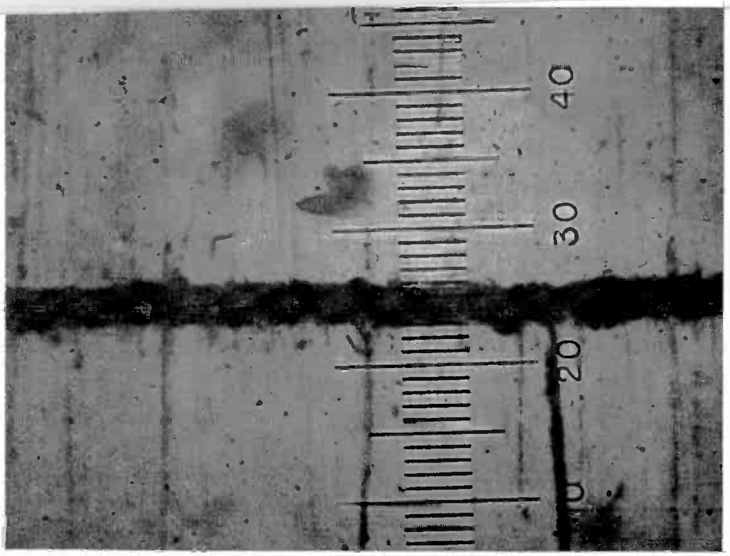
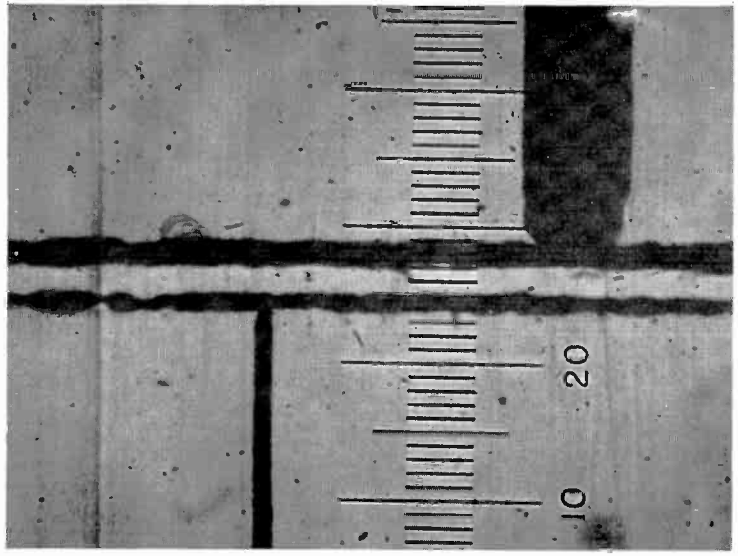


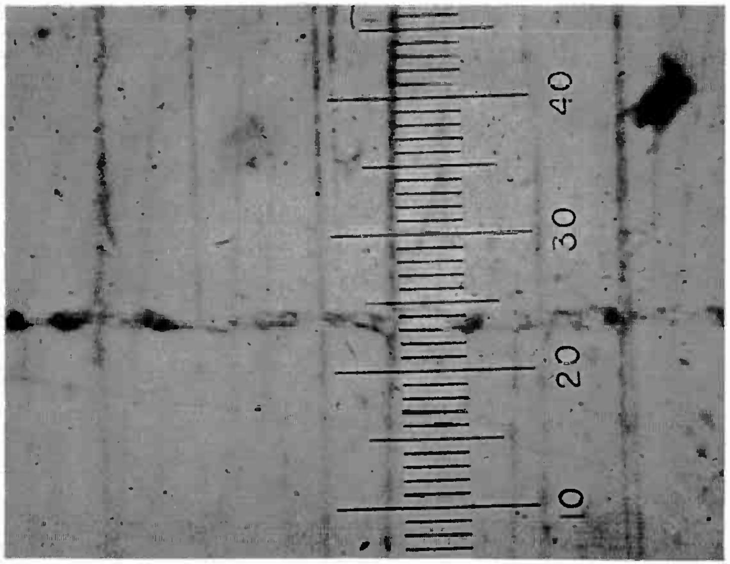
Figure 10 Frequency Response after Adjusting Posts, Covers and Loops



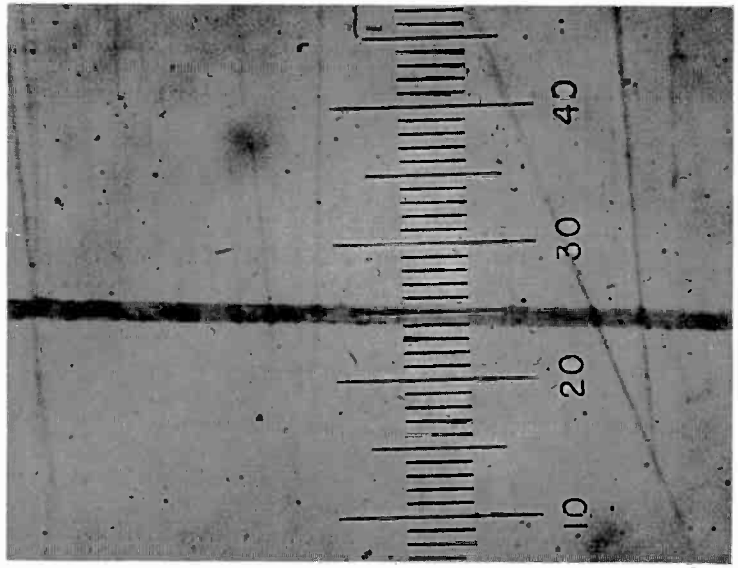
a Gap Photomicrograph (crooked edges)



b Gap Photomicrograph (cores not touching spacer)



c Gap Photomicrograph (gap smearing)



d Gap Photomicrograph (satisfactory gap)

Figure 11

Vertical Interval Test Signals

S. C. Jenkins, Transmission Engineer
Long Lines Department
American Telephone and Telegraph Co.

Wednesday, April 8, 1964

Vertical Interval Test Signals

The Television networks, the individual TV broadcasting stations, and the Telephone Company are all concerned with improving the quality of the picture seen by the viewing public. From the point of origination of a picture, these signals may traverse many hundreds of miles of intercity video facilities, then the studio and transmitter of the broadcasting station, until they leave the transmitting antenna. In the day-to-day operation of the television networks, many changes are made in the interconnection of these transmission facilities. This includes changes in broadcasters' facilities, changes in local Telephone Company facilities, and changes in inter-exchange channels. Although designed for long term stable performance, no part of the overall network is immune to trouble. Since many of these troubles are temporary or transient, it is desirable that they be located quickly, while they are present. This means that trouble location must be done on an in-service basis, rather than by tests made on an out-of-service basis, after the program is over.

In addition, it is often difficult either to identify or to diagnose troubles from observations of the normal picture signal. Some more rigorous test signal is needed. The technique which seems to come closest to meeting these requirements and seems to hold the most promise is the use of Vertical Interval Test Signals. We have succumbed to the trend of the times, and call them VITS.

VITS are signals generated and transmitted by equipment provided by the broadcasters. They are keyed into designated lines during the vertical blanking interval of the picture. These signals are then transmitted along with the normal picture signal. They may be observed, and/or photographed, at appropriate existing monitoring locations by network, Telephone Company, and local station personnel. They can be used for quantitative measurements. Appropriate comparison or analysis of the test results should facilitate trouble location during actual service. Incidentally, VITS signals may be seen in the picture on a home receiver if the picture is rolled half a frame to expose the vertical interval. They appear as a light horizontal streak in the normally dark area between frames.

The Network Transmission Committee has developed a plan and a program for implementing VITS. This Committee is an organization of both the Broadcasters and the Telephone Company to solve problems of operation and transmission which are common to both parts of the industry and which cannot be handled satisfactorily through normal organizational channels.

The Committee included the following considerations in developing its program:

1. Initially, the signals should be such that existing equipment may be used to observe the signals. There should be a minimum requirement for new or modified equipment during the early stages.

2. The following signals should be incorporated in the Vertical Interval Test Signals:

    a. Multiburst

    b. Sine squared signal (pulse and bar)

    c. Modulated stair-step

    d. A color signal (to be specified at a later date)

    e. White and black reference level signals, combined into one or more of the above

3. Directives and training should be initiated to insure early effective use of Vertical Interval Signals.

4. Ultimately, all the test signals should be available simultaneously for most effective usage.

5. Any new equipment being developed should be designed to accommodate ultimate requirements.

6. The test signal specification should be capable of modification to incorporate the benefits of experience with initial use.

Paragraph 3.682 of Part 3 of the FCC Rules allocates the interval beginning with the last 12 microseconds of line 17 and continuing through line 20 for the transmission of test signals. Line 20 is reserved by the broadcasters for other purposes. The Committee felt it desirable that ultimately lines 18 and 19 of both fields contain different test signals. It was agreed however, that most existing oscilloscopes are not adapted to this sophisticated technique. In addition, most equipment available for keying in these signals is not capable of meeting this requirement.

Because of these considerations, NTC decided on a program which is divided into two parts: an interim period and an ultimate period. The Vertical Interval Test Signals specified for the interim period are planned to satisfy the first three considerations listed previously:

1. Adaptable to existing monitoring equipment.
2. Incorporate multiburst, sine-squared signal, modulated stair-step, and black and white reference levels.
3. Aim directives and training at earliest possible effective use of VITS.

The signal proposed for the interim period is shown in the slide. (Figure 1) The multiburst, including black and white reference levels, is considered the most important and most revealing signal. It will therefore be keyed into line 18 of both fields. The sine-squared pulse, with bar, will be keyed into line 19 of both fields, as will also the modulated stair-step signal. These will appear alternately for periods of two and one-half minutes each. This figure is simplified so that the detail does not detract from the information. The printed version of this talk will include a detailed drawing with all dimensions specified (Figure 2.)

It is planned that the interim portion of the program will terminate on January 31, 1965. The optimum test signals should be available by February 1, 1965. The next slide (Figure 3) shows the plan for optimum test signals.

This plan proposes a continuous display of four test signals, combined with amplitude reference signals, keyed into lines 18 and 19 of both fields. It leaves line 20 of both fields available for other purposes. In this optimum arrangement line 18 of the odd fields will have the multiburst, combined with black and white reference levels. Line 19 of the odd fields will have a sine-squared pulse, with bar, combined with black and white reference level signals.

