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MULTIPLE GENERATIONS ON VIDEO TAPE RECORDERS.
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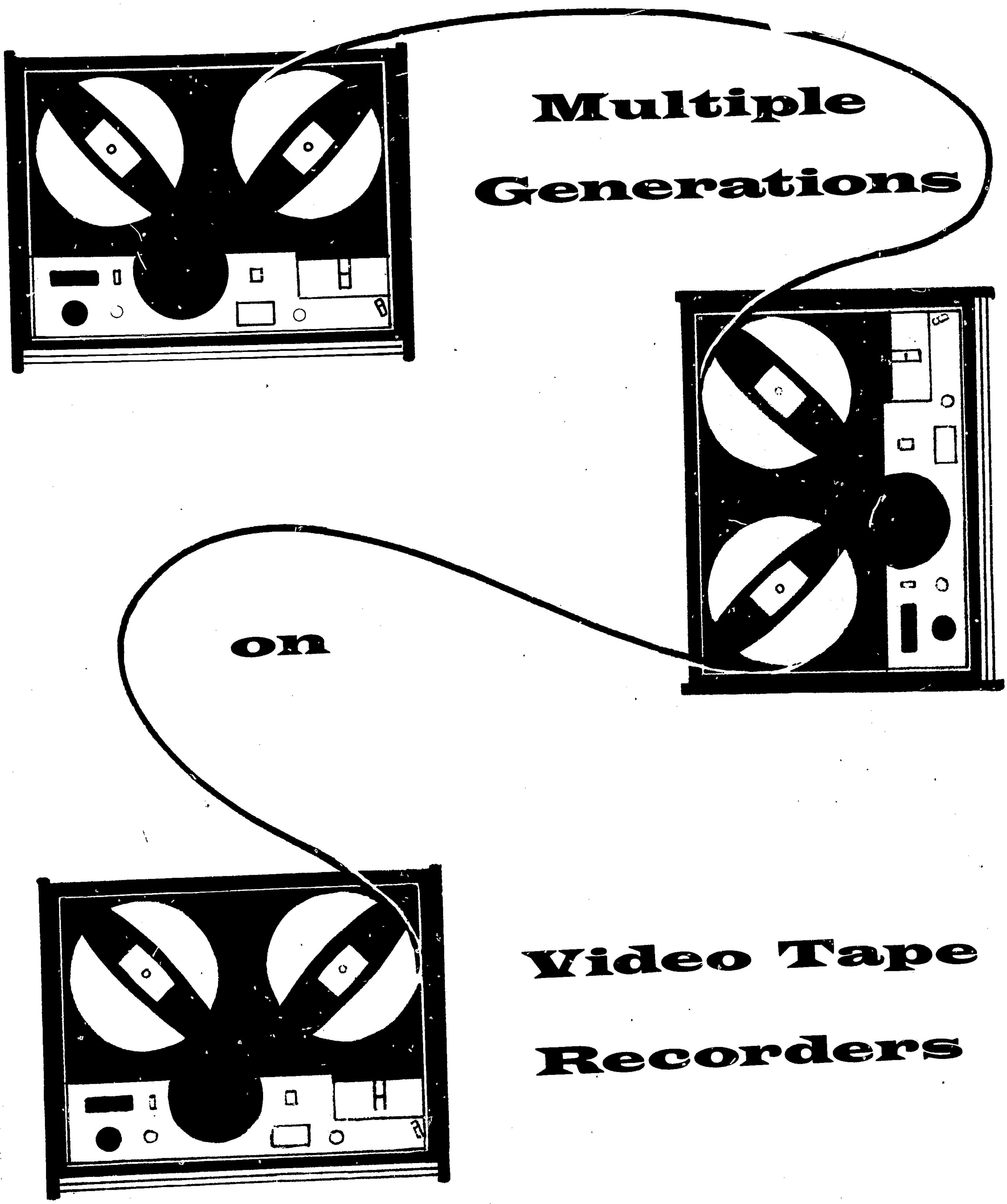
Helical scan video tape recorders were tested for their dubbing characteristics in order to make selection data available to media personnel. The equipment, two recorders of each type tested, was submitted by the manufacturers. The test was designed to produce quality evaluations for three generations of a single tape, thereby encompassing all levels of probable use in the school situation. The experiment tested four conditions: making a recording and playing it back; playing the recording back on a second machine; making a copy of the recording and playing it back; and making a recording of the copy and playing it back. This representation in the study appears in two forms: on the standard waveform monitor, which has meaning for the engineer; and on a picture monitor, which has meaning to the media specialist. For each of the four experimental conditions, still photographs of the waveform oscilloscope image and the picture monitor image were made to analyze performance and for reproduction in the report. Various design elements in the recorders studied determine their value for various uses. The conclusion is that there are three groupings of recorders based on picture quality and price range. When the intended use has been determined, the appropriate grade of machine may then be selected from one of the groups. (MT)

Multiple Generations on Video Tape Recorders



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SACRAMENTO 1968

MULTIPLE GENERATIONS ON VIDEO TAPE RECORDERS

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For the
Bureau of Audio-Visual and School Library Education
California State Department of Education

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PREFACE

The purpose of this study was to investigate the dubbing characteristics of helical scan video tape devices so that media personnel may have graphically presented data available to allow them to make more realistic appraisals of machines under consideration. The representation in this study is on a standard waveform monitor which has meaning to engineers and on a picture monitor which has more meaning to the media specialist. In the former, the reproduced electrical characteristics are represented; and in the latter, a visual or pictorial representation is presented.

The equipment examined was voluntarily submitted by the manufacturers for testing. Their engineers were invited to supervise the tests and to assure that the equipment was functioning properly.

The tests on the machines were arranged for by the State Department of Education and were funded in part by the National Defense Education Act. Special acknowledgments should be made for the work of the team of electronics specialists which conducted the tests under the direction of Guy M. Helmke, Bureau ot Audio-Visual and School Library Education. The team was composed of Dr. Jacob H. Wiens, Director of the College of the Air; Francis J. Morgan, Chief Engineer, KCSM-TV; and Walter C. Nichol, Technician, KCSM-TV; all from the College of San Mateo, San Mateo, California. The conclusions of this report do not necessarily reflect the official recommendations of any State agency.

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Multiple Generations on Video Tape Recorders

Introduction

Video tape recorders have now become an integral part of our education program. The video tape recorder makes it possible to record material for review and instruction, as well as to provide the means for storing instructional material for subsequent playback. Ideally, the video tape recorder should be capable of playing back the recorded material without degradation. This means that the picture as viewed on a picture monitor on playback would be as good as the original picture.

The state of the art has advanced to the point where it is physically possible with the highest quality equipment to produce a recorded picture that cannot be distinguished by the eye from the original picture. The cost of this equipment, however, is high and, the attention of many school administrators is focused upon the less expensive and more portable helical scan type of video tape recorder.

Moreover, in addition to making the initial video tape, educators see a need to make copies of tapes. Any deterioration of picture quality in the process of recording and playing back will have a negative effect on the final product.

It is hoped that this test may serve as an aid in determining which of the helical scan video tape recorders present capabilities which promise to fulfill the planned needs of educational programs.

Helical Scan Tape Recorders

The equipment investigated and studied in this report is limited to the helical scan type video tape recorder. In the helical scan machine, the signal is laid down on a slant across the video tape. The industry is currently producing helical scan video tape recorders in the two-inch, one-inch, and half-inch format. The two-inch format machine tested in this series is the Sony PV-120-U.

A large number of mechanical configurations are used to make contact between the video tape and the recording head. A simple configuration uses a 180° tape-wrap and two recording heads so that one head is constantly in contact with the video tape. This configuration requires a head switching assembly that complicates the mechanical adjustment.

In another configuration, the tape wraps entirely around the drum of the head using a conical wrap. This is sometimes referred to as an alpha wrap because of its similarity to the Greek letter α. The alpha-wrap machines generally employ a single head.

The most common tape configuration, the omega wrap, uses a wrap which makes a loop around the head very similar to the Greek letter "omega" Ω. This type of machine usually uses a single head.

A common fault in all helical scan machines is the difficulty encountered in switching from one slant track to the next. It is virtually impossible to maintain tape contact with the head in passing from the end of one line to the beginning of the next line. This difficulty is easily observed from the tape configuration in the omega wrap in which the head is completely out of contact with the tape in passing through the small bottom segment of the tape traverse. In the Ampex VR-7000 series, for instance, approximately eight full video lines are missing due to loss of head contact with the tape, see Figures 55 and 57.

Since in the helical scan machine the head loses contact with the video tape for a small segment of time, no sync pulses are reproduced by the recorder for this time interval. During this time, the monitor or receiver reverts to a free-running state by virtue of the behavior of the horizontal oscillator circuit. When the sync pulses are again transmitted, the horizontal oscillator hunts for a short period of time before again locking with the sync pulses. The recovery time is a function of the time constant of the horizontal oscillator drive circuit and differs with the circuitry involved.

The momentary loss of sync pulses and the subsequent hunting of the local horizontal oscillator results in a displacement of the video picture and sometimes in a "hook" in the upper portion of the video picture, see Figure 53. The severity of this distortion depends upon the duration of the absence of sync pulses, the tension adjustment on the video tape, and the electronic circuitry.

The location of the head drop-out with respect to the video picture is important. The head drop-out in all machines is made to occur near the vertical sync pulses and the most favorable location is just before the series of vertical sync pulses. With the head drop-out located at this point in the time sequence, the horizontal oscillator has the longest time to stabilize before the first picture information of the next field is reproduced.

The problem presented by the head drop-out phenomenon is an important one in making copies of the video material. The loss of head-to-tape contact on the re-recorded material should fall at the same time sequence as in the original recording. If this does not occur, the number of missing sync pulses will increase with a resulting aggravation of the video picture hook.

Video Quality Test

The electronics engineer measures picture excellence in terms of bandwidth, distortion, and noise. The first factor, bandwidth, relates to the frequencies produced by the electronic device.

The frequency response is measured by use of a multiburst test signal generator. This generator produces a series of signals consisting first of a white level signal referred to as a white flag and followed by six pure sinusoidal frequency bursts of o.5 MHz, 1.5 MHz, 2.0 MHz, 3.2 MHz, and 4.2 MHz, locked to line time. See Figure A.

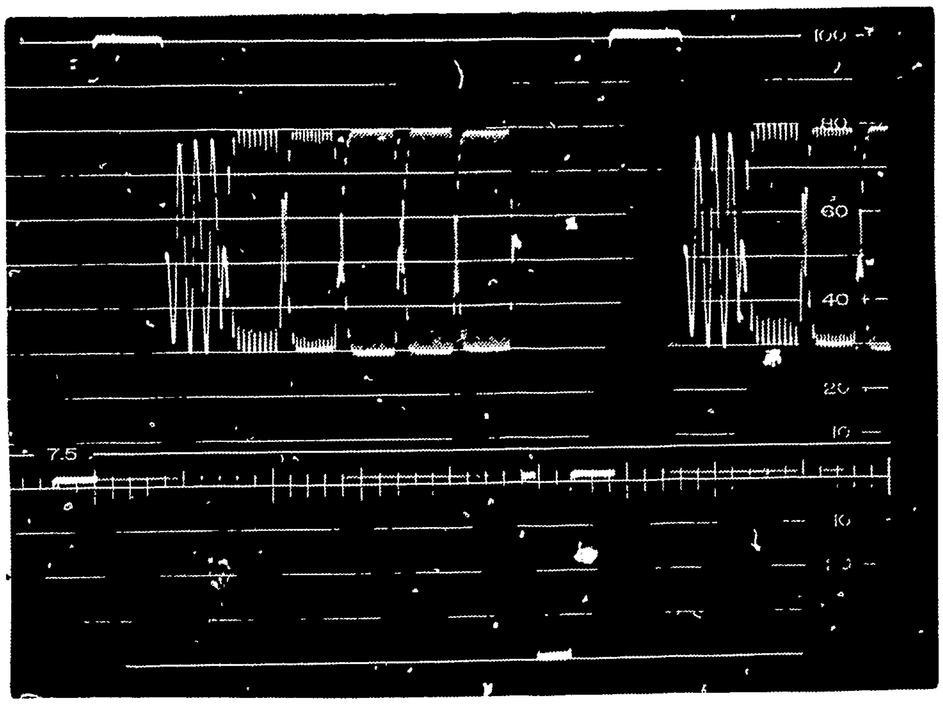

Fig. A - Multiburst Standard

The second factor, distortion, refers to the preciseness with which the signal is reproduced by the entire system. If the output signal is exactly similar to the input signal, the system is said to have no distortion.

The third factor, noise, in the signal is a form of distortion caused by extraneous, short duration pulses which produce sharp, white specks on the screen and are very distracting to the eye.

The resolution chart as viewed on a picture monitor is most meaningful to the layman, see Figure 1. This chart has a series of circles in the four corners of the picture, a series of line wedges, a series of gray steps, and another circle at the center of the picture. From the numbers along the line wedges, it is possible to determine the resolution in terms of lines. A deformation of the circles in the corners or in the center gives an indication of the linearity of the entire system. Vertical elements will give information about the line rate stability of the unit.

<u>The Test Procedure</u>

To simulate a school use as nearly as possible, the test consists of:

a. making a recording and playing it back,
b. playing the recording back on another machine,
c. making a copy of the recording and playing it back, and
d. making a recording of the recording and playing it back.

The real school situation might be that of making a tape, playing it over a school closed-circuit system, recording the material off the air or otherwise at one of the participating schools and then making copies of the tape to be used in other classrooms. The grade of video tape recorder equipment will depend upon the use made of the third generation tape and the necessity for editing and duplicating.

Two identical video tape recorders of each type were used in the test.

The entire test system was regulated by a Telemation Broadcast Synchronizing Generator, Model TSG-2000M.

The flag and multiburst test signal was produced by a Telechrome Video Test Generator, Model No. 3508-C2. The multiburst signals were calibrated by a Hewlett-Packard Waveform Oscilloscope, Model No. 191A, and fed directly to the input terminals to the first video tape recorder. A two-minute sequence of the multiburst signal was recorded.

The resolution chart was reproduced by using a Tele-Pat light box and a RETMA Resolution Chart, No. TM-302. The television camera was a Blonder-Tongue TTVC-1B-SN with a 75mm, f 1.9 lens set at f4. The video level of the camera signal was calibrated by means of the Hewlett-Packard waveform oscilloscope and the picture size was adjusted to properly fill the screen on a Conrac Picture Monitor, Model No. CNB8/C. A two-minute sequence of this material was next recorded.

The entire sequence was then played back by Machine No. 1 and the multiburst signal was reproduced on the Hewlett-Packard 191A waveform monitor and photographed by a Hewlett-Packard 179B Polaroid oscilloscope camera using Polaroid No. 107 film.