Line 18 of the even fields will contain a color test signal, to be specified at a later date. Again, it will include black and white reference levels. Line 19 of the even fields will contain the modulated stair-step, plus the reference levels as in the other three signals. Thus each frame will display the complete array of four test signals with black and white reference levels incorporated with each.

Keying equipment should be so developed that it incorporates separate inputs for each of the specified test signals. This means that there should be six inputs available (line 18, 19, and 20 of each field). This will permit maximum flexibility of the system. It will also permit an orderly change from the interim signal configuration to that of the optimum plan. It will also allow changes to be made in the signals, should it prove necessary or desirable. Information gained during the interim period may result in changes in the ultimate plan.

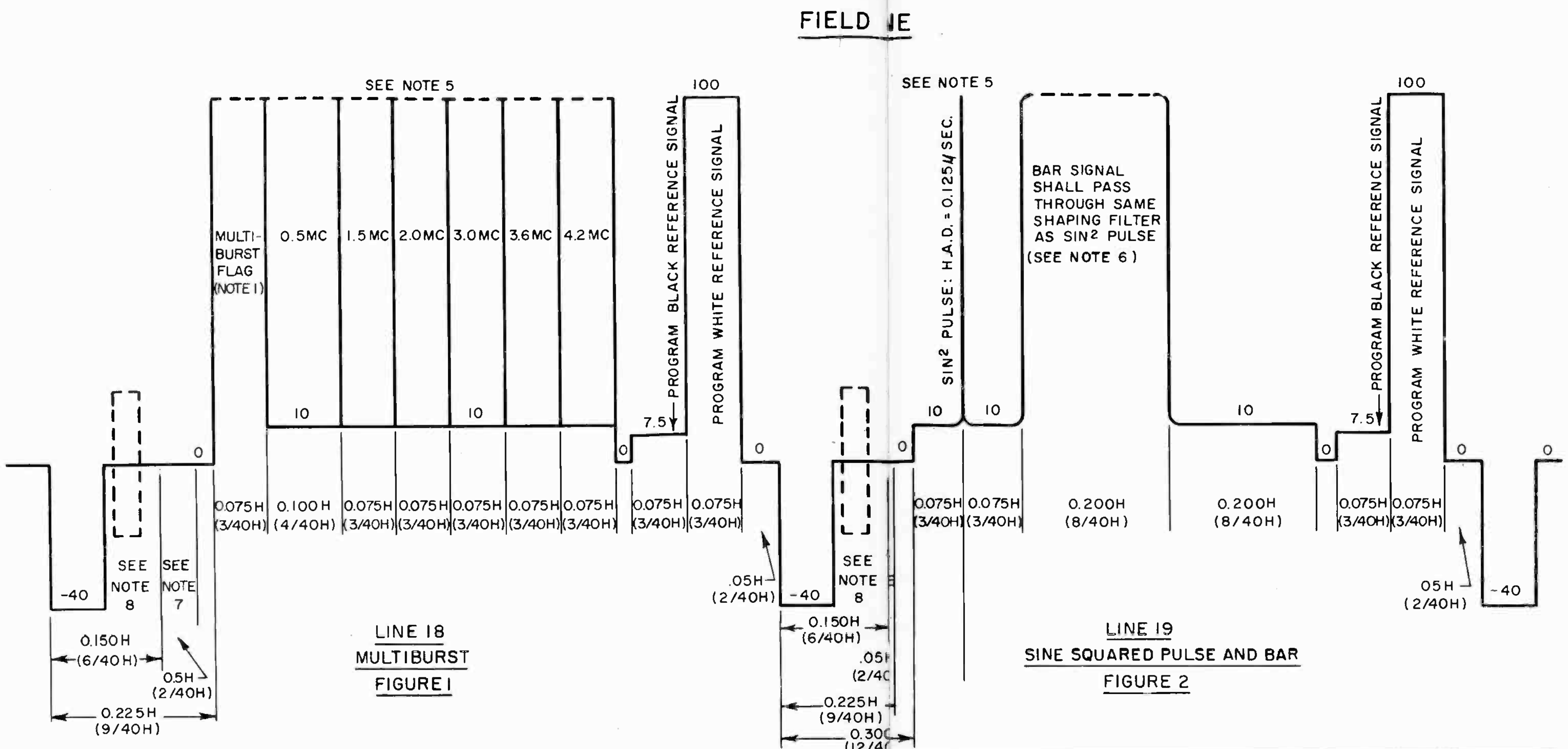
There are many problems involved in implementing a program which will result in Vertical Interval Signals being useful. One problem is that anyone desiring to observe the signals must have an oscilloscope which makes such observation possible. While there are several oscilloscopes available which can be tuned to produce an image of the vertical interval signals, none seems to be ideal. On some 'scopes it is difficult to find the proper line, on some it is difficult to switch from the odd field to the even, or vice versa, and on most of them the display of the 0.125 microsecond sine-squared pulse is not well illuminated. Since such instruments represent a fair sized investment due consideration should be given to the choice so that observations of the vertical interval signals will be satisfactory.

A second problem which needs to be investigated thoroughly is that the signal sources need to be of a high order of stability. This is particularly true since many of the other parts of the video networks are dynamic. In-service observations of changing condition will be of little value, without a source whose stability can be relied on. Observations will need to be made over a considerable period of time to insure that the signal sources meet this requirement.

A third problem is that of reaching agreement on signal standards for Vertical Interval Signals. This problem is heightened by the fact that we do not yet have agreement on standards for full frame test signals which are sent during test and line-up periods on the networks. NTC is working on both of these problems concurrently. We are at present exerting considerable effort on this problem, and progress should be visible in the near future.

One ramification of this problem of determining standards for Vertical Interval Signal observations is that these signals traverse a different path than test signals normally used. In the more usual case of out-of-service testing, the network does not go in and out of any broadcasting stations. While there may be several video sections in tandem, there are no local transmitting loops involved except at the originating point, and no local station facilities are in the transmission path. During actual program transmission, however, the networks utilize various configurations which include so called "in-and-out" points, where the signal actually is transmitted in and out of a local station. The Vertical Interval Signals follow the picture. They go in and out at in-and-out points. Since tests are normally not made for this combination of facilities, no standards for evaluating such measurements are available. Determination of signal standards for Vertical Interval Signals will thus be more complicated than for full frame test signals on an out-of-service basis. The standards will have to apply to a much greater range of network configurations.

In conclusion I should like to say that both the Broadcasters and the Telephone Company hope that Vertical Interval Signals will prove to be a useful new tool in providing increasingly better television service to the public. We are both working together toward this goal. We will appreciate and benefit from the cooperation of you members of the industry in carrying out this program. Thank you.



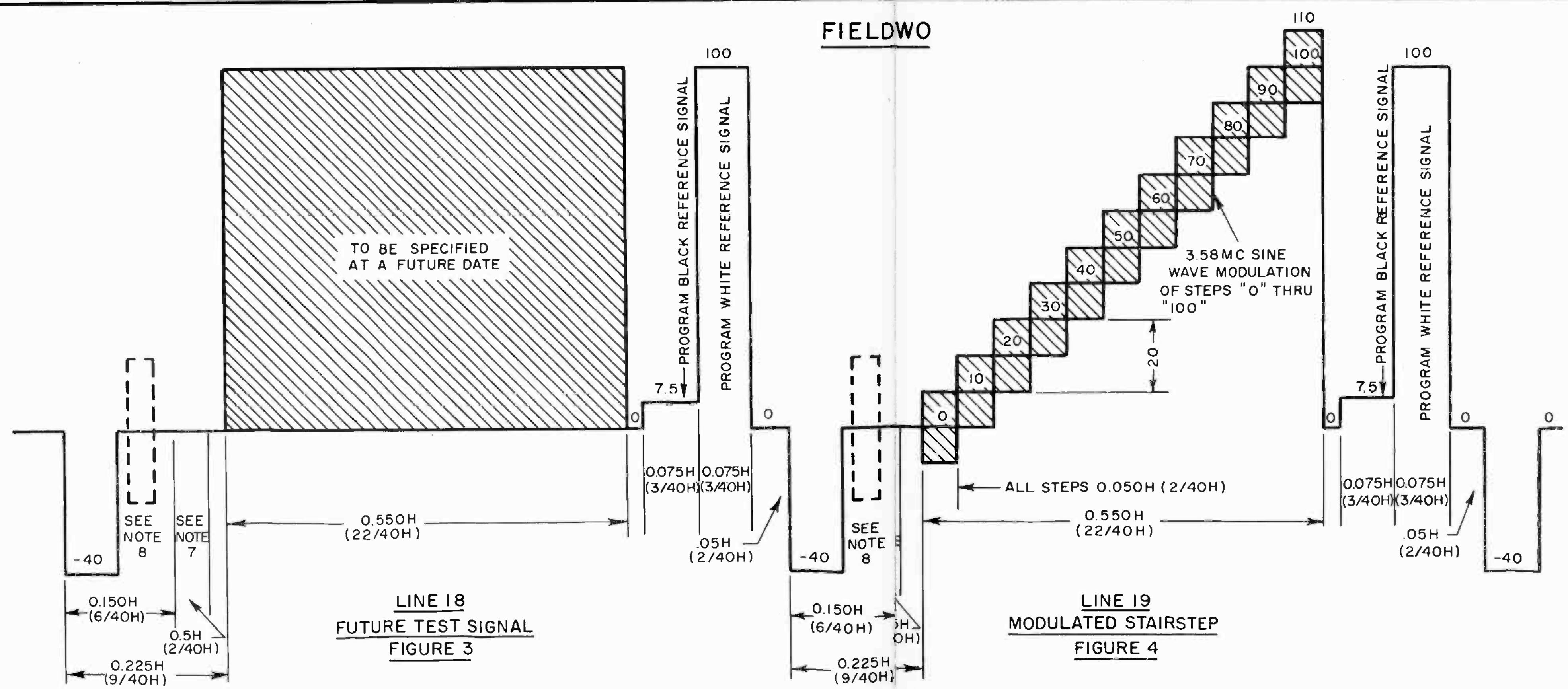


FIGURE 4

NOTES

1. POSITION OF FLAG IN MULTIBURST SIGNAL SHALL BE INTERLEAVED BETWEEN DIFFERENT BURSTS IN ORDER TO IDENTIFY POINTS OF ORIGIN AS FOLLOWS:

LOCATION IDENTIFICATION

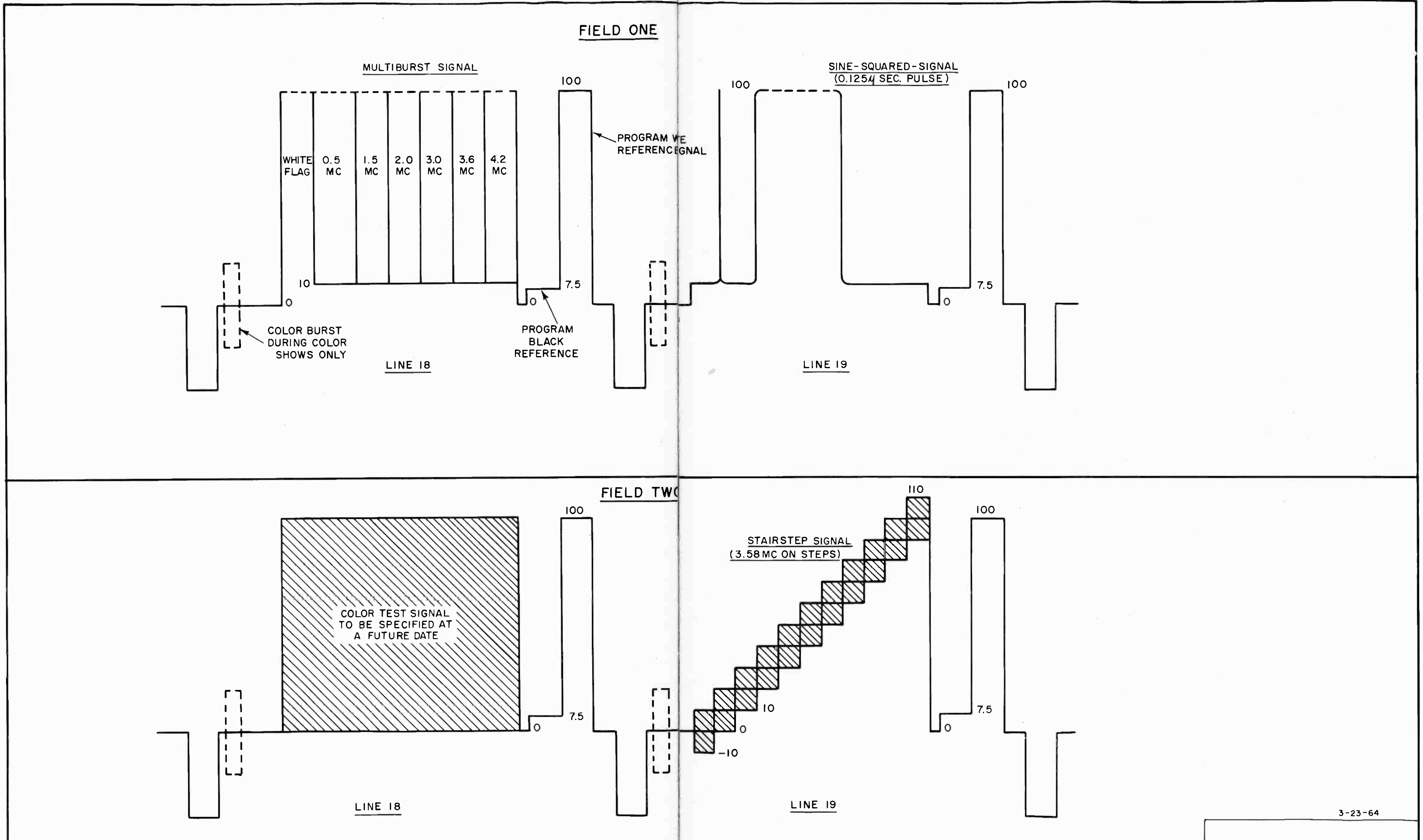
POINT OF ORIGIN	MULTIBURST FLAG
NEW YORK	PRECEDES 0.5 MC BURST
HOLLYWOOD	BETWEEN 0.5 MC & 1.5 MC BURST
CHICAGO	BETWEEN 1.5 MC & 2.0 MC BURST
FUT. 1	BETWEEN 2.0 MC & 3.0 MC BURST
FUT. 2	BETWEEN 3.0 MC & 3.6 MC BURST
FUT. 3	BETWEEN 3.6 MC & 4.2 MC BURST

2. MINIMUM VALUE OF RISE TIME OF PROGRAM REFERENCE SIGNAL PULSES SHALL BE 0.002H.
3. THE BAR SIGNAL WIDTH SHALL BE MEASURED AT 20 IRE UNITS ABOVE BLANKING LEVEL.
4. ALL FREQUENCY BURST WIDTHS SHALL BE MEASURED AT THE AXES OF THE BURSTS.
5. AMPLITUDE LEVEL BASED ON INTERIM PLAN EXPERIENCE TO BE SPECIFIED BEFORE ACCEPTANCE OF OPTIMUM PLAN.
6. IN FIGURE 2 THE RELATIVE POSITION OF THE PULSE AND BAR MAY BE REVERSED DEPENDENT UPON INTERIM PLAN EXPERIENCE.
7. THIS INTERVAL RESERVED FOR BROADCASTERS IN-PLANT USE. (A SIGNAL MAY OCCASIONALLY APPEAR ON NETWORK.)
8. FOR COLOR PROGRAMMING STANDARD COLOR BURST IS INSERTED AT PROGRAM ORIGINATION POINT.
9. THE DETAILS OF THIS OPTIMUM PLAN ARE SUBJECT TO LATER AGREEMENT BY VITEAC AND NTC FOLLOWING EXPERIENCE GAINED WITH INTERIM PLAN.

3-23-64

OPTIMUM PROPOSED SIGNALS

DETAILED

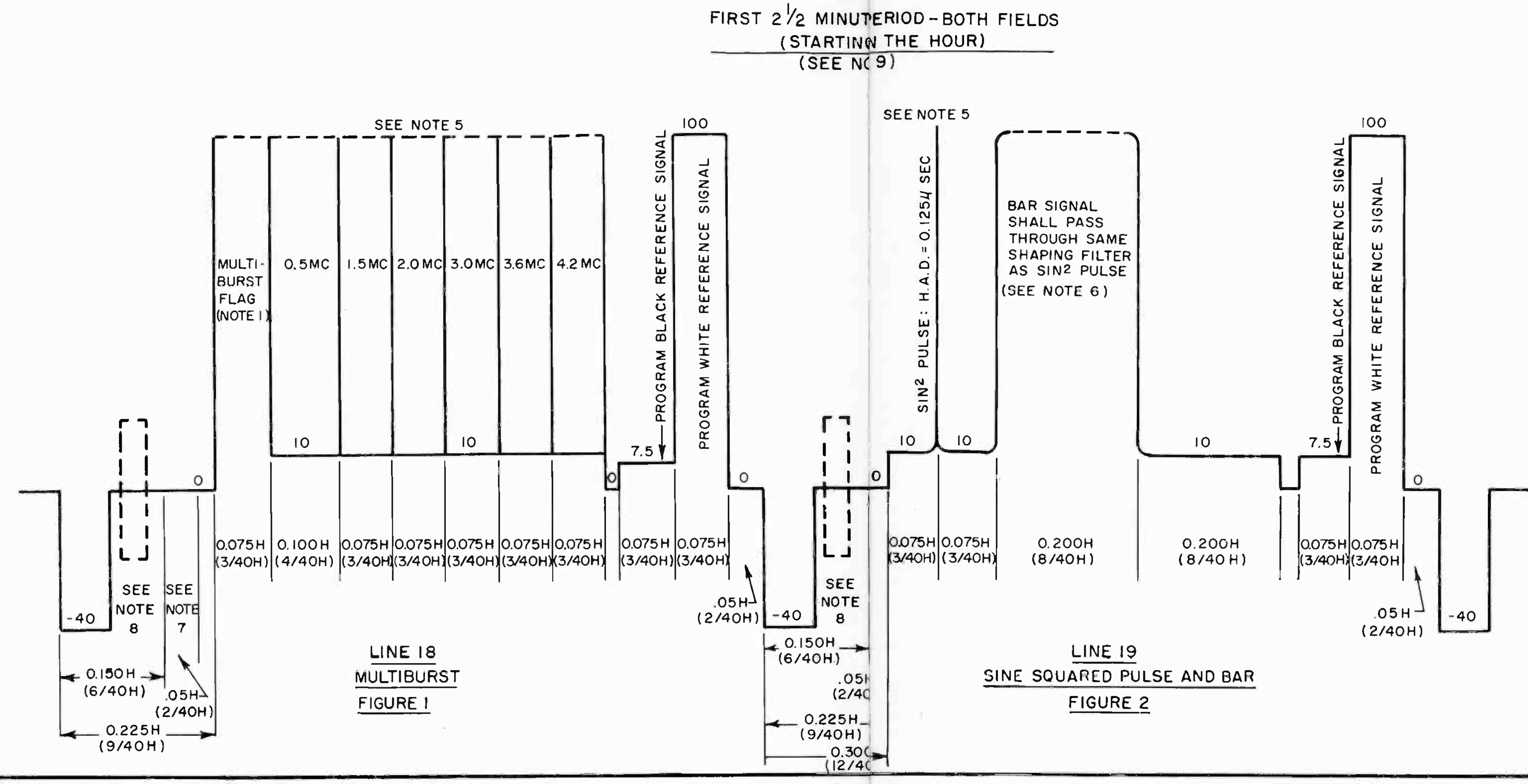


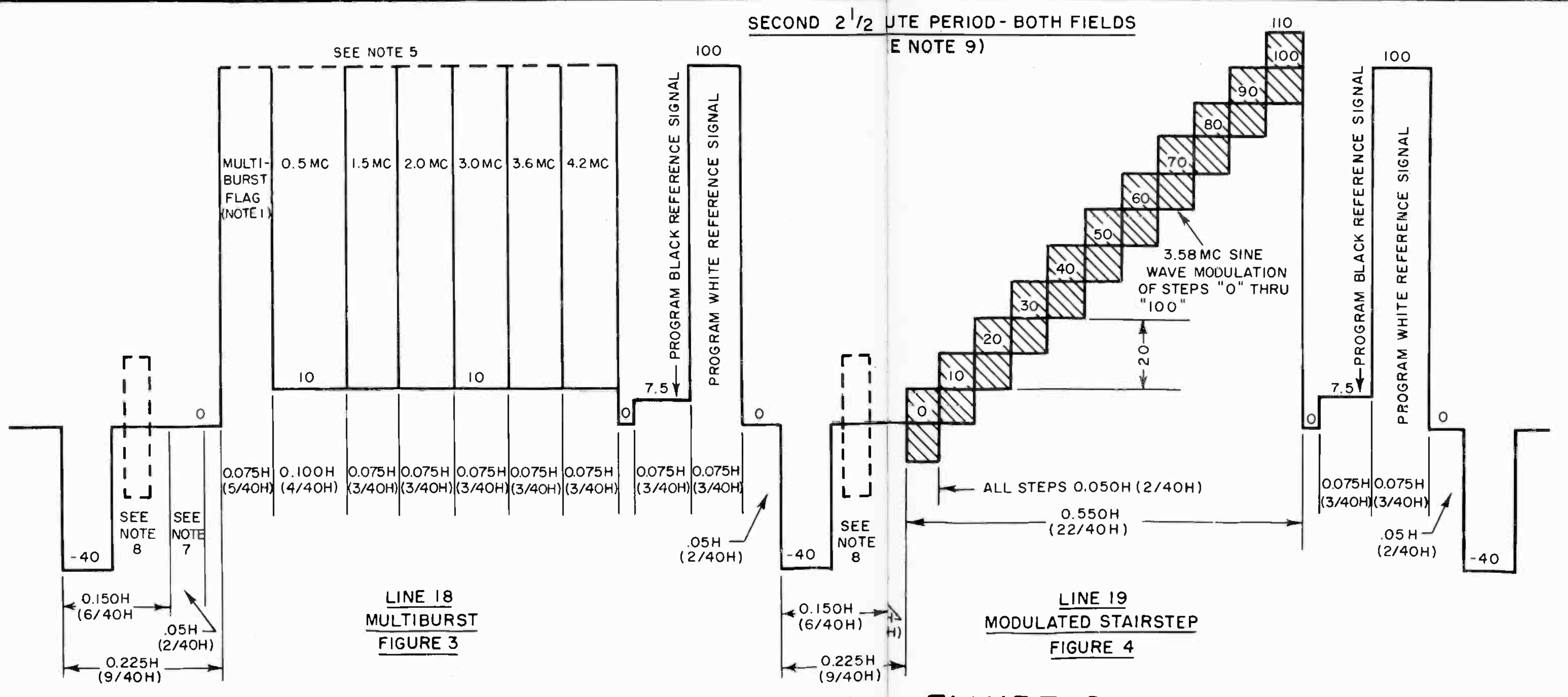
FIGURE

3-23-64

OPTIMUM PROPOSED SIGNALS

SIMPLIFIED





NOTES

1. POSITION OF FLAG IN MULTIBURST SIGNAL SHALL BE INTERLEAVED BETWEEN DIFFERENT BURSTS IN ORDER TO IDENTIFY POINTS OF ORIGIN AS FOLLOWS:

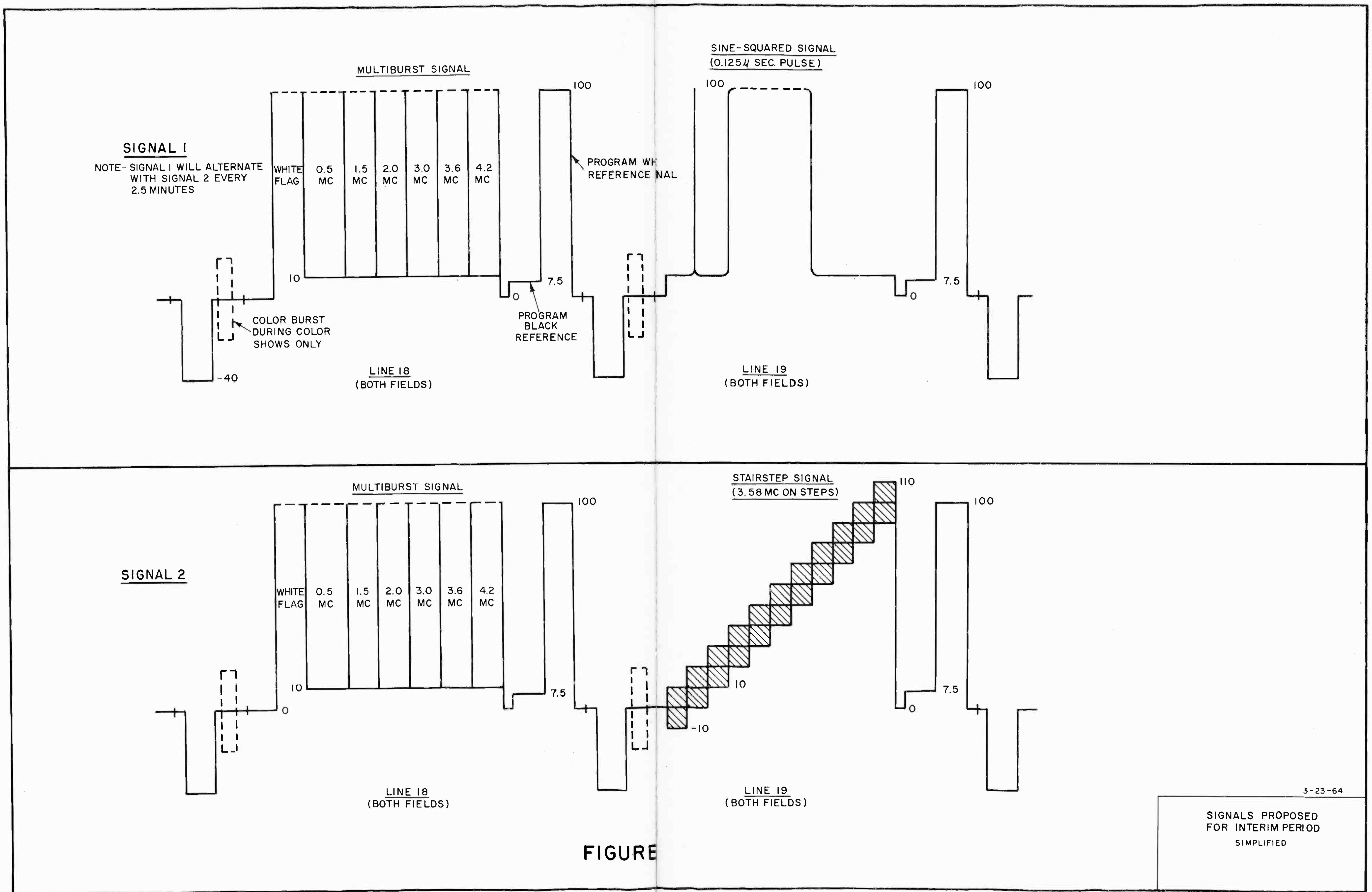
POINT OF ORIGIN	LOCATION IDENTIFICATION MULTIBURST FLAG
NEW YORK	PRECEDES 0.5MC BURST
HOLLYWOOD	BETWEEN 0.5 MC & 1.5 MC BURST
CHICAGO	BETWEEN 1.5 MC & 2.0 MC BURST
FUT. 1	BETWEEN 2.0 MC & 3.0 MC BURST
FUT. 2	BETWEEN 3.0 MC & 3.6 MC BURST
FUT. 3	BETWEEN 3.6 MC & 4.2 MC BURST

2. MINIMUM VALUE OF RISE TIME OF PROGRAM REFERENCE SIGNAL PULSES SHALL BE 0.002H.
3. THE BAR SIGNAL WIDTH SHALL BE MEASURED AT 20 IRE UNITS ABOVE BLANKING LEVEL.
4. ALL FREQUENCY BURST WIDTHS SHALL BE MEASURED AT THE AXES OF THE BURSTS.
5. AMPLITUDE LEVEL MAY BE VARIED FOR TEST PURPOSE, TARGET DATE FOR MUTUAL AGREEMENT ON LEVEL MAY 1, 1964.
6. IN FIGURE 2 THE RELATIVE POSITION OF THE PULSE AND BAR MAY BE REVERSED AT THE BROADCASTERS OPTION.
7. THIS INTERVAL RESERVED FOR BROADCASTERS IN-PLANT USE. (A SIGNAL MAY OCCASIONALLY APPEAR ON NETWORK.)
8. FOR COLOR PROGRAMMING STANDARD COLOR BURST IS INSERTED AT PROGRAM ORIGINATION POINT.
9. THE SEQUENCE OF 2 1/2 MINUTES OF FIG. 1 & 2 FOLLOWED BY 2 1/2 MINUTES OF FIG. 3 & 4 IS TO BE REPEATED CONTINUOUSLY WITH EACH PAIR OF SIGNALS OCCURING 12 TIMES EVERY HOUR, AS AN OPTION TO THIS TIME SEQUENCE ARRANGEMENT THE BROADCASTER MAY ELECT TO IMPLEMENT THOSE FEATURES OF THE OPTIMUM PLAN (SEE ATTACHMENT NO. 2) RELATING TO LINE 19, BY KEYING IN THE SINE SQUARED PULSE & BAR SIGNAL ON LINE 19 OF FIELD 1 AND THE MODULATED STAIRSTEP SIGNAL ON LINE 19 OF FIELD 2 ON A CONTINUOUS BASIS, WITH THE MULTIBURST SIGNAL REMAINING ON LINE 18 OF BOTH FIELDS.