The resolution chart was reproduced and exhibited on the Conrac picture monitor and was photographed by a 3-1/4 x 4-1/4 speed graphic plate camera using Eastman pan film with a camera setting of F11 and 1/5 second. The picture monitor pictures were reproduced by standard enlargement techniques.

The numerical identification refers to the model of the tape recorder. The letter designation refers to the picture sequence with "a" representing the playback of the material on the machine used for recording.

The video tape was then transferred to Machine No. 2 and a similar set of two photographs was made, these being designated "b."

The video tape was then transferred back to the original machine and a second video tape was used to make a re-recording on Machine No. 2. This sequence of pictures was marked "c."

The output of Machine No. 2 with tape No. 2 was then fed back to Machine No. 1 and a third dub was made on tape No. 3, Machine No. 1. This sequence of pictures is identified as "d."

Each participating company was invited to have its engineers supervise the tests to insure that the equipment was functioning properly. Sony, Ampex, and Concord were represented by field engineers.

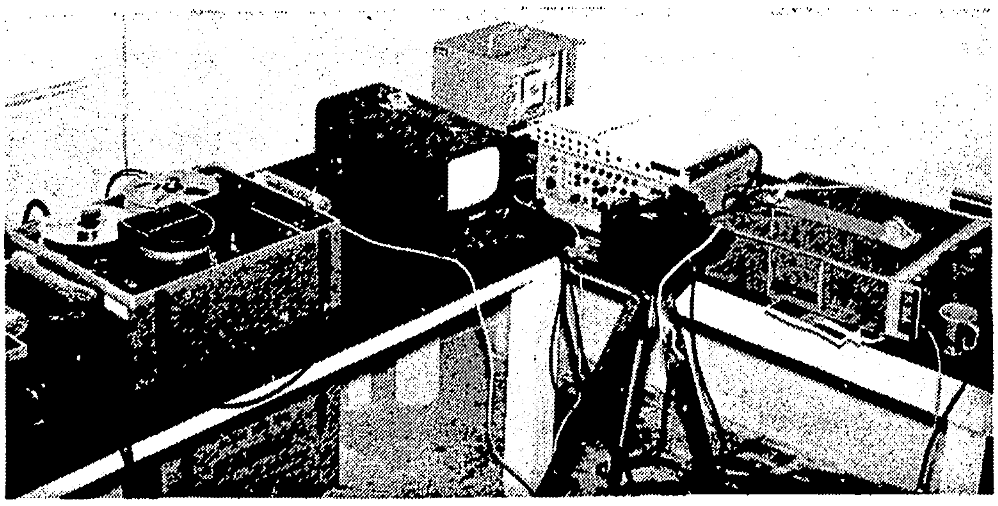

Fig. B - Test Set-Up

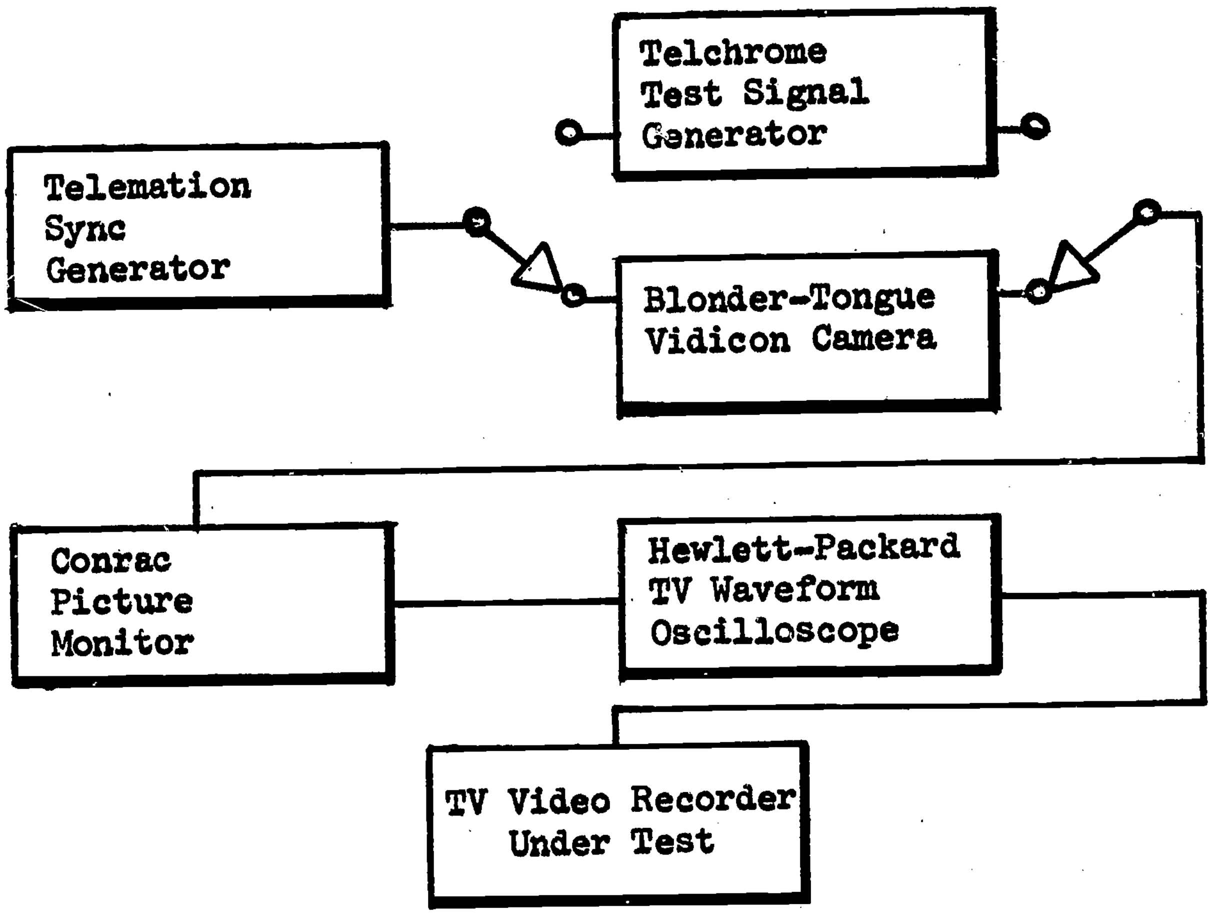

Diagram No. 1
Equipment Arrangement for Recording

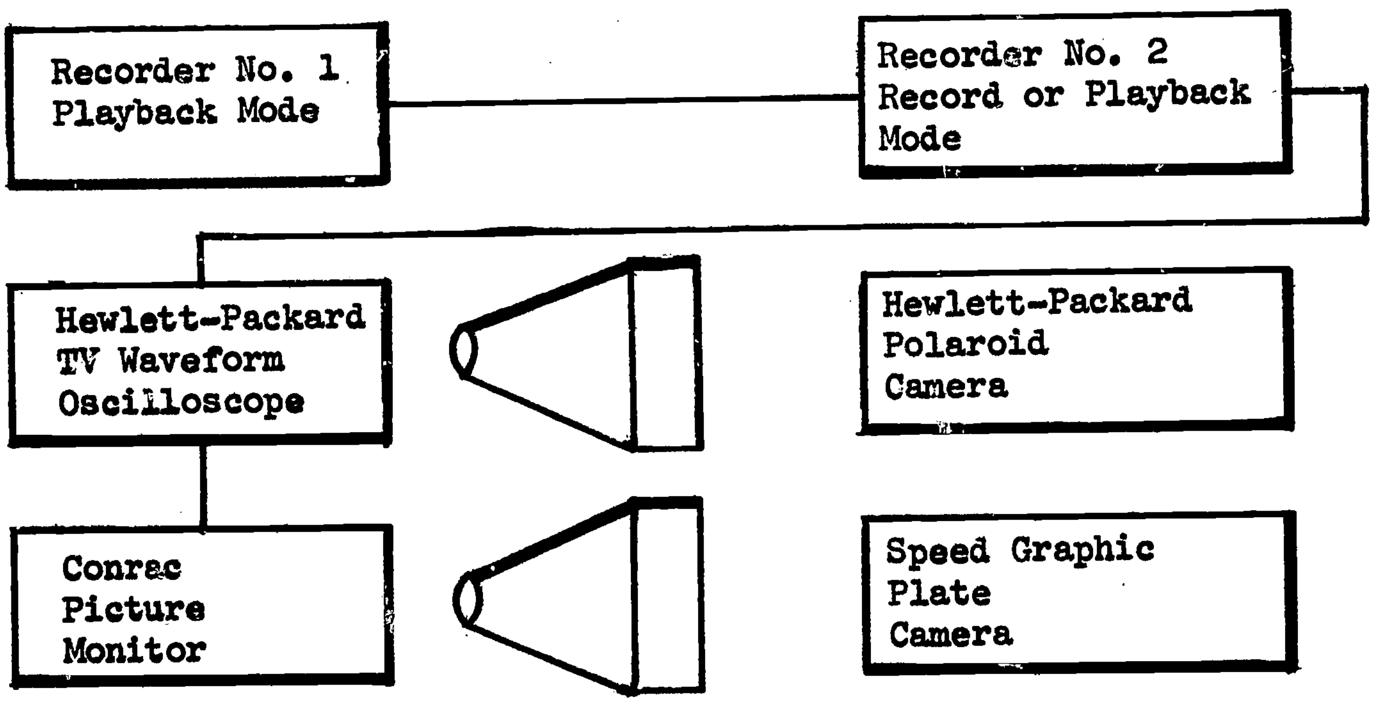

Diagram No. 2
Equipment Arrangement for Re-Recording and/or Playback

Calibration

Figure 1 is a photograph of the resolution of the camera system. The horizontal resolution is in excess of 600 lines at the center.

The multiburst standard is not shown but each of the multiburst amplitudes were individually adjusted to 10 and 90 on the waveform oscilloscope scale. The white flag was adjusted to 100 and the black flag to -40.

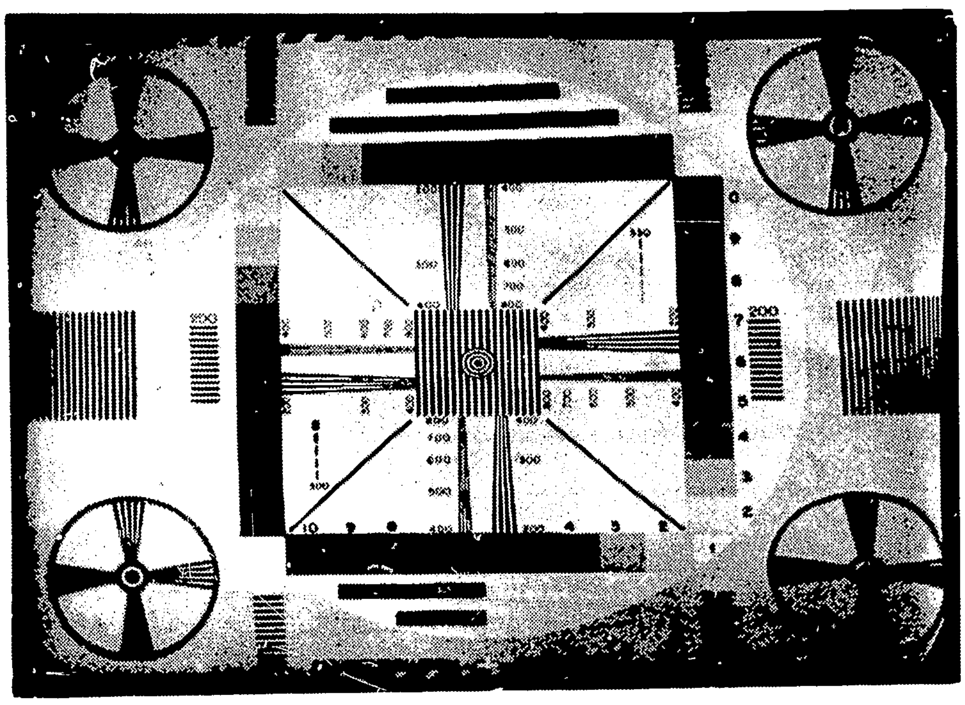

Fig. 1 - Standard Resolution Chart

Sony EV-200 Series

Figure 2 is a playback of the resolution chart. This shows a horizontal resolution of 300 at the center with approximately the same corner resolution but with some skewing of the lower half of the picture.

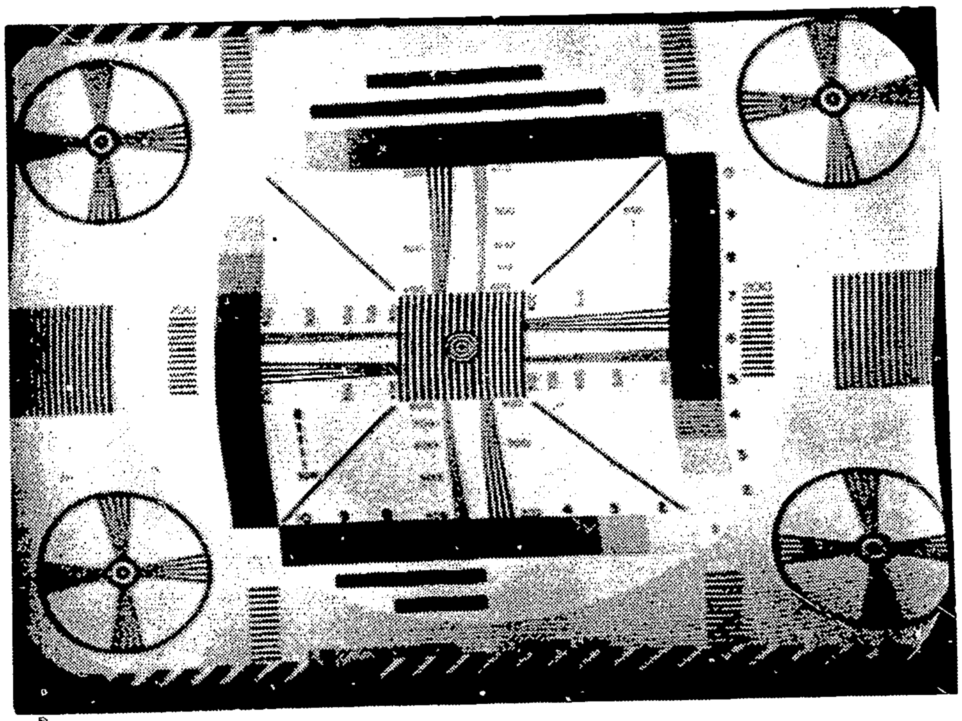

Fig. 2 - First Generation Resolution

Figure 3 is the playback of the multiburst frequencies, 0.5 MHz, 1.5 MHz, 2.0 MHz, 3.2 MHz, 3.6 MHz, and 4.2 MHz. The response is down approximately 3 db at 2.0 MHz and 6 db at 3.2 MHz with essentially no signal at 4.2 MHz.