3-23-64

SIGNALS PROPOSED
FOR INTERIM PERIOD
DETAILED

FIGURE 2


SIGNAL 1
NOTE - SIGNAL 1 WILL ALTERNATE WITH SIGNAL 2 EVERY 2.5 MINUTES
MULTIBURST SIGNAL
WHITE FLAG
0.5 MC
1.5 MC
2.0 MC
3.0 MC
3.6 MC
4.2 MC
100
10
7.5
0
-40
COLOR BURST DURING COLOR SHOWS ONLY
PROGRAM BLACK REFERENCE
PROGRAM WH
REFERENCE NAL
LINE 18 (BOTH FIELDS)
SINE-SQUARED SIGNAL (0.125μ SEC. PULSE)
100
100
7.5
0
LINE 19 (BOTH FIELDS)
SIGNAL 2
MULTIBURST SIGNAL
WHITE FLAG
0.5 MC
1.5 MC
2.0 MC
3.0 MC
3.6 MC
4.2 MC
100
10
7.5
0
LINE 18 (BOTH FIELDS)
STAIRSTEP SIGNAL (3.58 MC ON STEPS)
110
10
-10
100
7.5
0
LINE 19 (BOTH FIELDS)
3-23-64
SIGNALS PROPOSED FOR INTERIM PERIOD
SIMPLIFIED
FIGURE

A NEW FIELD TELEVISION CAMERA

J L Wilson
Director of Engineering
National Broadcasting Company, Inc

and

J Castleberry, Jr
Radio Corporation of America
CSD

Paper Given at the NAB Convention
In Chicago, Illinois, April 8, 1964

A NEW FIELD TELEVISION CAMERA

J L Wilson
National Broadcasting Company, Inc

and

J Castleberry, Jr
Radio Corporation of America

Broadcasters have long had the need for a compact, portable television camera that could be utilized for field events where light weight and freedom of action are essential. Several models of such semi or fully self-contained portable camera systems have been developed over the years.

One of the first was utilized by NBC in the 1952 political convention coverage. This very early model of the ultraportable camera was, like most of those following, built around the vidicon tube. It provided important coverage of the 1952 convention activities with passable quality, but left much to be desired as a reliable operational tool. This camera was nick-named the "Creepy-Peepy" -- "Creepy" derived from the difficulties the man had in carrying around a cumbersome and heavy system; and the "Peepy" from those people who felt that whatever privacy they had had before was now violated forever.

This prototype camera, although it proved to be not very dependable in the field, did demonstrate without question the principle and value of a portable rf connected camera for television news coverage.

A more modern system was developed for the succeeding political conventions in 1956. This 1956 camera was used extensively for convention coverage but was still limited for production use by reliability, picture quality, and flexibility of operation. Since substantial base station equipment was required to reprocess the camera signal into a form suitable for broadcast, there were severe limitations in the use of this equipment for anything but a semi-permanent installation. It was difficult, if not impractical, to move the camera system into the field on a moment's notice for instantaneous news coverage.

This same system was rebuilt with more modern components and circuitry for improved reliability and was used in the 1960 political conventions. Although the remodeled camera performed better and was more dependable than at the prior convention, the system still possessed many of the operational disadvantages of the earlier design. A photograph of this equipment as used in 1960 is shown in Figure 1. This camera was powered by Silver-Zinc batteries with a capacity of one and three-quarter hour's operation. The backpack contained the power supply, synchronizing signal generator (non-EIA standard), the necessary control circuitry, and a 100 milliwatt 2,000 megacycle transmitter radiating through an omnidirectional antenna above the operator's head. The camera was equipped with a three lens turret and an integral 2" electronic viewfinder and was, consequently, quite heavy and difficult to hold in position for more than a few minutes at a time.

At the base station, the operator attempted to minimize the effects of standing waves and reflections by careful and educated manipulation of his 2' receiving dish. The demodulated video signal was processed through a stabilizing amplifier, and the derived sync was used to genlock a standard studio sync generator. This sync was then mixed with the ultraportable camera video to provide an EIA picture signal for program use.

Performance of this improved camera was good, but extensive field use was limited because of the many sizable components required to assemble a working system, the critical adjustments and maintenance required for satisfactory operation, and the difficulty in maintaining a battery pack ready for immediate use.

The principle and need for ultraportable camera facilities had certainly been demonstrated, but the existing equipment was not sufficiently versatile to meet the needs for reliability and mobility demanded by the increased emphasis on news and sporting events in the broadcast field.

Our earlier experiences and potential needs were analyzed, and specifications were developed for an ultraportable camera that would overcome the major disadvantages of the prototype units with the principal stress on quality and dependability of performance. With the techniques available today, it was possible to anticipate the construction of a system that could reliably generate high-quality picture signals which could be broadcast or taped directly without complex reprocessing.

Drawing on their prior experience in specialized camera design, the Communications Systems Division of RCA has translated these specifications into a highly functional and reliable package suitable for field use under a wide range of conditions.

A photograph of the assembled camera system is shown in Figure 2.

The lower part of the backpack contains the batteries, power supply, and basic circuitry for the entire camera chain. The upper portion above the snap fastener is a 300 milliwatt 13 KMC transmitter feeding into the wave guide antenna above the operator's head.

The camera and zoom lens is fastened on a swiveled telescoping unipod designed to permit solid, strain free, one-handed operation of the camera and zoom lens in any position.

The viewfinder and control box supported in front of the cameraman makes it possible to free the camera itself from the cameraman's eye level -- a deficiency with the earlier integral camera/viewfinder assemblage or with the use of an optically coupled viewfinder.

Although the basic camera operation is automatic, manual override controls are provided on the viewfinder assembly to permit electrical readjustment for the unusual scene where subjective judgment of picture transmission is essential for satisfactory results.

The overall system can be used to supply full standard video signals directly out of the backpack through a coaxial cable or through microwave interconnection to the base station receiver -- which is a standard commercial unit.

One method of overall system operation is shown in the attached block diagram -- Figure 3. The 160 mc link shown is used to furnish aural cues to the cameraman and also to transmit the 60 cps framing signal to the camera to permit framelock with other studio or portable cameras as necessary.

The monitor, oscilloscope, and processing amplifier at the base station are used to clean up the sync as necessary after microwave transmission and to monitor operation and adjust levels as necessary to correspond to other program equipment.

For applications where cable connection is feasible, the cameraman can carry only the camera and lens system, and utilizing an optical viewfinder attachment, operate a substantial distance from the backpack. The camera can be either hand-held or mounted on a unipod for stability. Where feasible, this mode of operation will permit him to perform his basic pictorial camera functions with a minimum of burden.

Additionally, the transmitter can be coupled to a higher gain antenna to extend its range of operation. For use with a high gain antenna, the transmitter must of course be mounted on a stable platform. The backpack and camera can, however, be operated a considerable distance from the transmitter. If operationally desirable, a separate power supply and battery pack could be utilized at the transmitter location so that only a video interconnection to the backpack or to any other picture source would be needed. This method of operation is illustrated in Figure 4.

Highly successful operation in this pattern has been obtained over a range of 20 miles, and undoubtedly could be extended even further.

A more detailed description of the ultraportable system follows:

The system block diagram - Figure 5 - shows the distribution of circuit functions among the various sub-units. The location of a function in a particular sub-unit was determined on the basis of:

1. Operator convenience and safety
2. Electrical performance
3. Simplicity of design.

For example, the design would have been simpler if the vidicon controls were on the rear of the camera, but this control location would have precluded one-hand camera operation. Weight and power would have been saved if the kinescope high voltage supply had been integrated into DC-DC converter, but this entailed running a 5,000 volt lead in the viewfinder cable.

Figure 6 shows the camera assembly - in this instance with the optional optical viewfinder.

The lens provides a range of focal lengths from 23 to 115 mm. This zoom range, with the portrait attachment, covers all but the most extreme conditions. Pushing with the thumb on the trigger increases the focal length, and pulling with the forefinger decreases the lens focal length. The pistol-grip handle, the trigger mechanism, and the optical focus thumbwheel are symmetrical so that the camera may be used by either right or left-handed cameramen.

Since the viewfinder "sampling mirror" remains in the optical path at all times, the speed of the lens is not affected by the attachment or removal of the optical viewfinder.

The camera electronics are housed in an aluminum casting with a formed aluminum cover which slides in grooves along the sides of the casting. This packaging technique results in a lightweight unit which is weather resistant and provides good rf shielding. The casting contains the vidicon/deflection assembly, the video amplifier and filters for the vidicon control voltages. The vidicon/deflection assembly is mounted on a carriage whose position relative to the lens is controlled by a thumbwheel, making it possible for the cameraman to hold the camera and adjust optical focus with the same hand.

The backpack, shown in Figure 7 with the rear cover removed, contains the power supply, control circuit, synchronizing and video processing circuitry.

The Silver Cadmium battery pack, not shown in this photograph, is located in the bottom compartment. Provisions are made for quickly replacing the batteries, charging them in place, or operating the system from an external power supply.

The DC-DC converter supplies the regulated voltages required by both the television and microwave systems. A series regulator at the input of the DC-DC converter compensates for variations in battery voltage and variations in load such as are caused by changing from rf output to video output.

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

The sync generator master oscillator may be operated in either of two modes: (1) locked to an external 60 cps signal or (2) locked to a self-contained crystal. The circuitry is so designed that when the system in turned "on", it always starts in the "crystal" mode. If the operator so desires, and a 60 cps signal is available, he can switch over to 60 cps lock. If the 60 cps signal is lost, the oscillator will automatically change back to "crystal". The output of the master oscillator is used to derive the EIA synchronizing signals and the drive pulses utilized with the system.

The video processing circuitry sets the black level of the video signal, adds synchronizing and blanking signals to the video, provides switchable gamma and aperture correction, and provides two 1-volt, 75-ohm composite video output signals. The automatic pedestal control circuit senses the blackest portion of the picture and causes video black to assume this level.

An AGC circuit senses the average amplitude of the video signal over several frames and varies the gain of an amplifier to maintain constant video output over a wide range of scene content.

The microwave transmitter is contained within the small box attached to the top of the backpack. A single connector carries the video signal and power to the transmitter. The transmitter can be operated directly on the backpack as shown, or connected by means of a cable and operated remotely, as mentioned previously. The only operational control on the transmitter is the "standby-operate" switch. The set-up controls require adjustment only when the transmitter is set on a new channel range or the klystron is replaced.

A modulating amplifier in the transmitter varies the klystron repeller voltage linearly with the video signal amplitude, thus changing the klystron output frequency with the amplitude of the video signal, in accordance with commercial microwave transmission standards.

The transmitter contains several devices which, at the expense of slightly increased weight, greatly enhance system performance and stability. An isolator at the klystron output effectively eliminates the possibility of changes in antenna or waveguide characteristics affecting the klystron frequency. A 40 db attenuator may, by turning a cam, be in erted into the waveguide leading to the antenna, making it possible to tune the transmitter without radiating a signal. A directional coupler samples the transmitted signal and provides for attachment of an external wavemeter so that the transmitter frequency may be determined accurately.

The antenna, shown at the top of the unit, has an omnidirectional radiation pattern in the horizontal plane, and a beam width of approximately 45° in the vertical plane, with the peak power point tilted up 10° with respect to the horizontal. This pattern was chosen to radiate most of the energy over any surrounding obstacles toward the receiving antenna which normally would be located at a higher position.