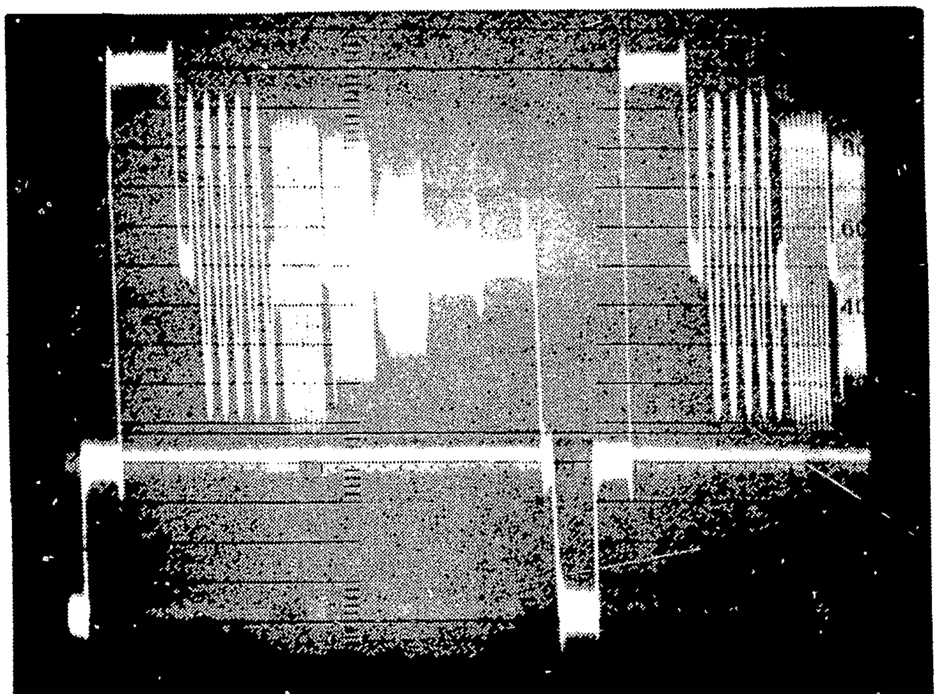

Fig. 3 - First Generation Multiburst

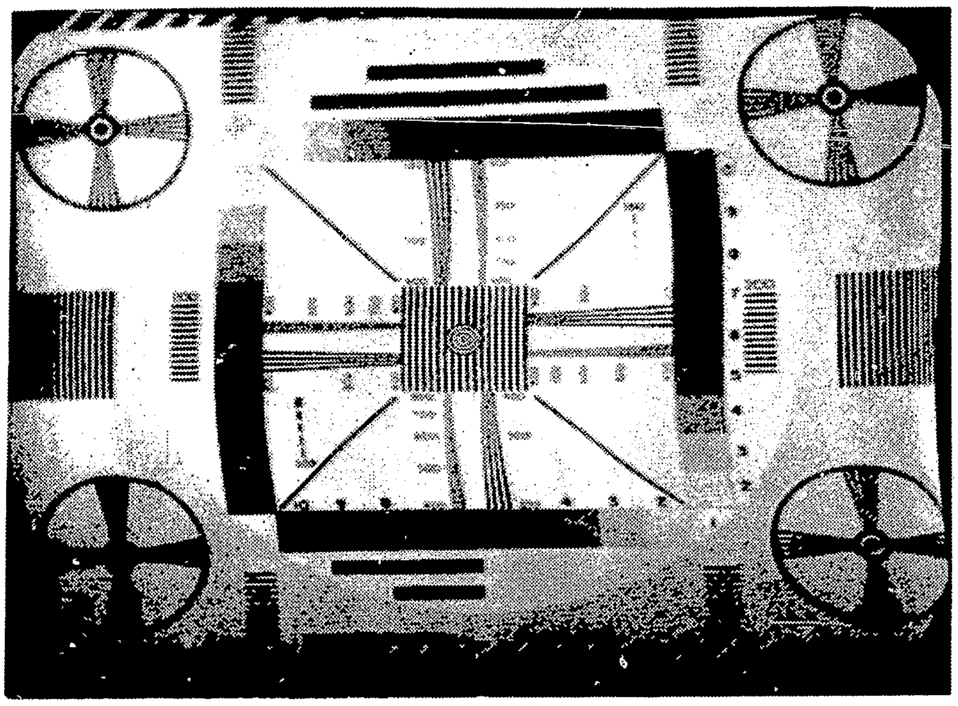

Fig. 4 - Tape Interchange

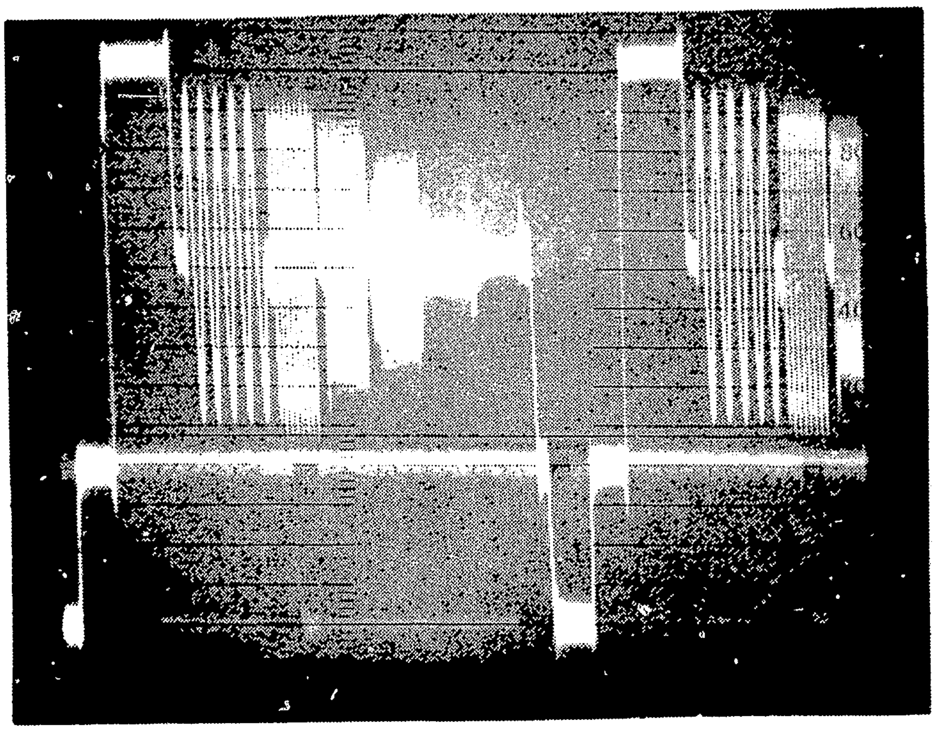

Fig. 5 - Tape Interchange

Figures 4 and 5 are identical to Figure 2 except that the tape was played back on a different machine of the same model. The Sony EV-200 has excellent tape interchange capability as the two sets of pictures are virtually identical.

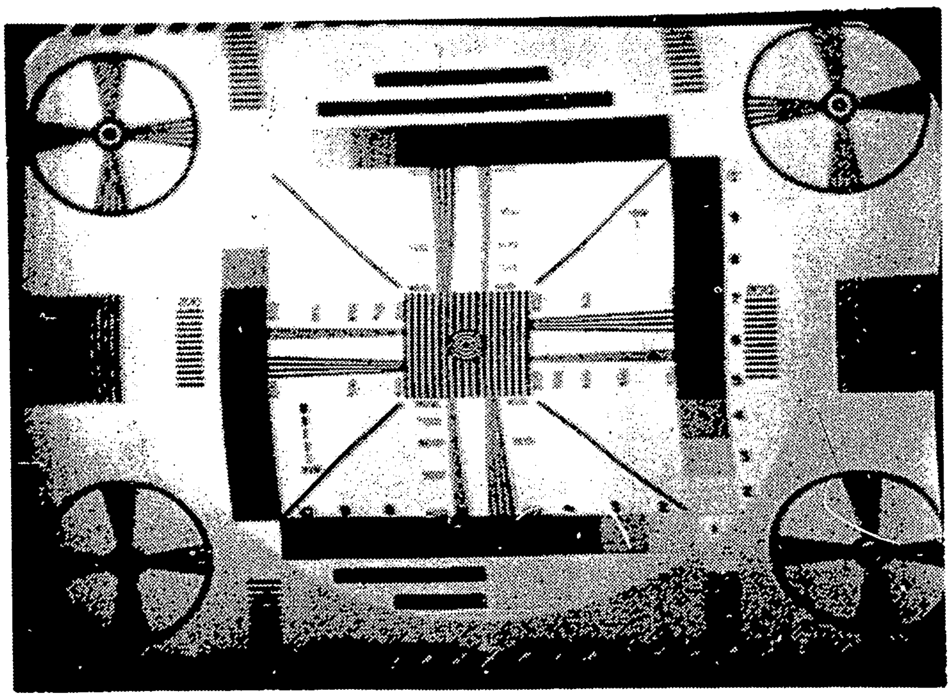

Fig. 6 - Second Generation Resolution

In Figures 6 and 7, the original tape was played back on Machine No. 1, recorded on Machine No. 2, and reproduced on Machine No. 2. This is a second generation picture. The resolution has decreased slightly as has the frequency response.

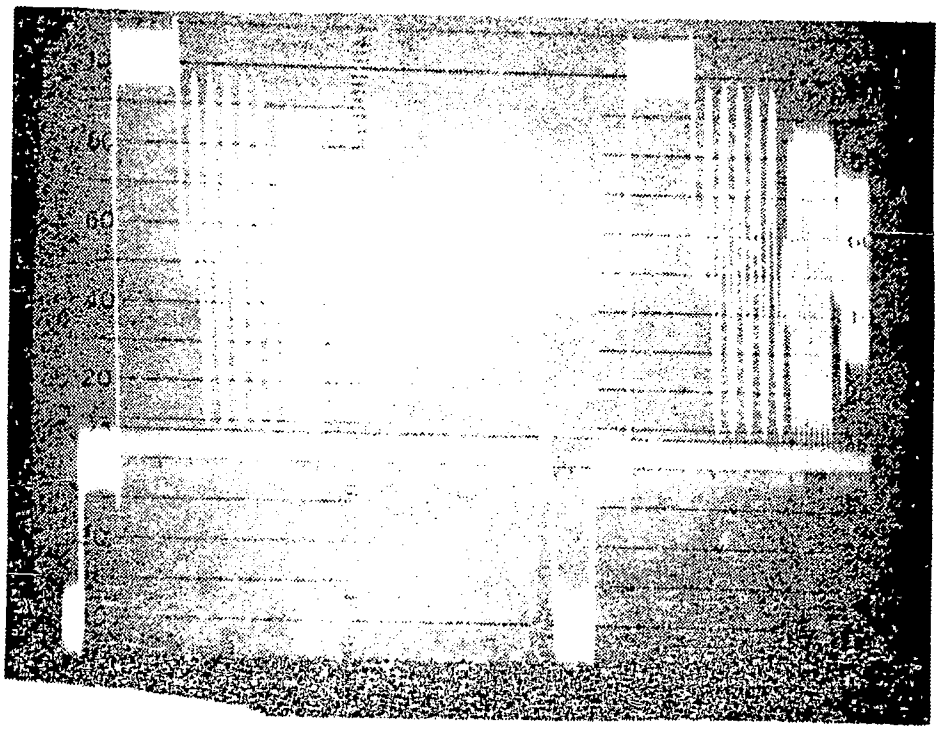

Fig. 7 - Second Generation Multiburst

The 0.5 MHz frequency has been accented and the 3.2 MHz frequency has suffered. The noise components of the video signal have increased due to the additional electronics and the last two multiburst signals are entirely masked by noise.