Tests have shown that this antenna with the 300 milliwatt transmitter will reliably produce broadcast quality signals over ranges of at least several hundred yards. Good picture quality has been attained at a range of 1.5 miles with a 2-foot parabolic receiving antenna.

A reflector, shown just below the antenna on the waveguide, may be snapped in place on top of the antenna to increase directivity and gain to one quadrant of the horizontal plane. Direction of radiation is established by rotating the reflector.

The viewfinder - shown in Figure 8 - is held in front of the cameraman by the harness. In this position, the cameraman can look out at the scene or, by glancing down at the mirror in the viewfinder hood, see the picture being fed to the transmitter. Thus, the viewfinder serves to permit the cameraman to "frame" and "focus" the chosen scene as well as to quickly evaluate system performance.

The viewfinder is developed around a specially developed 3-inch kinescope featuring small spot size, high brightness, and good deflection sensitivity. The effects of external fields are minimized by the magnetic shield around the kinescope.

The filament, accelerating and control voltages for the kinescope are developed in the viewfinder from a 44-volt, peak-to-peak, 1,000 cps square wave obtained from an isolated secondary winding on the DC-DC converter transformer.

The two groups of controls on the viewfinder are arranged according to function. The viewfinder controls (contrast, brightness, and focus) are, with the modulation indicator and crystal mode switch, on the small shelf toward the cameraman. The modulation indicator is a miniature meter which shows the percentage modulation of the transmitter by indicating video level. The crystal mode "reset" switch contains a light which is "on" when the master oscillator is in the "crystal" mode and a 60 cps signal is available.

The camera controls and the seldom-used kinescope controls are on the side of the viewfinder away from the cameraman and are recessed to preclude accidental misadjustment, as shown in Figure 9.

The harness - shown in Figure 10 - was adapted for this application from the harness developed by Bell Aerosystems for their one-man rocket (in the rocket application, the soldier carries a total load of 150 pounds). Outstanding features of the harness are (1) the weight of any load attached to the harness is transferred to the hips of the wearer -- not to his back or shoulders, thus minimizing fatigue and strain; (2) both hands are free; and (3) the harness is adjustable for a wide range of body sizes; and (4) provides a relatively stable mounting for the camera equipment. Note how the backpack, the viewfinder brackets, and the camera support unipod are attached to the harness so that each is easily removable. It has been demonstrated that a man, without assistance, can readily put on or take off the harness with all sub-units in place.

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

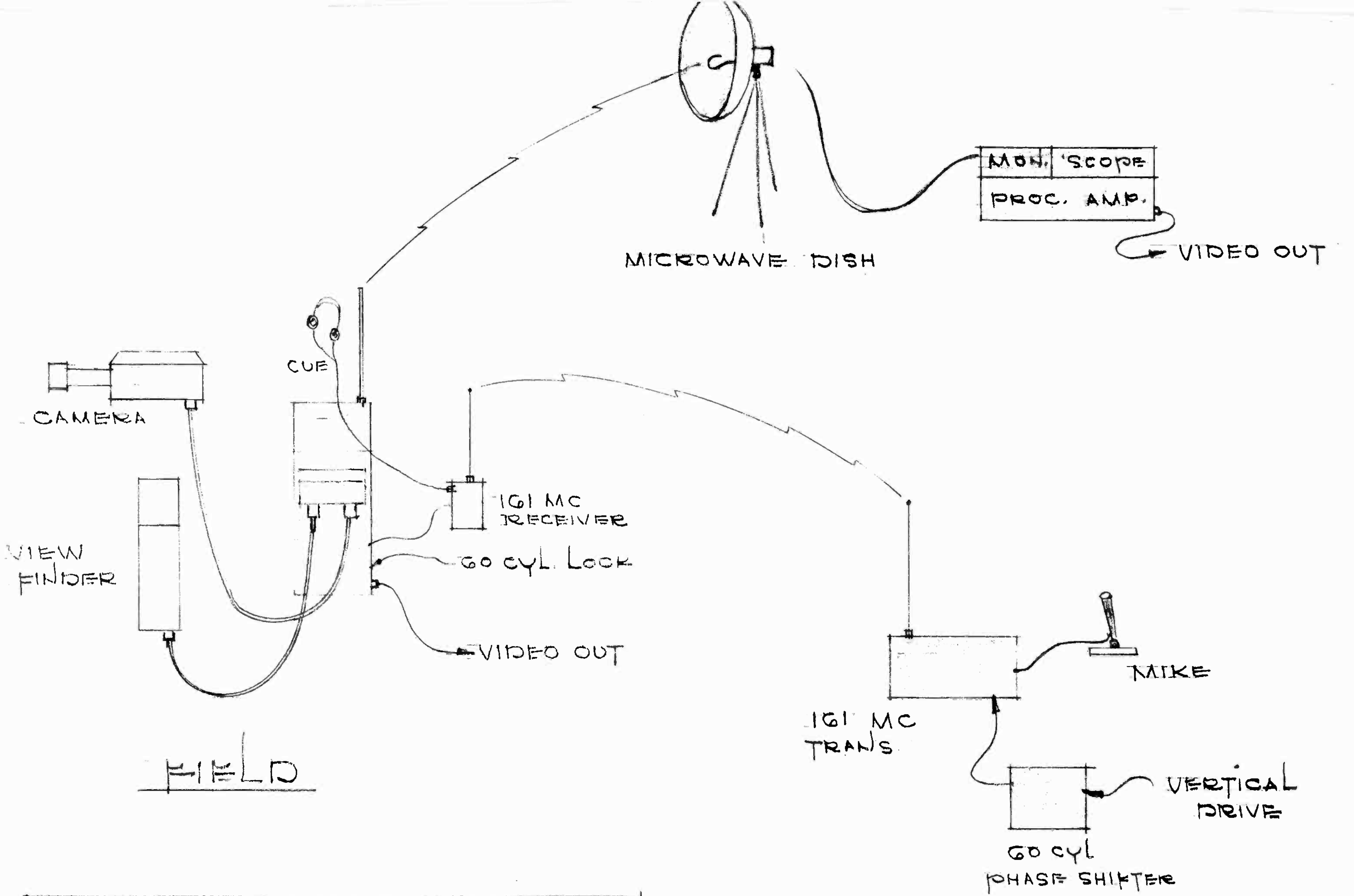
The construction throughout is ruggedized and designed to provide reliable performance over a wide range of operating conditions.

A number of the photographs were taken from the engineering prototype model of this camera. Several modifications have been made in the production model without sacrifice of performance or reliability. In particular, the backpack unit is now considerably reduced in size and weight, and some of the internal configuration has been modified. Also, the harness assembly has been modified to reduce weight and bulk without sacrifice of rigidity or flexibility.