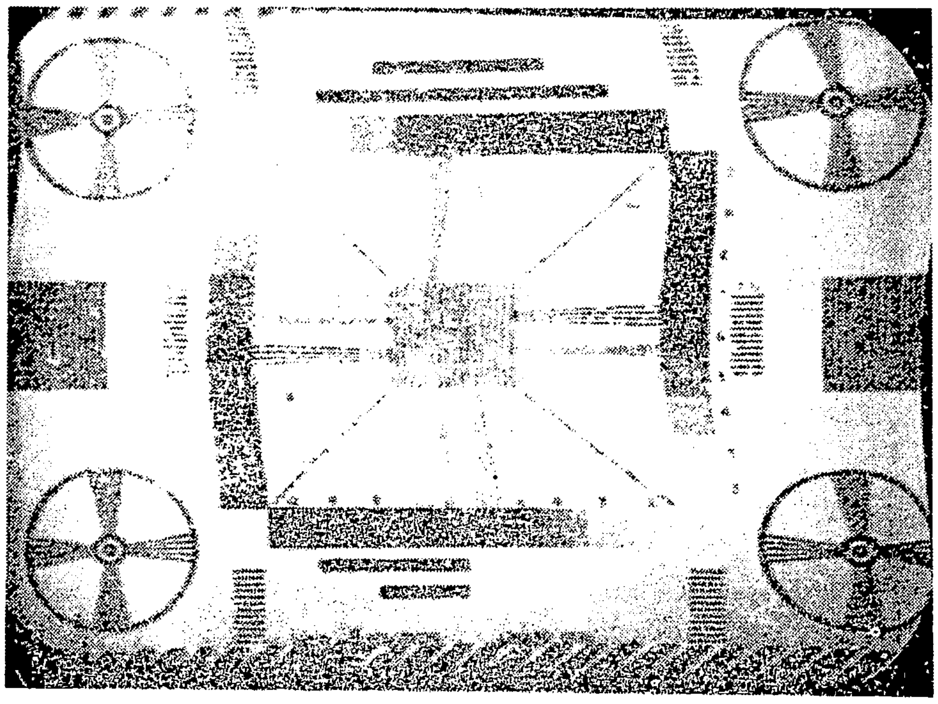

Fig. 8 - Third Generation Resolution

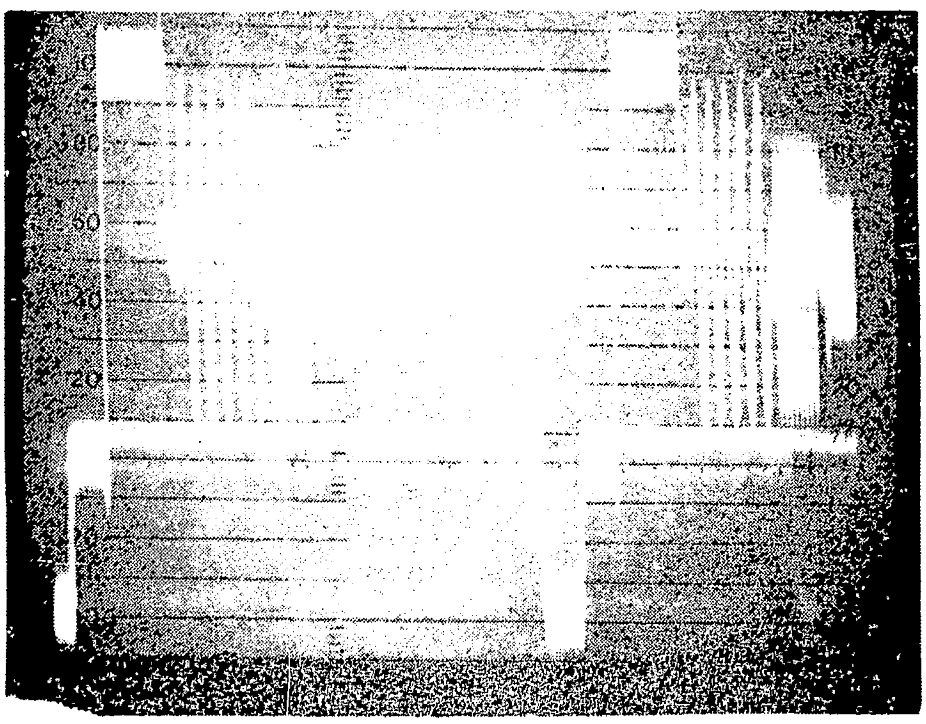

Fig. 9 - Third Generation Multiburst

Figures 8 and 9 were produced by re-recording the entire test sequence of Figures 6 and 7. This is a third generation picture. The horizontal resolution at this point is not more than 200 but the vertical linearity and the useful picture information has remained. The loss of detail is, of course, due to the decreased bandwidth as shown on Figure 9 of the multiburst, where the noise level now entirely blanks the last three multiburst frequencies and where the 1.5 MHz response is down by approximately 3 db. The white flag shows remarkably little tilt and the leading edges of the sync pulses are clean and distinct. A processing amplifier would reproduce the sync pulses very satisfactorily.

End of Sony EV-200 series

Sony SV-300 Series

Figures 10 and 11 represent the initial playback on the Sony SV-300. The record amplitude control was adjusted to the manufacturer's specifications but on playback there is both a low frequency displacement resulting in the center line falling on 60 rather than 50 on the scale. The amplitude, furthermore, has decreased from 80 units to approximately 70 units on the 0.5 MHz frequency and the signal has dropped by approximately 9 db at the 1.5 MHz frequency. The remaining multiburst signals are masked by noise. This results in a poor horizontal resolution and the 200-line bars are almost totally obliterated. The picture linearity exhibits almost no vertical hook.

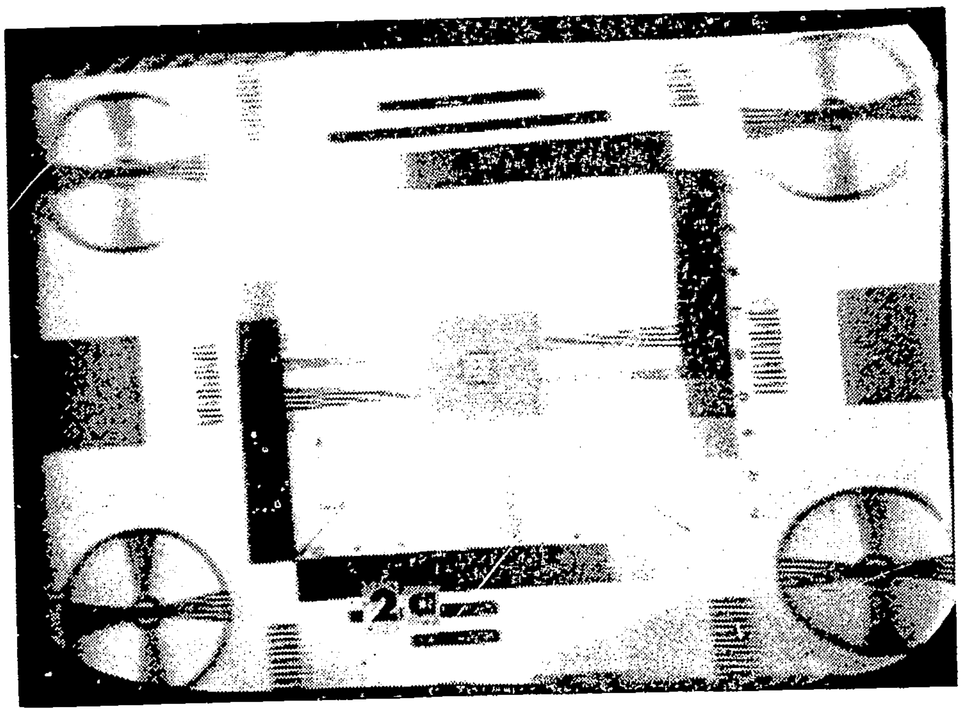

Fig. 10 - First Generation Resolution

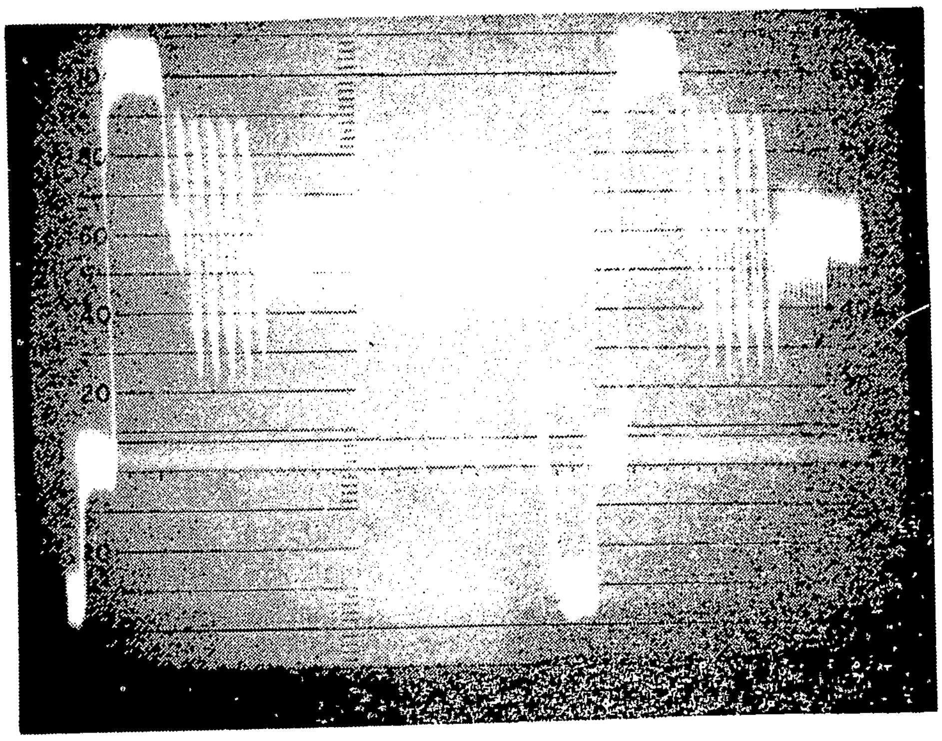

Fig. 11 - First Generation Multiburst

Figures 12 and 13 show good tape interchange characteristics. The response on Machine No. 2 is nearly identical to that on Machine No. 1.

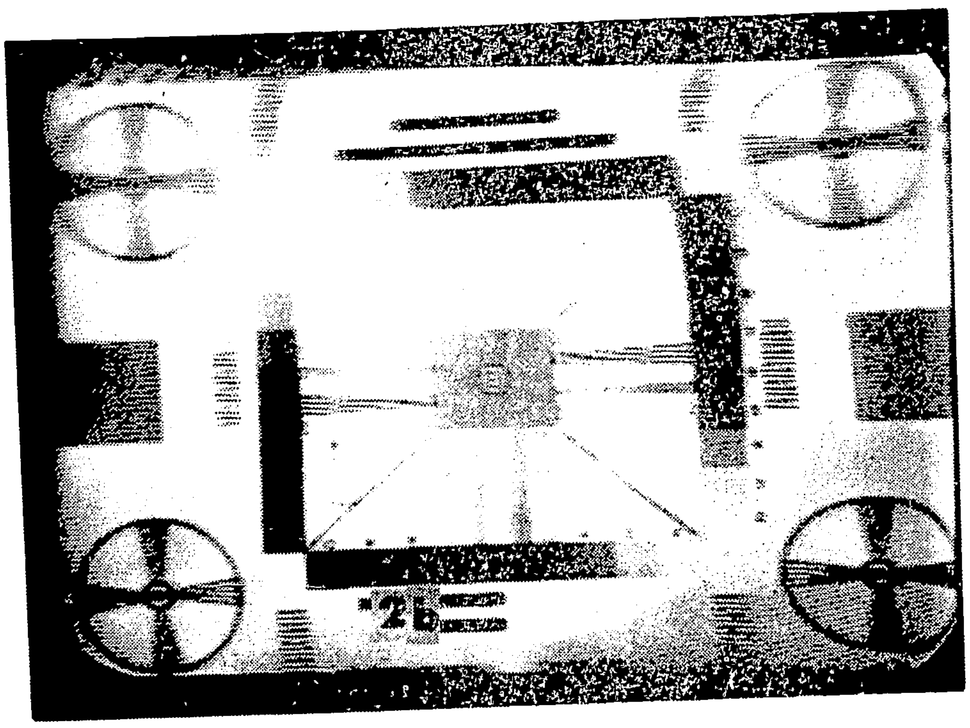

Fig. 12 - Tape Interchange

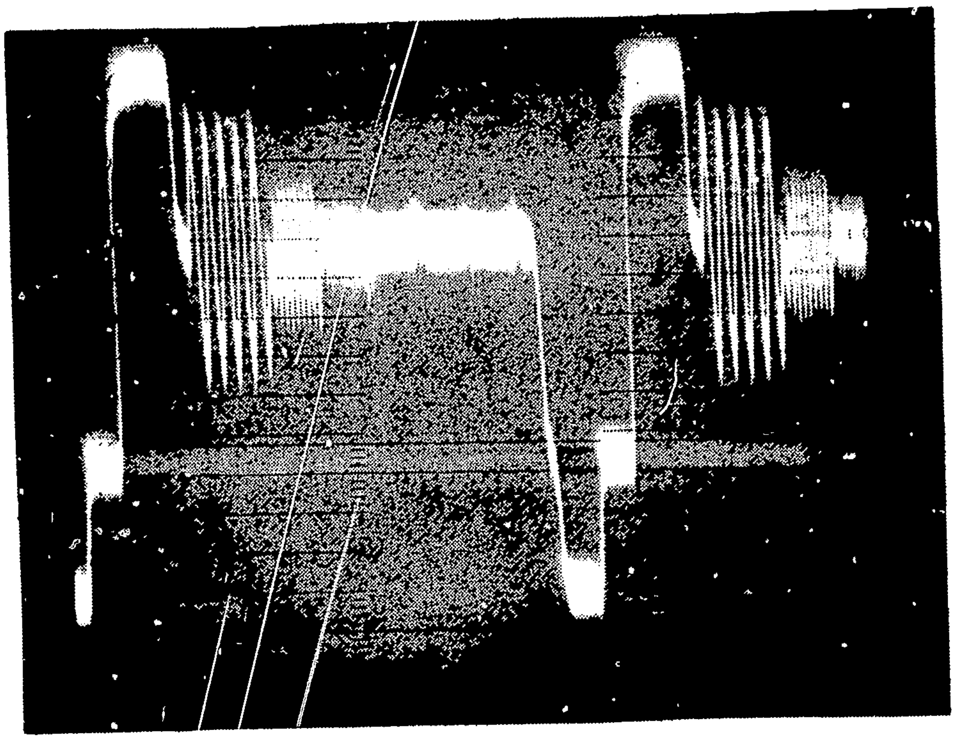

Fig. 13 - Tape Interchange

The sync pulse and flag are indistinct because of a drop-out of the higher frequency components of the signals and the slope of the sync pulse made it difficult to prevent the picture from fluttering.

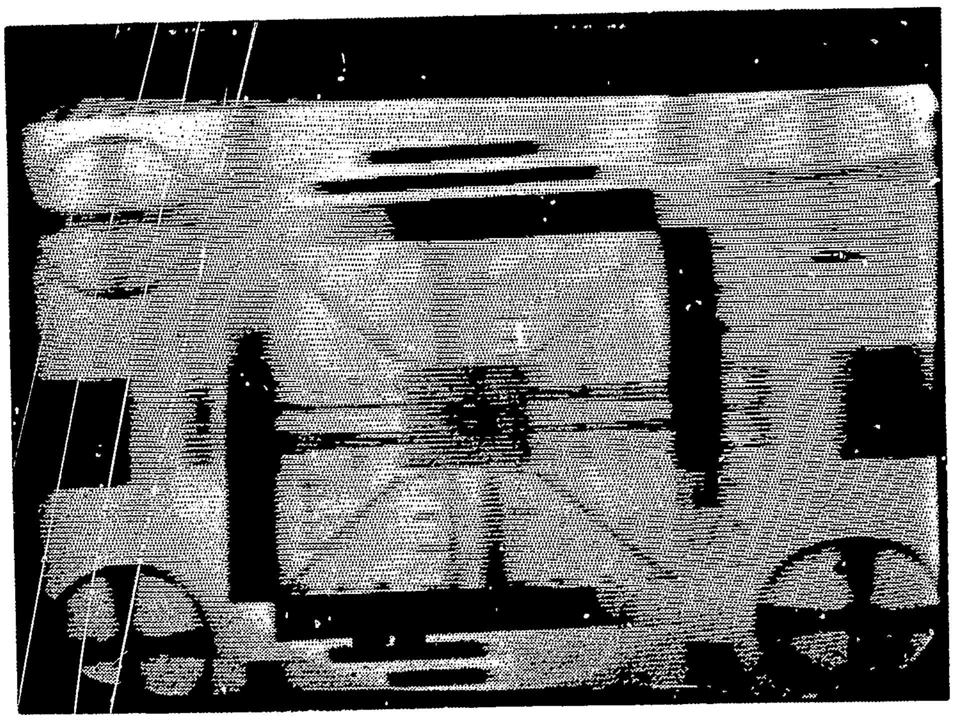

Fig. 14 - Second Generation Resolution

Figures 14 and 15 show the second generation pictures. As will be noted, only the first multiburst frequency, 0.5 MHz, is now visible and all but the major components of the resolution chart are blurred. It is doubtful that a television picture with this limited resolution is useful in classroom instruction. Efforts to make a third generation were unsuccessful.