J L Wilson
J Castleberry, Jr
4/8/64

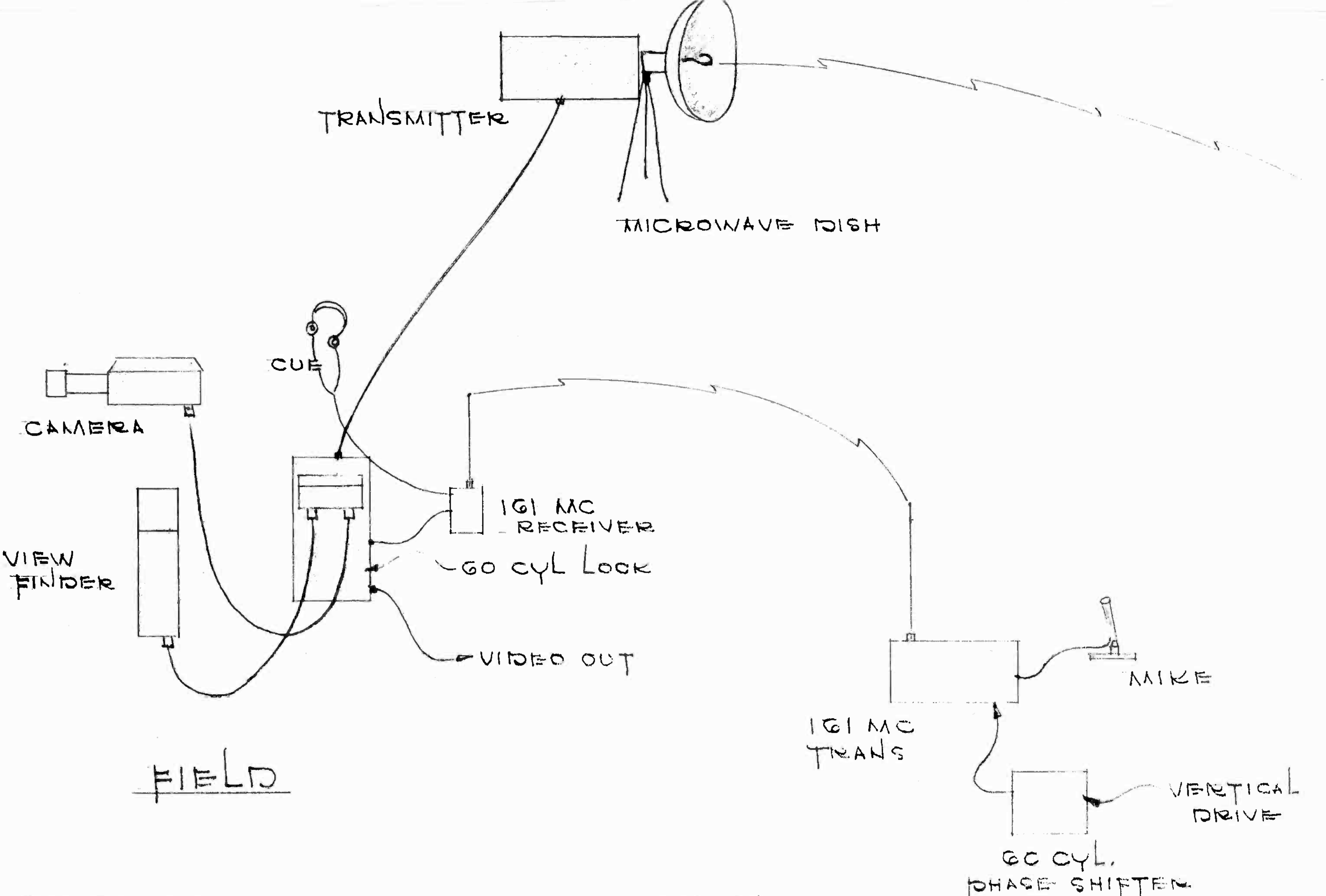
FIG. 1

FIG. 2



ULTRAPORTABLE CAMERA
NORMAL OPERATION

FIGURE # 3



ULTRAPORTABLE CAMERA
EXTENDED RANGE OPERATION

FIGURE #

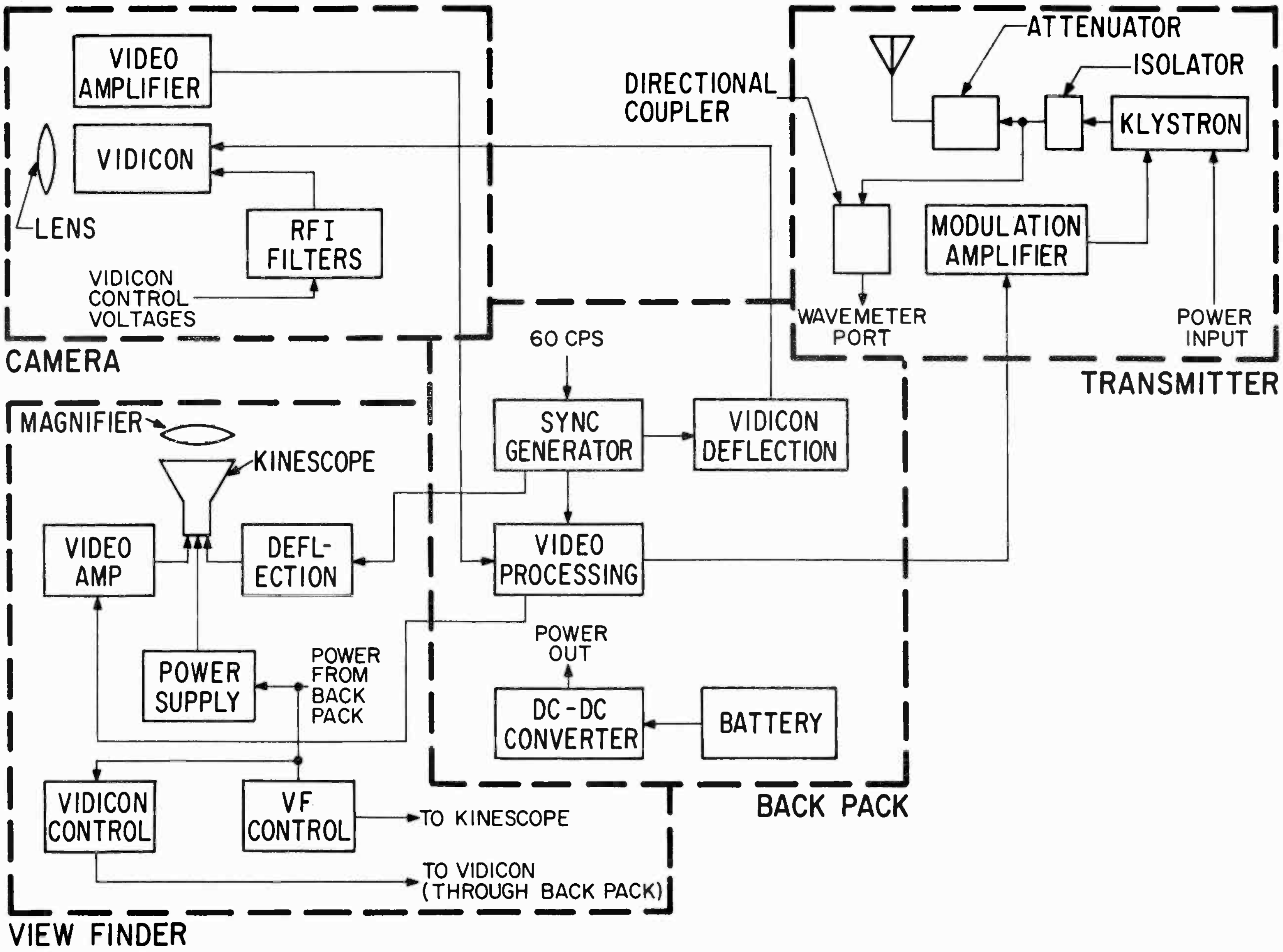

VIDEO AMPLIFIER
VIDICON
LENS
RFI FILTERS
VIDICON CONTROL VOLTAGES
CAMERA
DIRECTIONAL COUPLER
ATTENUATOR
ISOLATOR
KLYSTRON
MODULATION AMPLIFIER
WAVEMETER PORT
POWER INPUT
TRANSMITTER
60 CPS
SYNC GENERATOR
VIDICON DEFLECTION
VIDEO PROCESSING
POWER OUT
DC-DC CONVERTER
BATTERY
BACK PACK
MAGNIFIER
KINESCOPE
VIDEO AMP
DEFL-ECTION
POWER SUPPLY
POWER FROM BACK PACK
VIDICON CONTROL
VF CONTROL
TO KINESCOPE
TO VIDICON (THROUGH BACK PACK)
VIEW FINDER

FIG. 5

FIG. 6

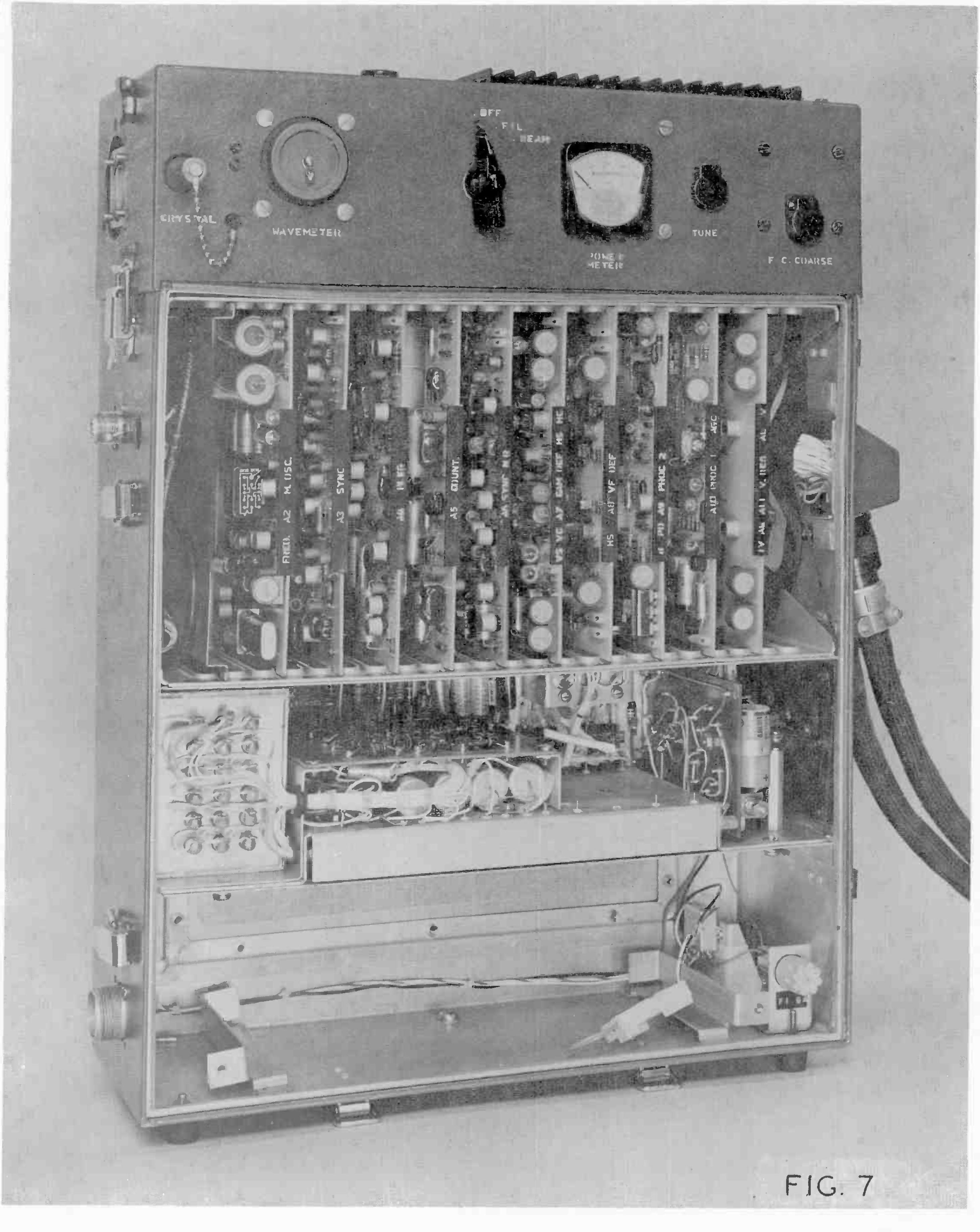

OFF
FIL
BEAM
CRYSTAL
WAVEMETER
POWER METER
TUNE
F. C. COARSE
A2 M. OSC.
A3 SYNC
A5 COUNT.

FIG. 7

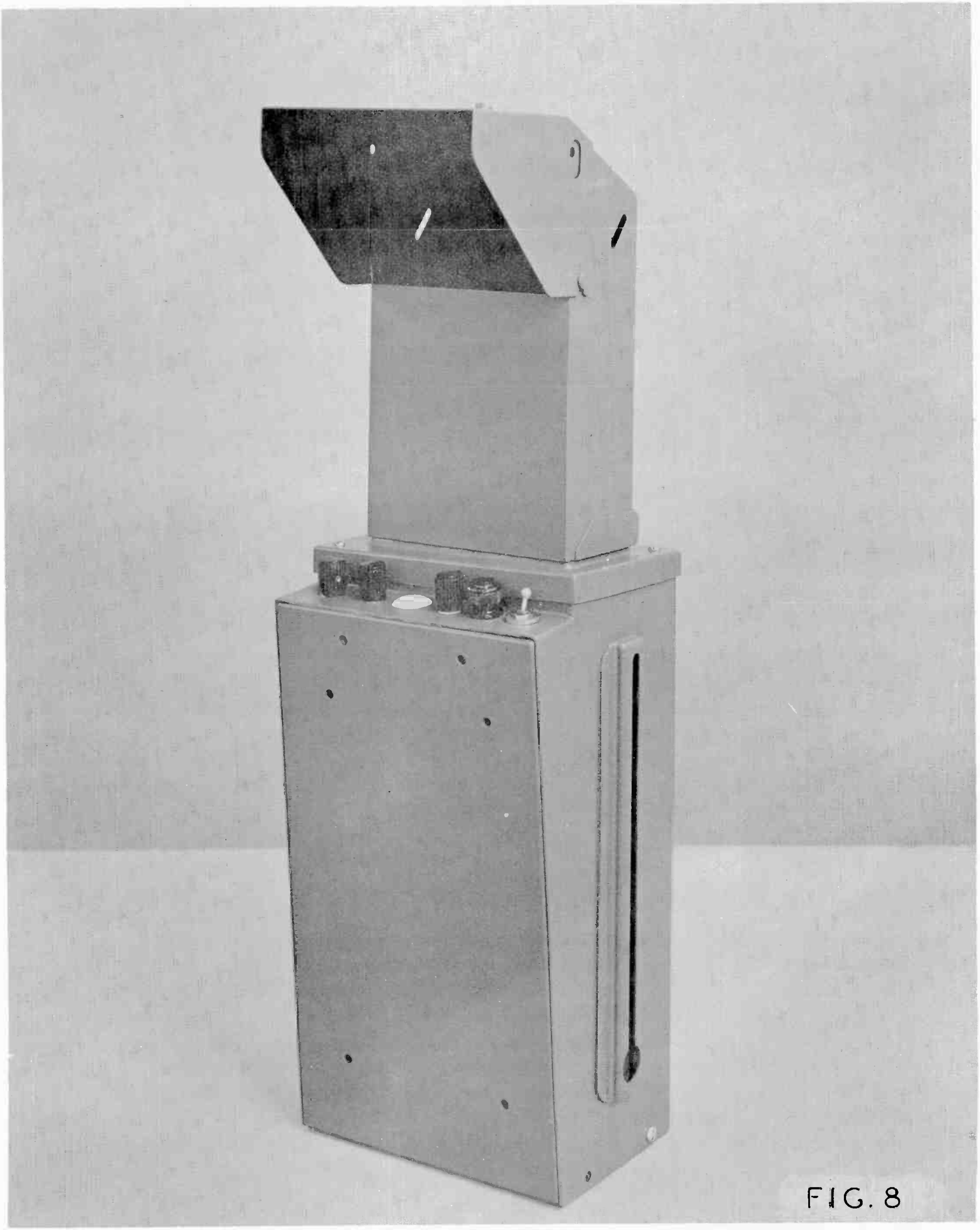


FIG. 8

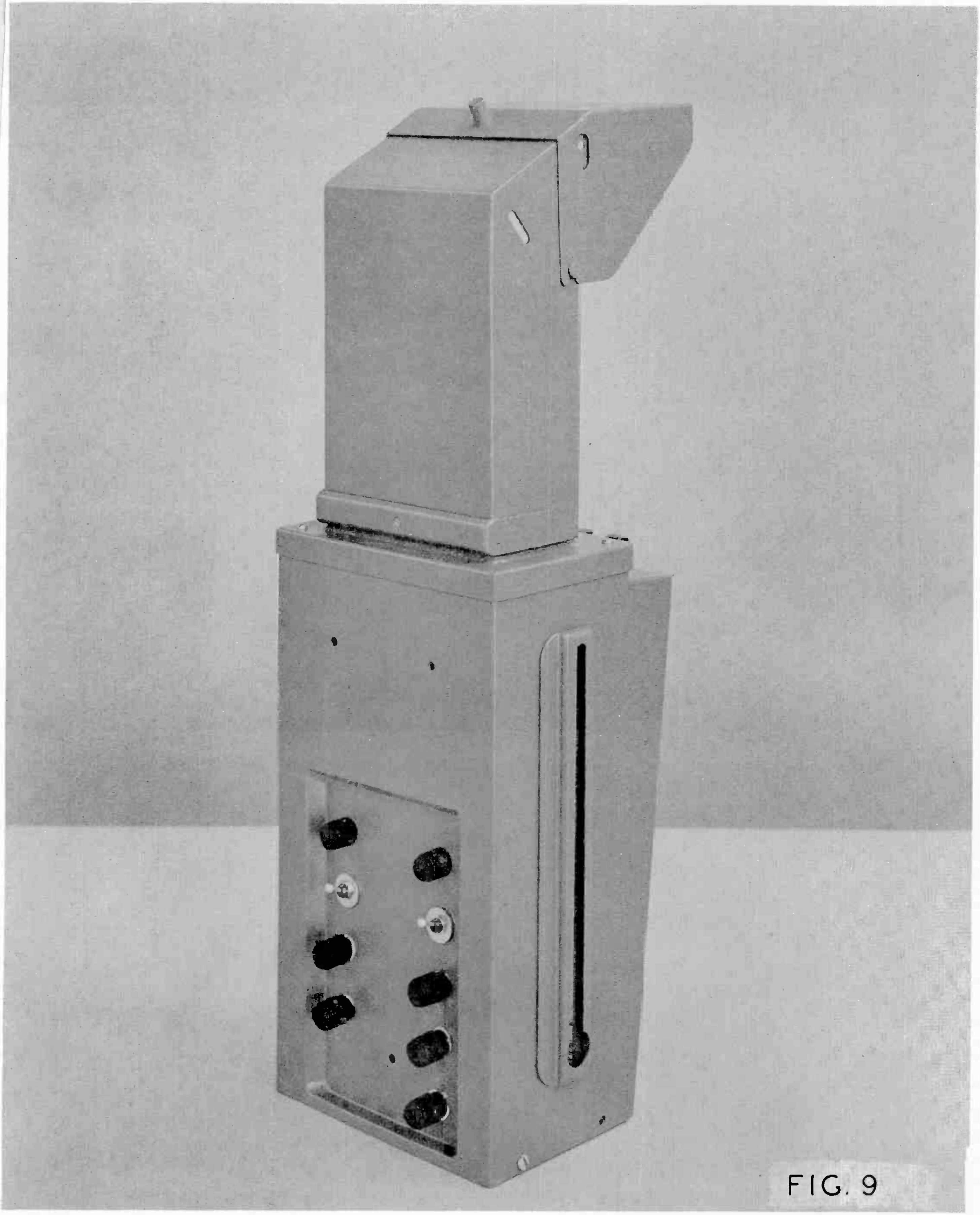


FIG. 9

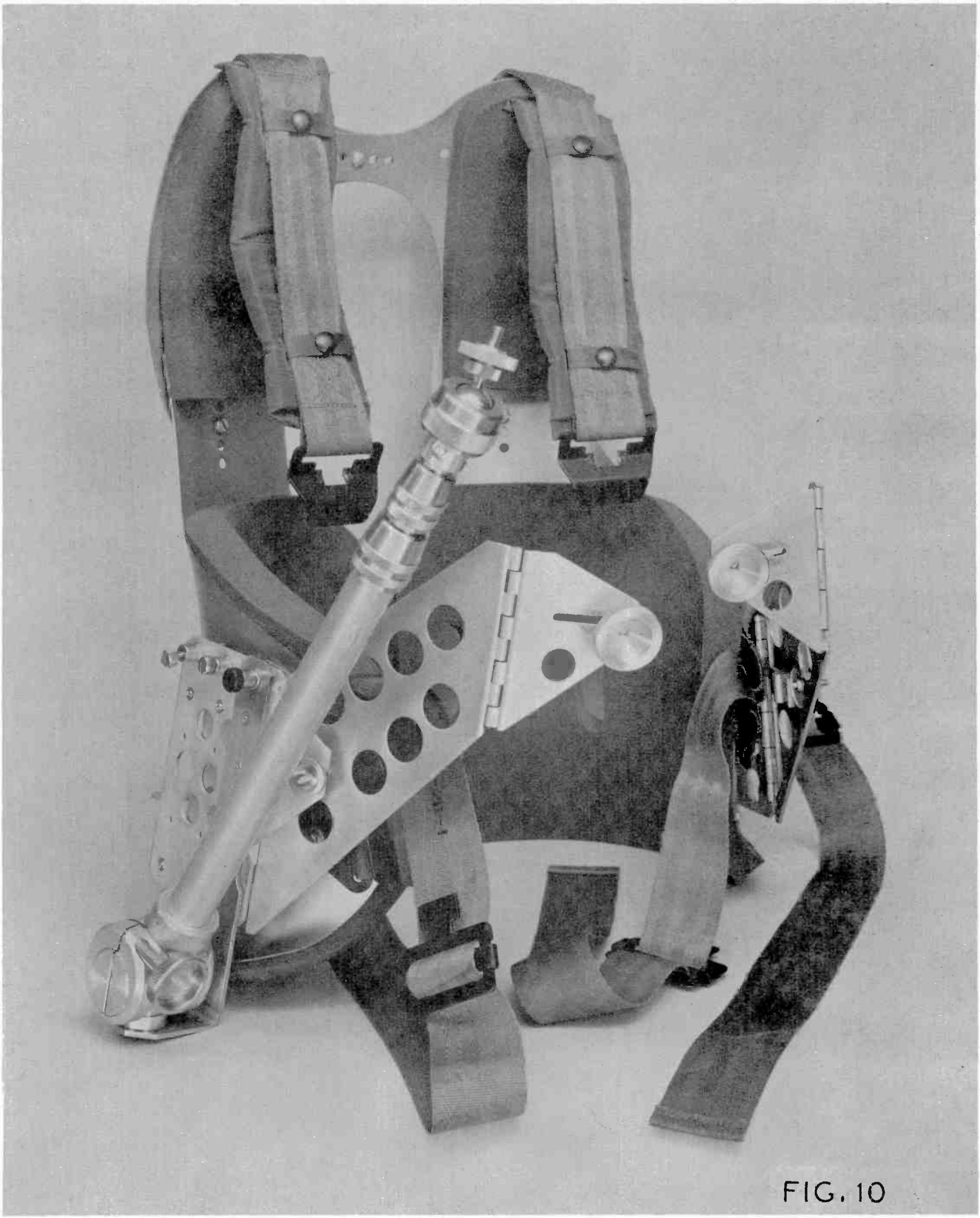


FIG. 10