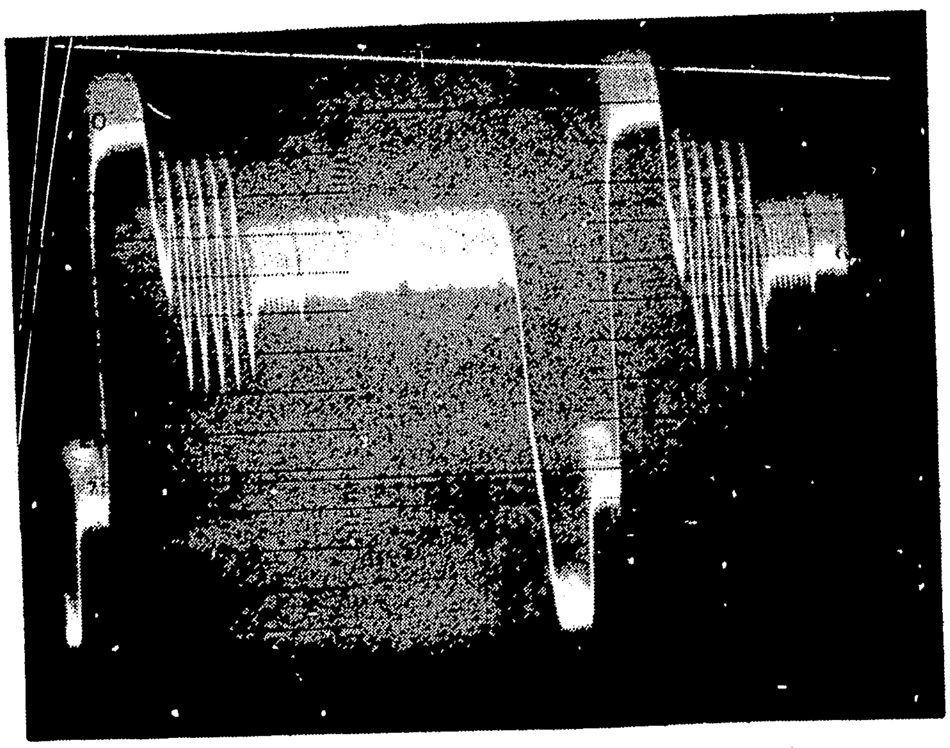

Fig. 15 - Second Generation Multiburst

End of Sony SV-300 series

Sony PV-120-U Series

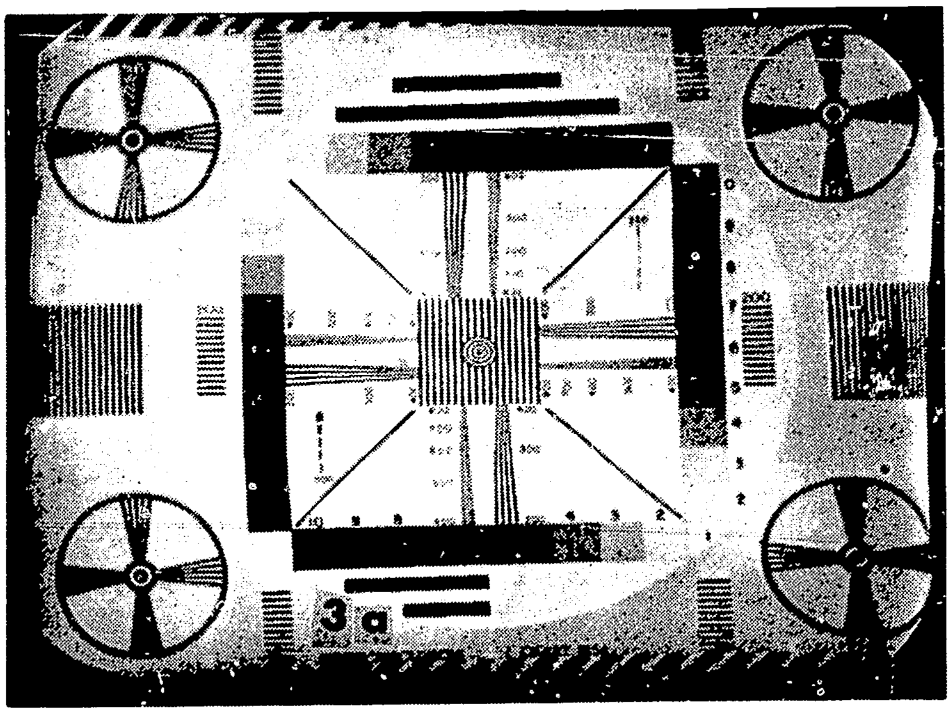

Fig. 16 - First Generation Resolution

Figure 16 is a playback of the resolution chart. The Sony PV-120-U can be adjusted to produce nearly perfect vertical linearity. The horizontal resolution is approximately 300 lines in the center and with each of the corners exhibiting roughly the same resolution. The vertical linearity is necessarily limited by the 525-line format of the American television system. The gray scale shows at least six shades of gray. But this does not mean that the video tape recorder was at fault. The camera adjustment and the photographic equipment crowd together the shades beyond number seven and the reproduced PV-120-U picture is equal to the standard resolution picture in this respect.

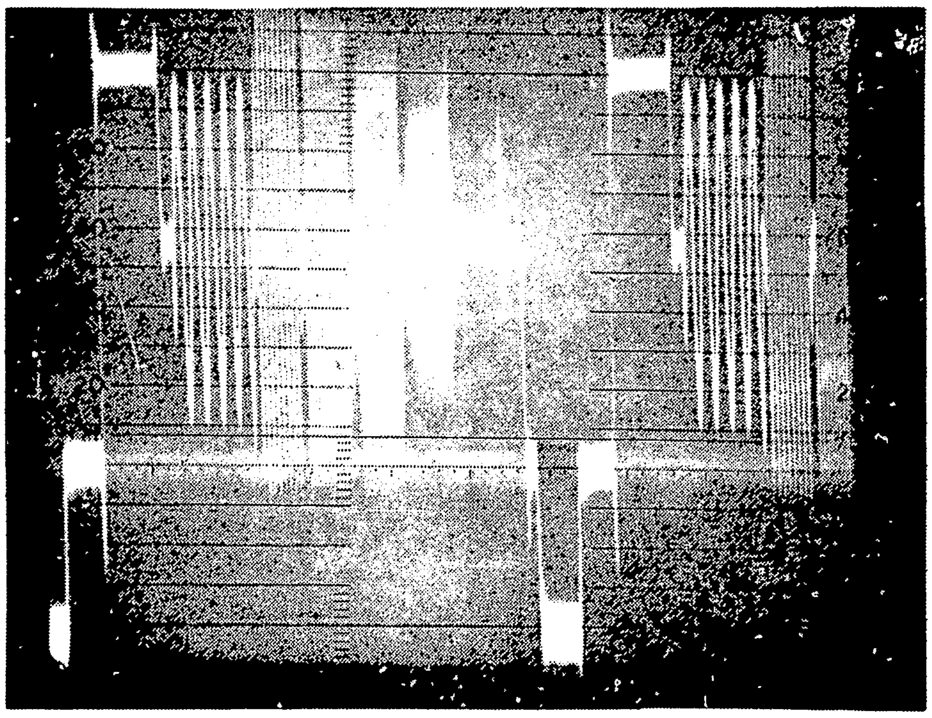

Fig. 17 - First Generation Multiburst

Figure 17, the multiburst playback, shows evidence of high frequency peaking especially in the 1.5 MHz, 2.0 MHz, and 3.2 MHz bursts. The 4.2 MHz burst is masked by noise. The spikes on the leading and trailing edges of the sync pulses further show the effect of high frequency peaking.

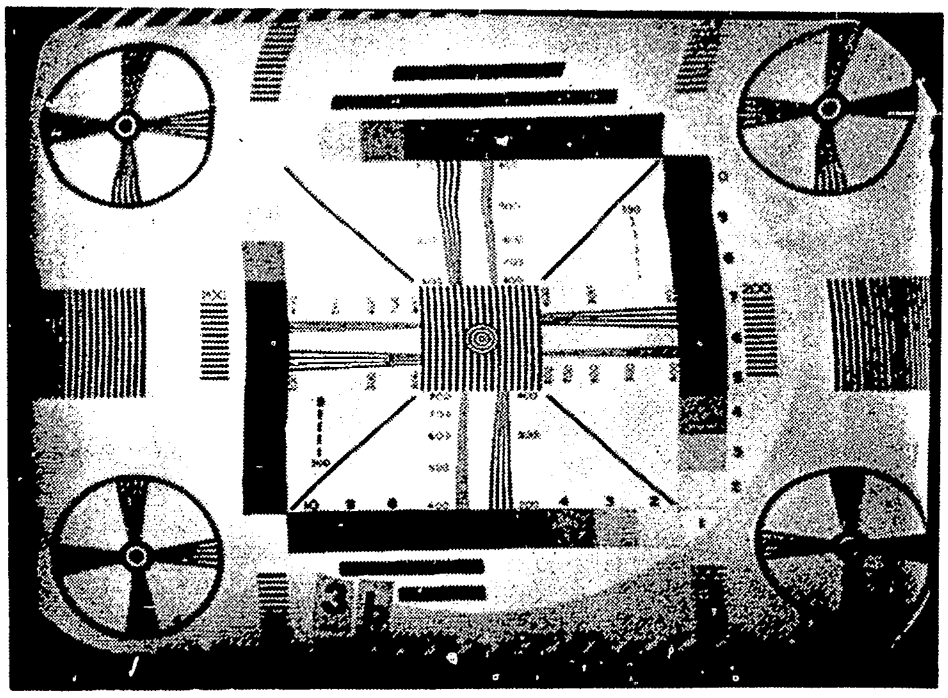

Fig. 18 - Tape Interchange

Figures 18 and 19 show that there is some difficulty in maintaining optimum tension when the tapes are played back on a second machine. Again, it would appear that careful adjustment of the mechanism would minimize this and that the same picture resolution could be obtained on a second machine as on the original.

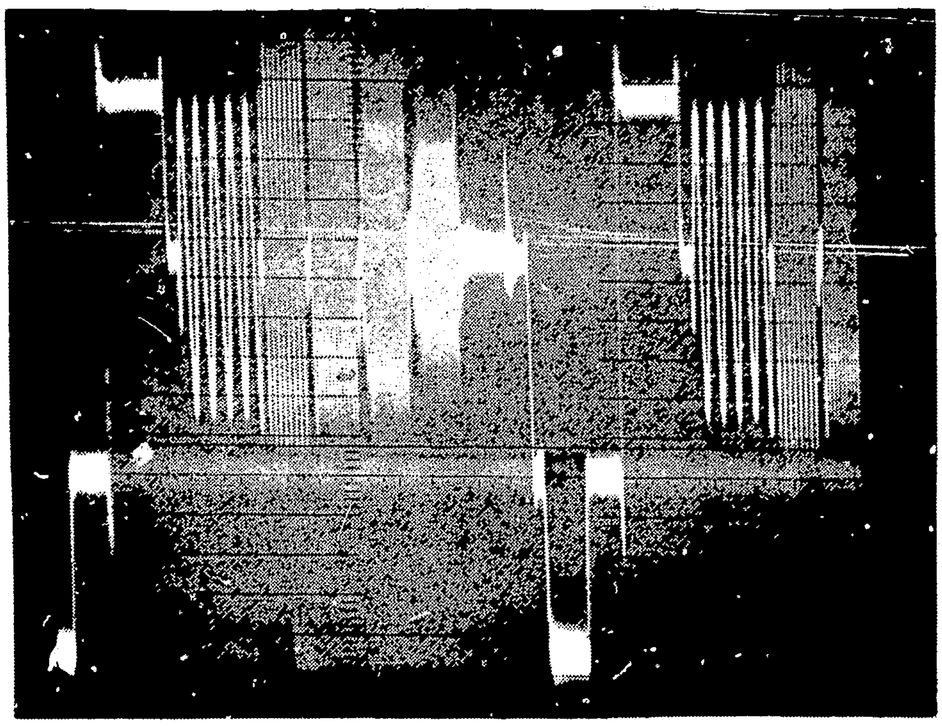

Fig. 19 - Tape Interchange

In Figure 19, the multiburst, the high frequency peaking is not as predominant as in the original machine indicating that adjustable electronic circuitry is provided for this purpose.

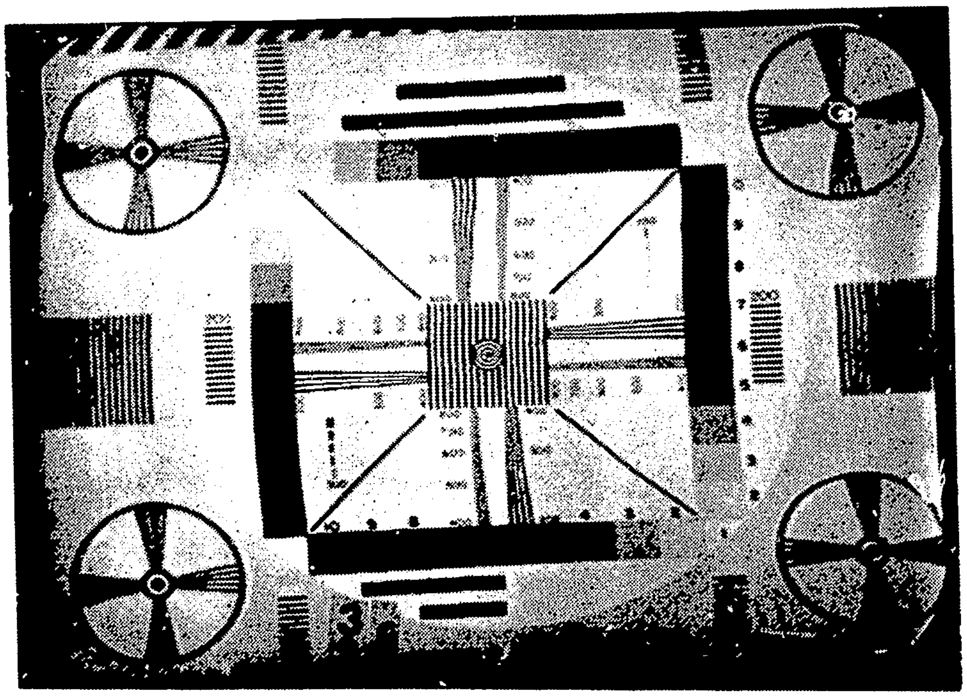

Fig. 20 - Second Generation Resolution

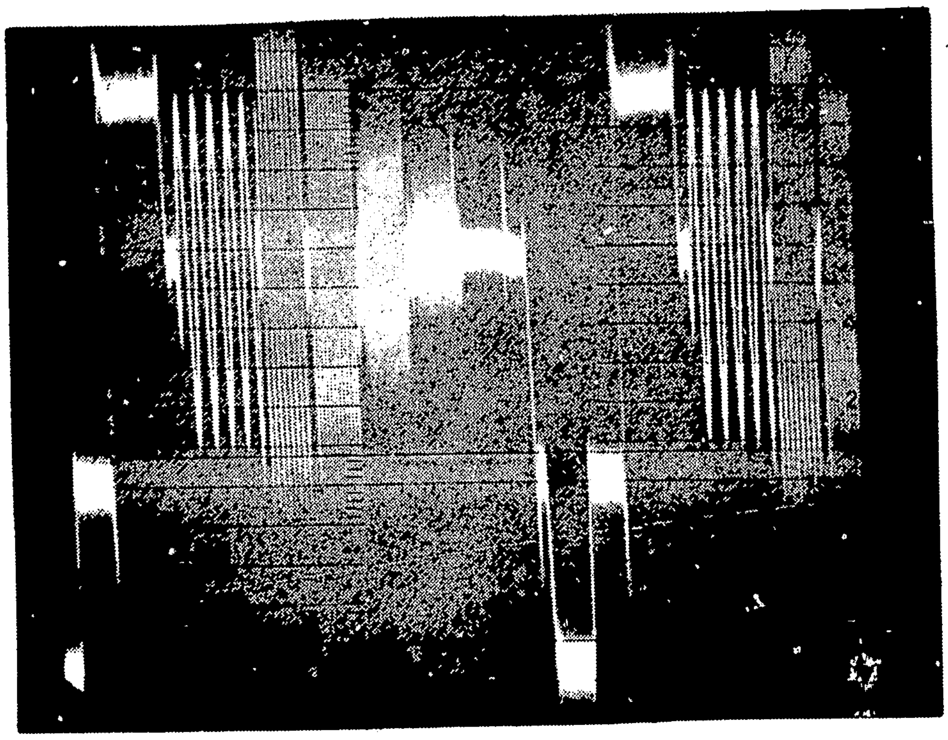

Fig. 21 - Second Generation Multiburst

Figures 20 and 21 show that excellent reproductions can be expected from the Sony PV-120-U. Furthermore, tapes played back on the machine used for producing the tape show better vertical linearity than the machine exhibited when playing back a tape made on another machine. The multibursts on Figure 21 show the effect of two successive peaking circuits as the 1.5 MHz burst has exceeded the amplitudes of the original or the playback burst. The effect of high frequency roll-off is likewise in evidence as the 3.6 MHz burst is down by approximately 9 db.

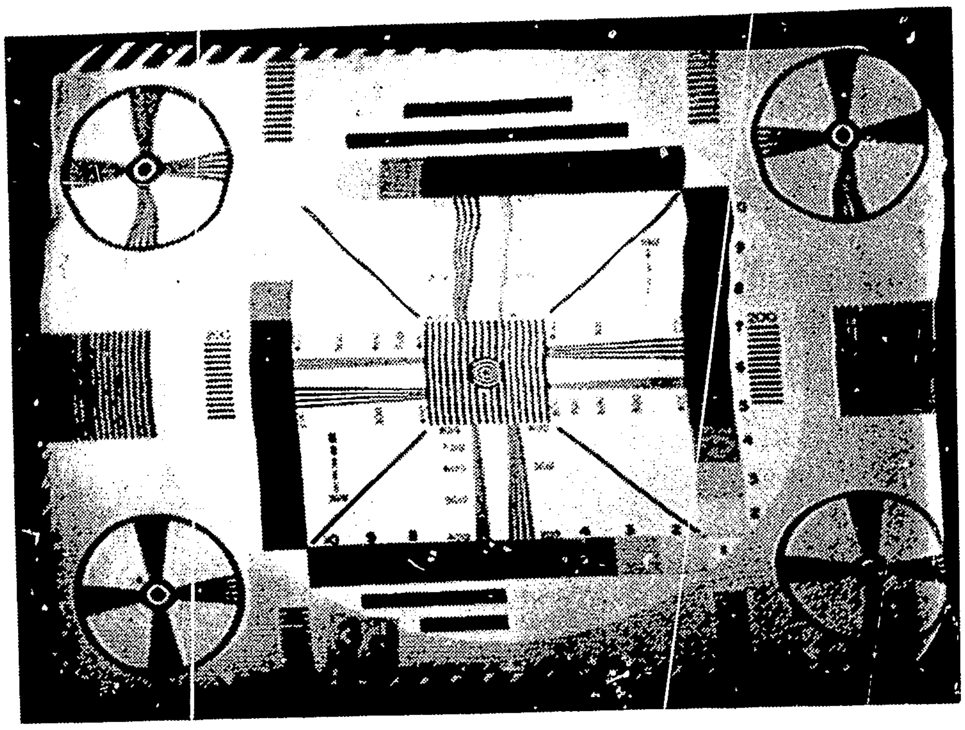

Fig. 22 - Third Generation Resolution

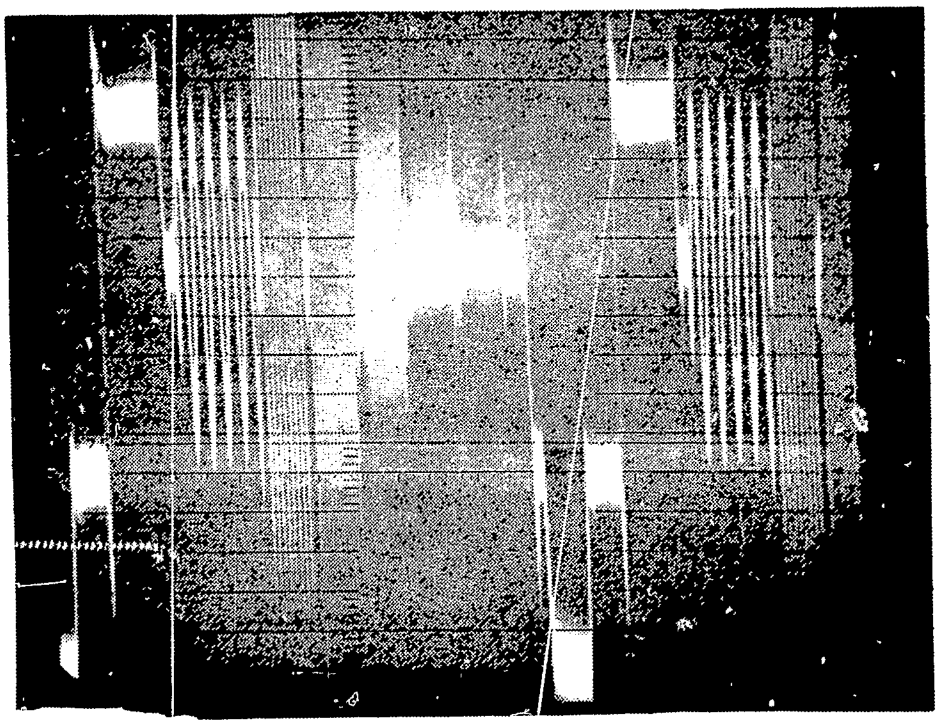

Fig. 23 - Third Generation Multiburst

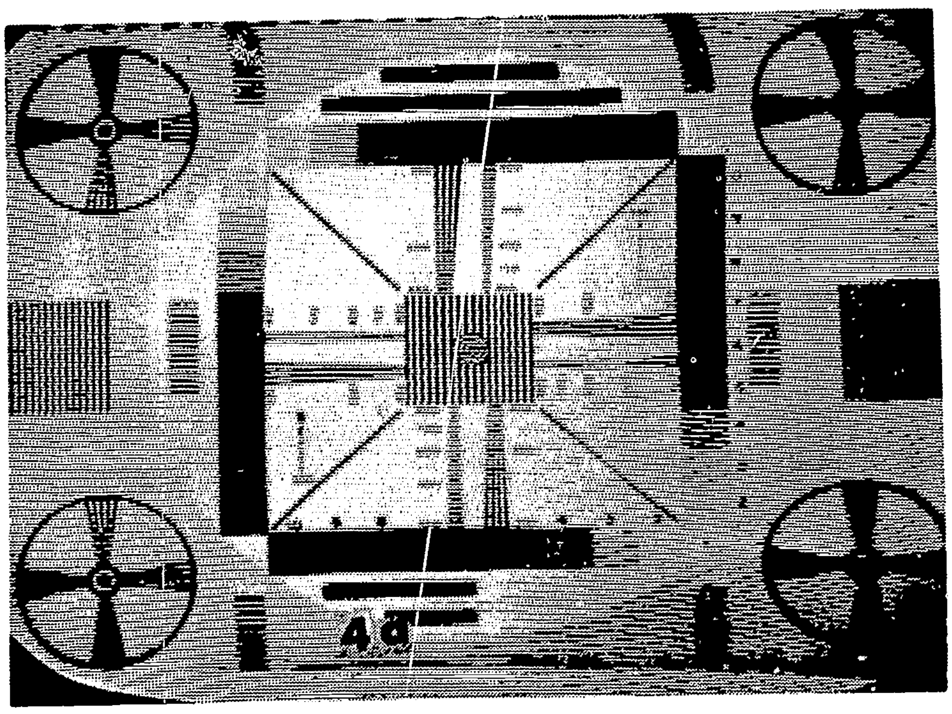

Fig. 24 - First Generation Resolution

Figures 22 and 23 are the respective third generation resolution and multiburst pictures. The additive effect of the vertical irregularities become evident as a general wavy line of the vertical components. Nevertheless, the horizontal resolution in the center section is very nearly 300 lines and the vertical resolution remains close to 500 lines, the theoretical maximum. The third pass through the peaking circuitry has increased the amplitude of the 1.5 MHz and 2.0 MHz bursts completely out of proportion but the amplitude of the 3.2 MHz burst is approximately normal. The spikes or overshoots on the sync pulses have increased to excessive proportions and in some receivers this may cause malfunctioning of the horizontal sync circuits. The video tape recorder is capable of satisfactory high frequency response but a frequency selective attenuation system would improve the over-all performance.

End of Sony PV-120-U series

Ampex VR-7500 Series (High Band)

Figure 24 is a playback of the resolution chart showing in excess of 350 lines center resolution and 300 on the corners. While the vertical lines show excessive hook, this is a function of the tension adjustment and on subsequent pictures the hook was entirely eliminated by the proper adjustment. This then is more an operator's error than a malfunctioning of the equipment.

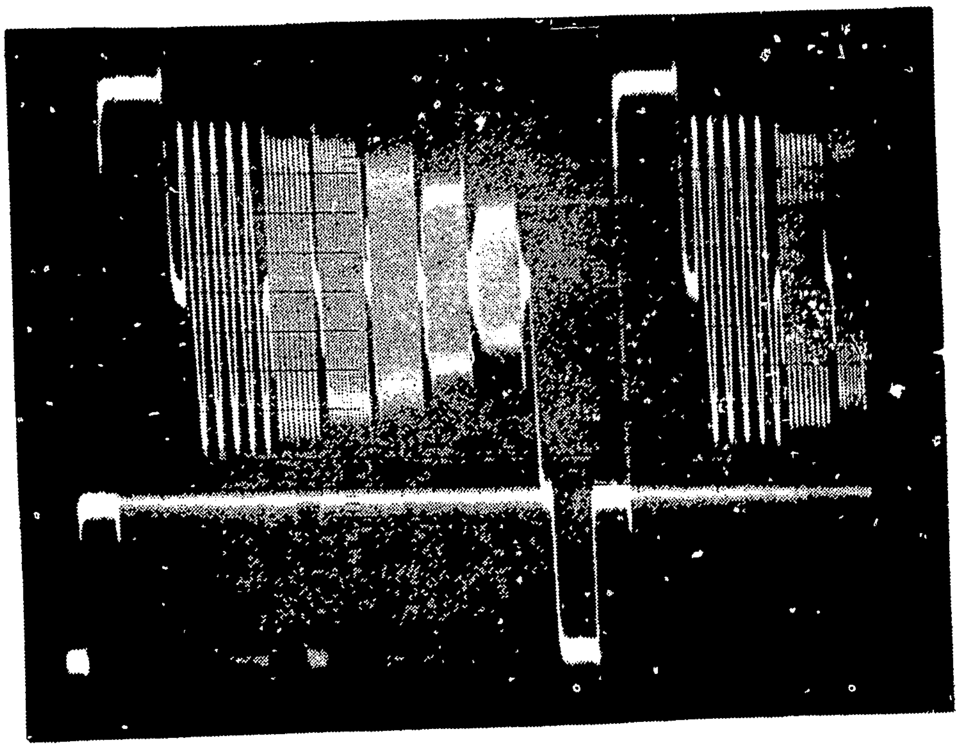

Fig. 25 - First Generation Multiburst

Figure 25, the multiburst playback, shows remarkable linearity in the first three bursts. The fifth burst frequency of 3.6 MHz is down not more than 4 db and the 4.2 MHz burst is down approximately 6 db. This machine was switched to high band.

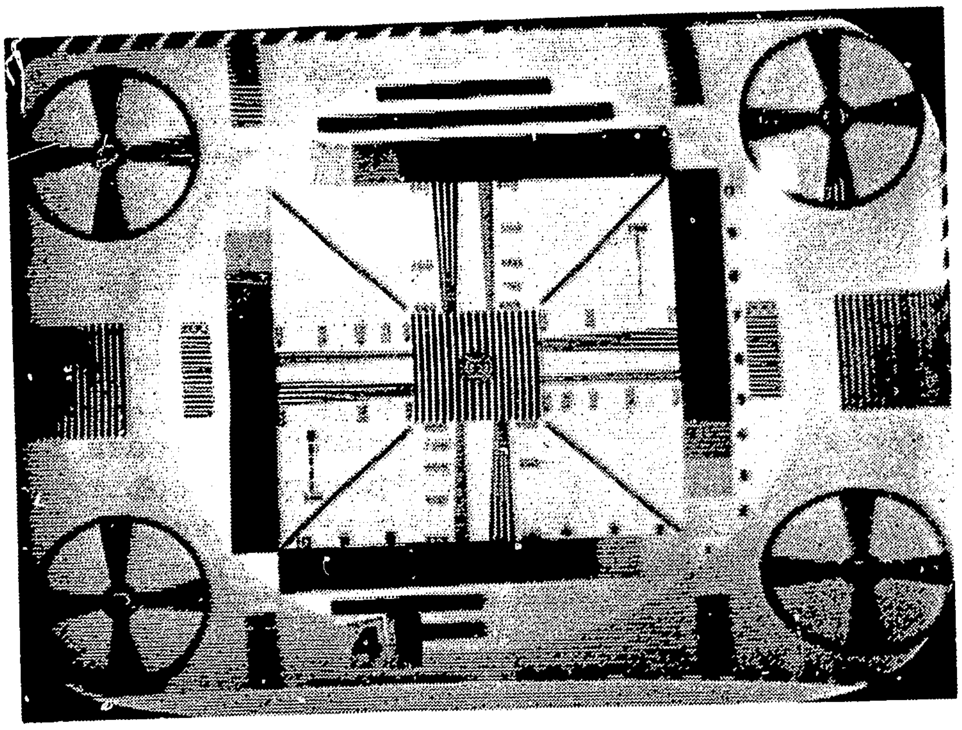

Fig. 26 - Tape Interchange

Figures 26 and 27 show the performance of the machine on tape interchange with the maximum resolution of approximately 350 lines in the center. As will be noted, the tension adjustment has virtually cleared up the linear picture hook. The multiburst on tape interchange is superior to that of the original machine indicating that there must be some high frequency adjustment in the machine. Very little sync pulse distortion occurs with the exception of slight ringing at the trailing edges. This should not degrade the picture quality.

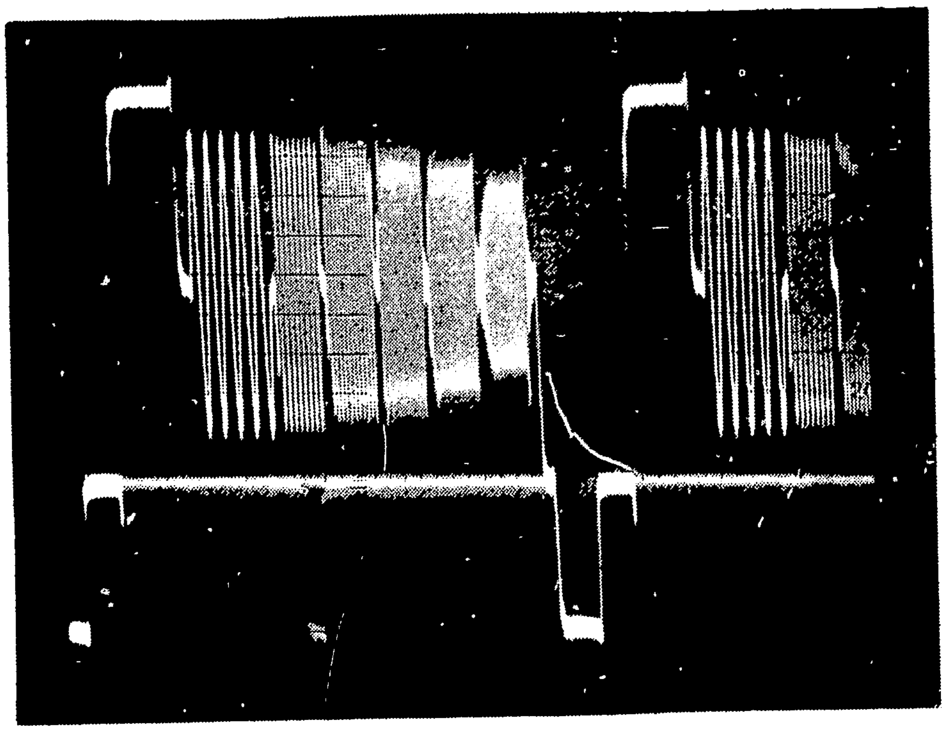

Fig. 27 - Tape Interchange

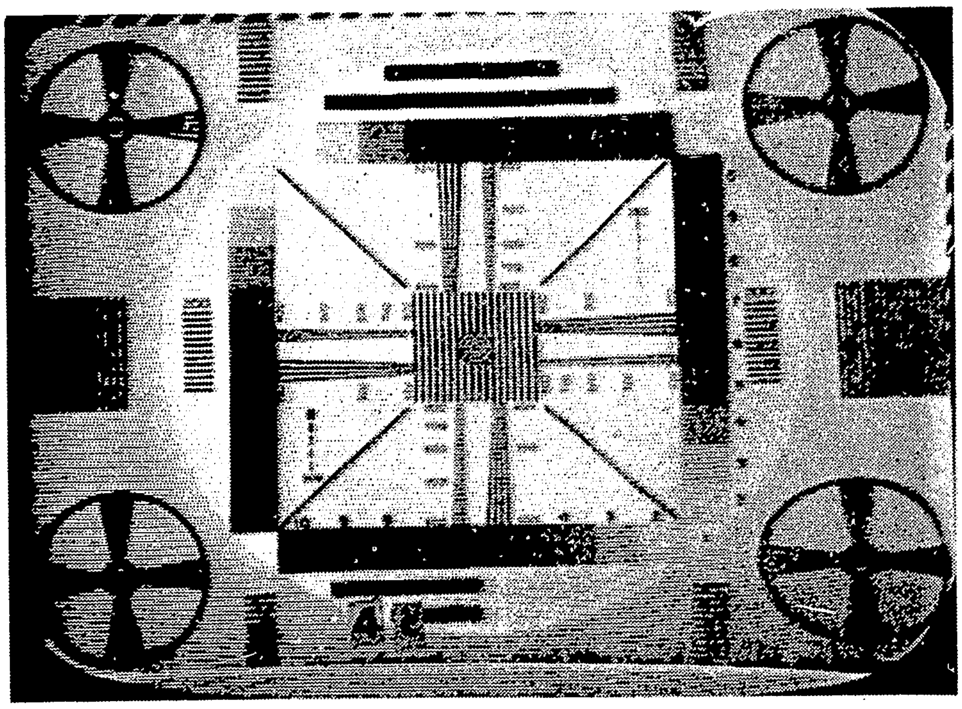

Fig. 28 - Second Generation Resolution

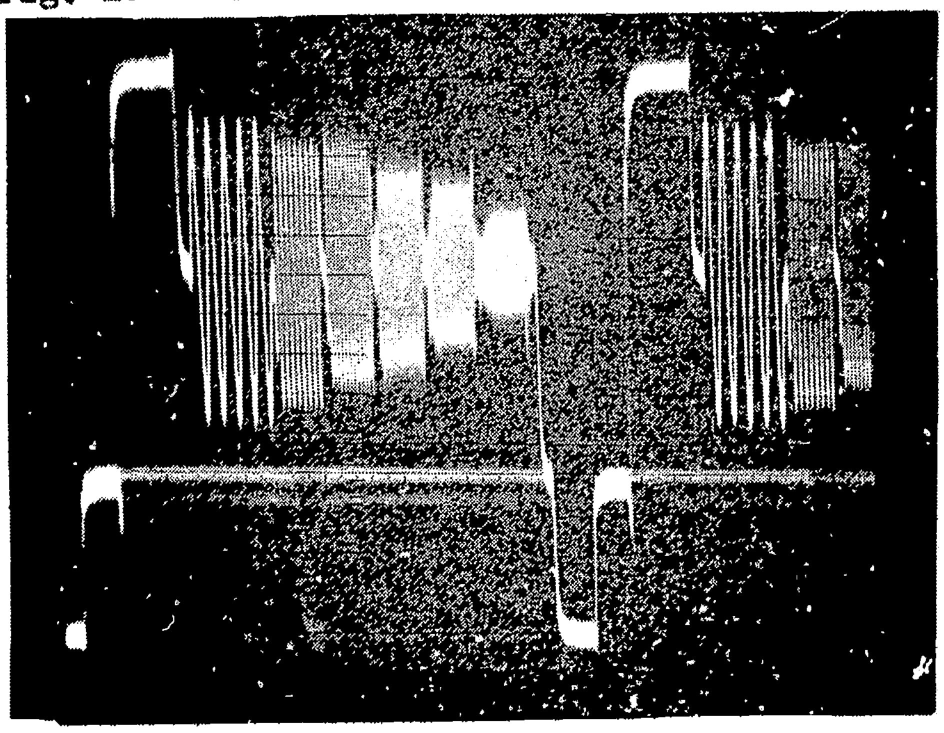

Fig. 29 - Second Generation Multiburst

Figures 28 and 29 are the second generation resolution and multiburst playback pictures. The vertical linearity is remarkably straight indicating that the machine can be adjusted to produce excellent pictures. The resolution is still in excess of 300 lines center resolution and about the same in the four corners. The multiburst amplitudes have decreased but little from the first generation tape and only a slight low frequency roll-off is evident. This low frequency roll-off does not affect the sharpness of the leading black edges of the resolution picture.

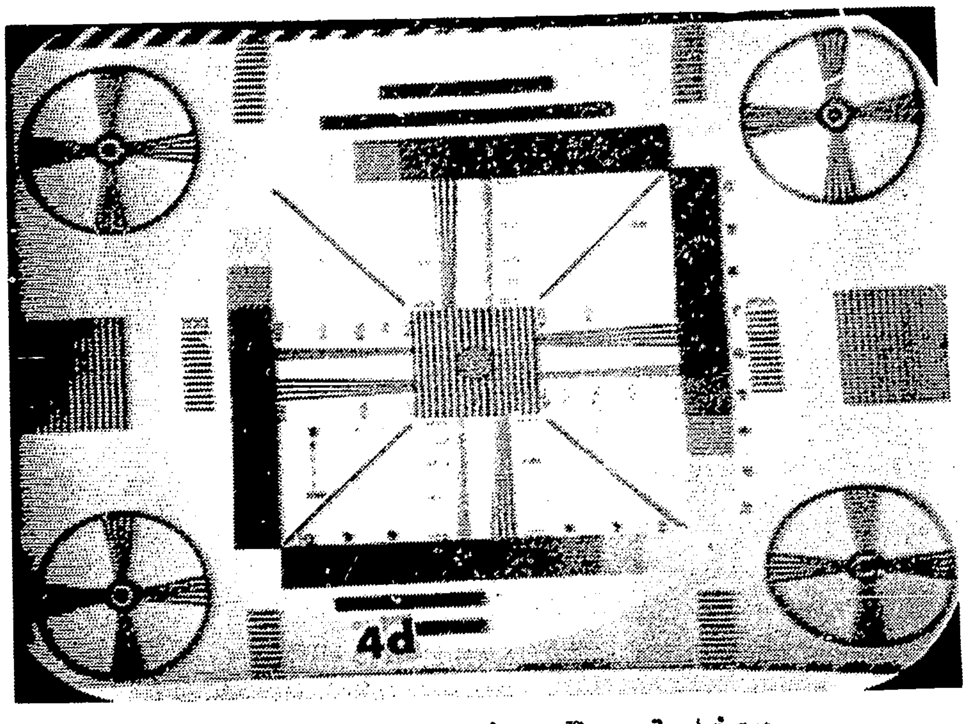

Fig. 30 - Third Generation Resolution

Figures 30 and 31 are the third generation resolution and multiburst respectively. The center resolution still remains at 300 lines and the numbers on the chart are still readable. The resolution chart picture speaks for itself.

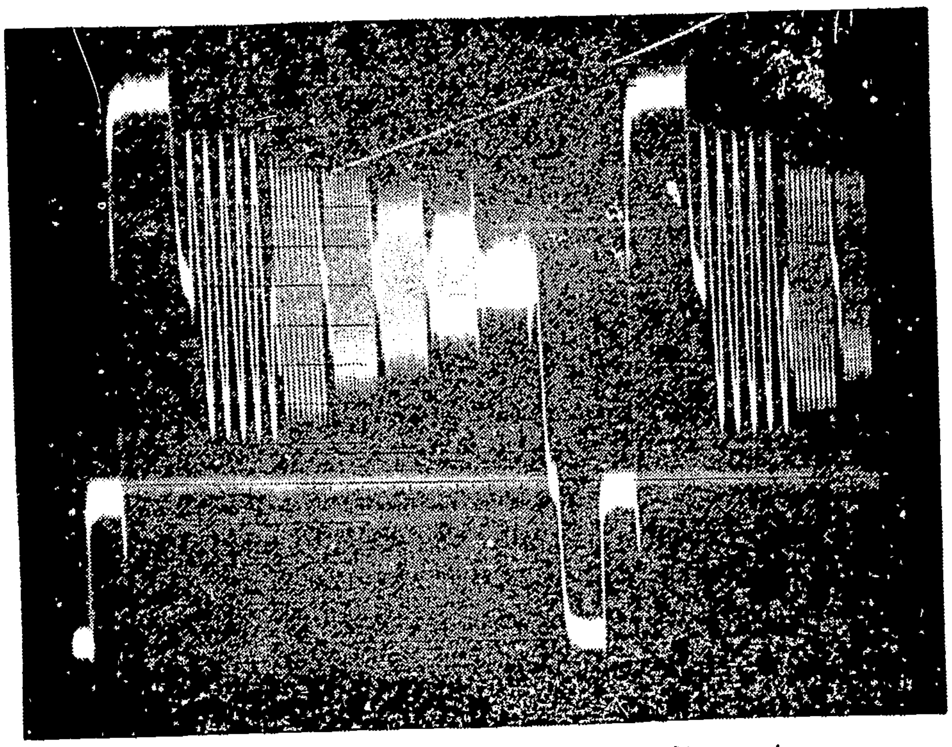

Fig. 31 - Third Generation Multiburst

The 4.2 MHz burst on the third generation is still above the noise level while the 3.2 MHz burst has dropped at least 3 db. The third generation results are highly satisfactory.

End of Ampex VR-7500 (High Band)

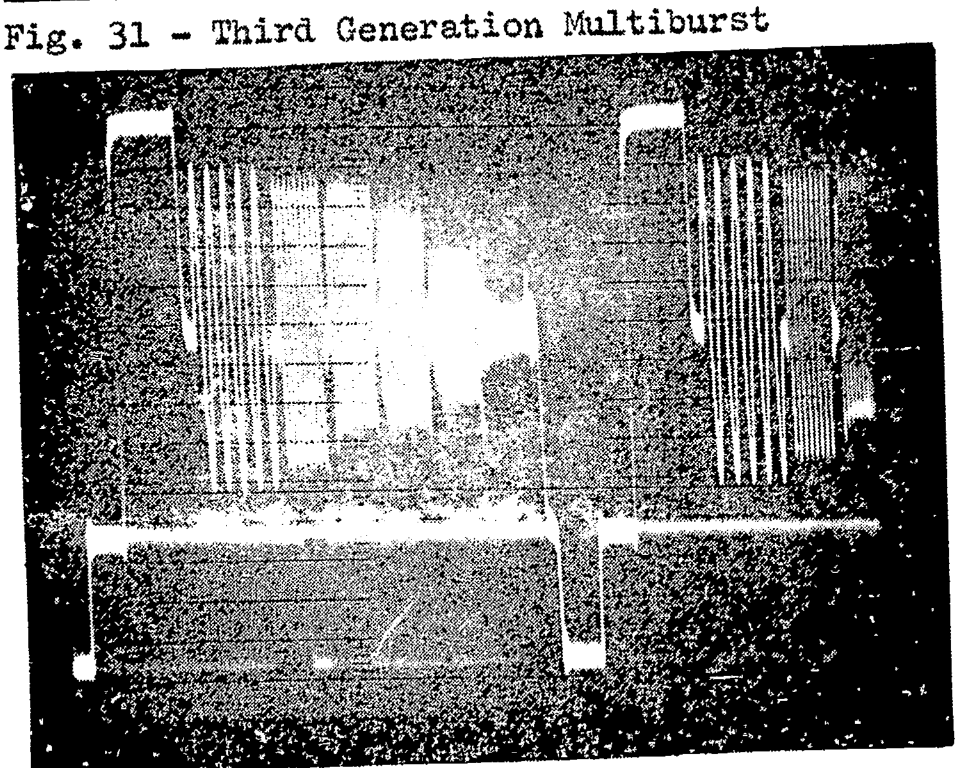

Fig. 32 - Low Band Multiburst

Figure 32 is a first generation multiburst picture of the Ampex VR-7500 on low band. The frequency response is not as good as on high band. The spike on the trailing edge of the sync pulse has disappeared and there is some improvement in the low frequency roll-off.

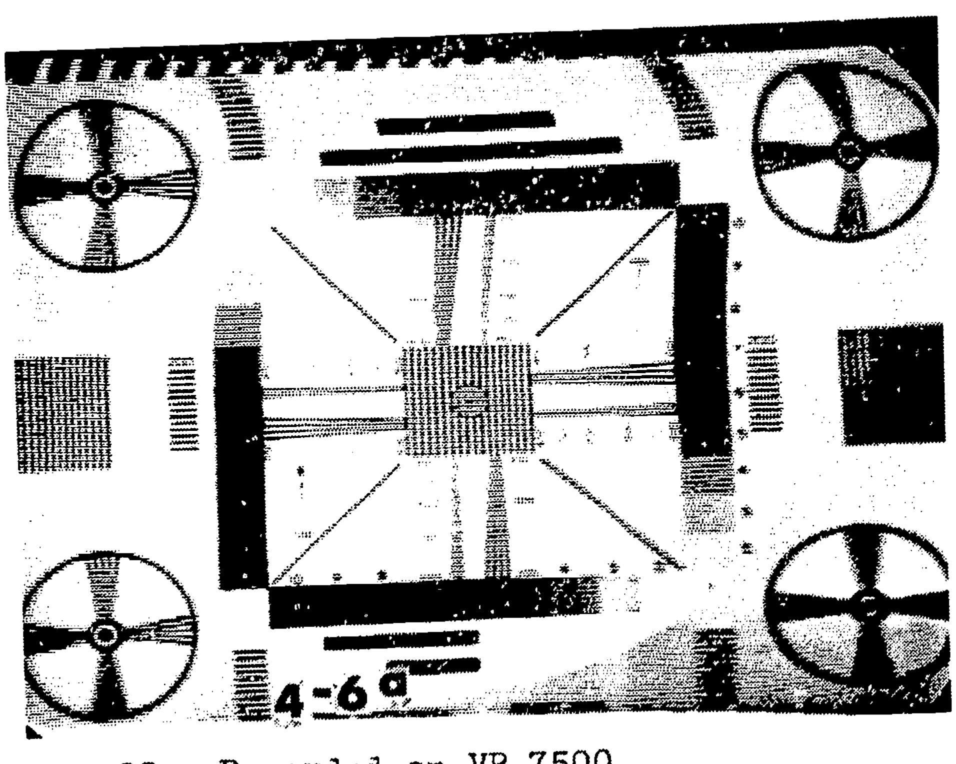

Fig. 33 - Recorded on VR-7500, Playback on VR-6000

Figure 33 is a first generation resolution chart recorded on an Ampex VR-7500 and played back on an Ampex VR-6000. It was impossible to adjust the Ampex VR-6000 to completely eliminate the picture hook and therefore some consideration should be given to the problem of proper tape tensions on record and/or range of tension adjustment on playback. There is some decrease in picture resolution but 250 lines are clearly identified in the center.

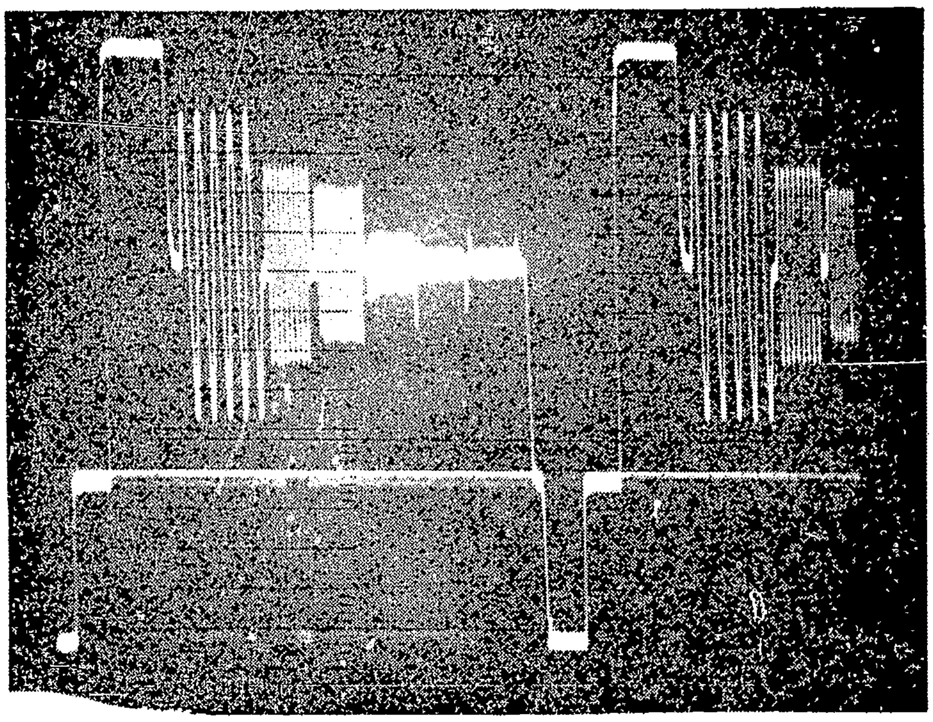

Fig. 34 - Recorded on VR-7500, Playback on VR-6000

Figure 34 is the multiburst recorded on an Ampex VR-7500 and played back on an Ampex VR-6000. By referring to Figure 44 the first generation multiburst playback of the Ampex VR-6000, it will be seen that the decreased bandwidth is entirely due to the playback portion of the Ampex VR-6000.

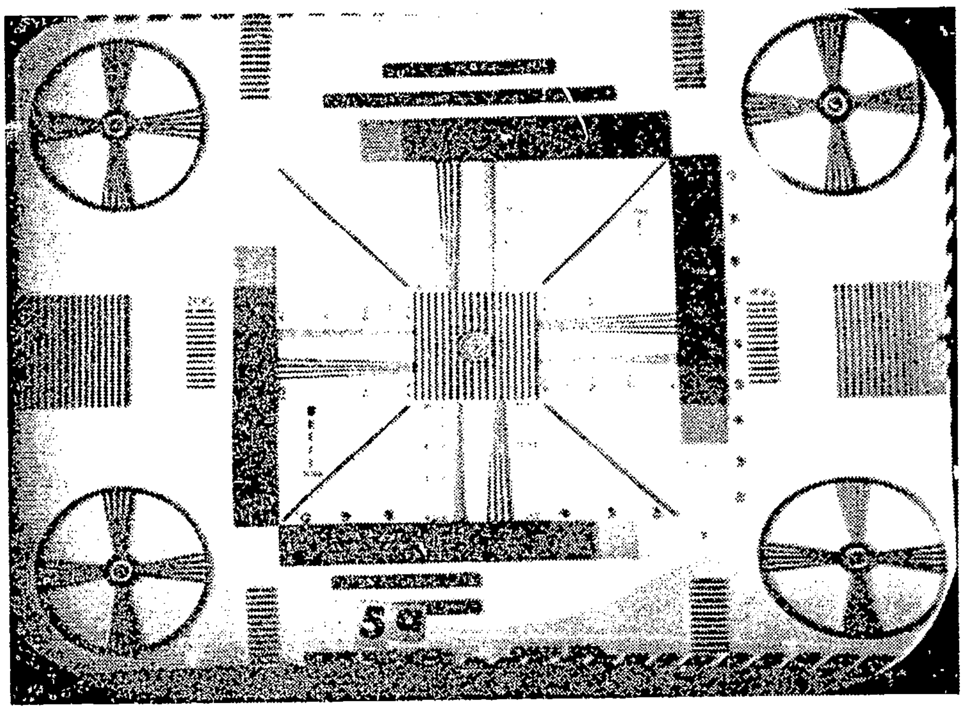

Fig. 35 - First Generation Resolution

Ampex VR-7000 Series

Figure 35 is the first generation resolution chart of the Ampex VR-7000. Picture linearity and adjustments are good and the machine has at least 300 lines resolution in the center with approximately the same resolution in the corners.

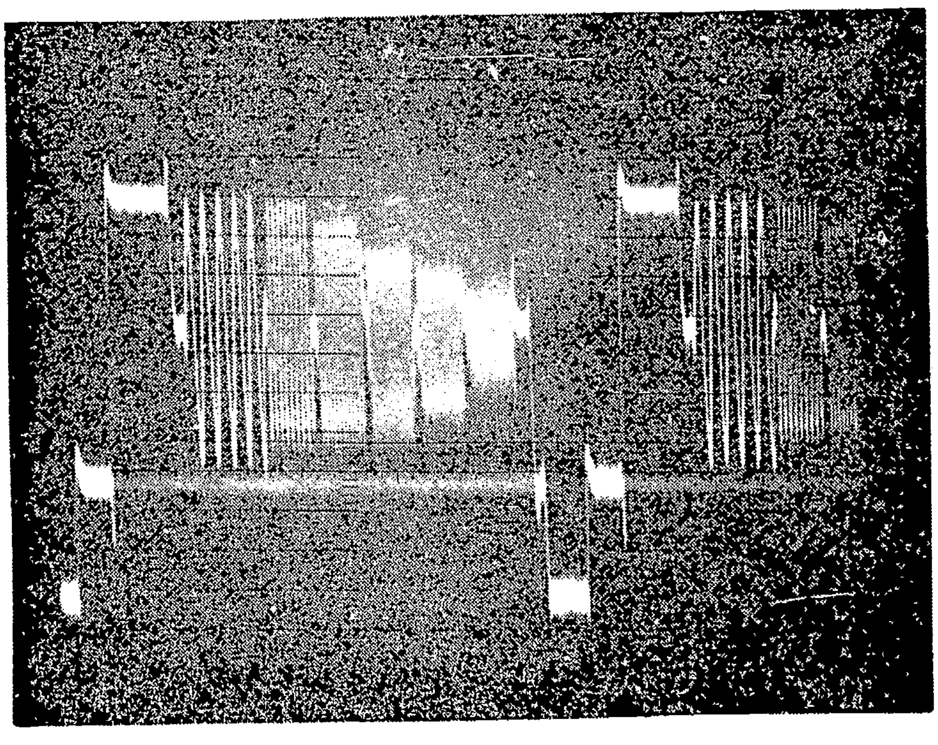

Fig. 36 - First Generation Multiburst

Figure 36 indicates some misadjustment in the machine as the multiburst amplitudes are not accurately reproduced. The white flag has dropped from the 100 level to 70 and yet the video level indicator was accurately adjusted to read 100. Except for this minor misadjustment, the multiburst amplitudes are very satisfactory with a remarkable signal in the 4.2 MHz burst.

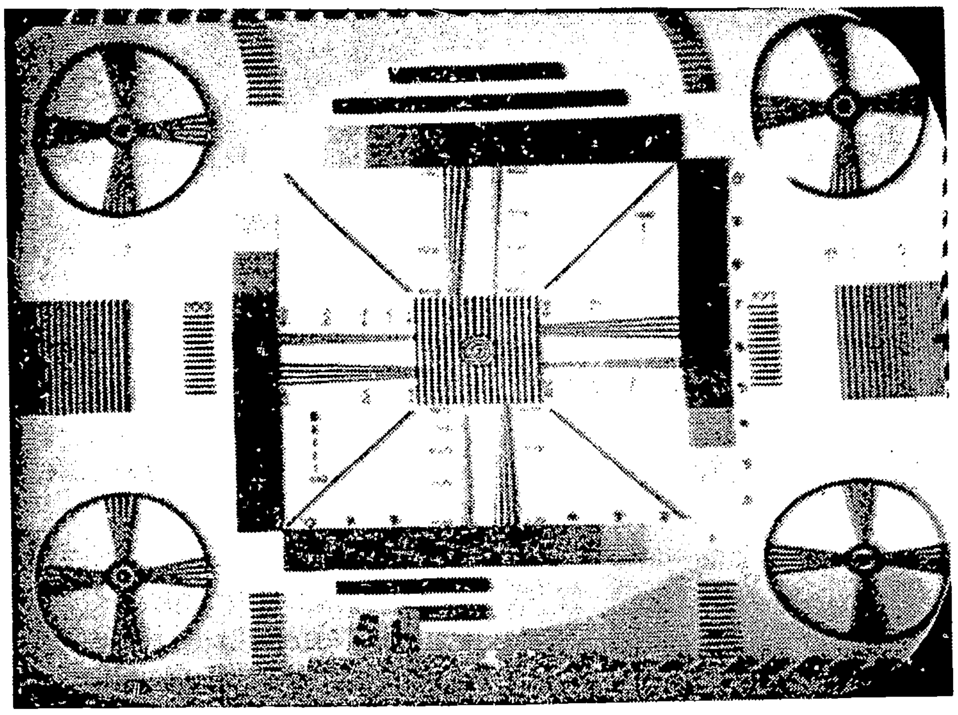

Fig. 37 - Tape Interchange

Figures 37 and 38 show the operating characteristics on tape interchange. The picture quality and the multiburst characteristics are essentially identical.

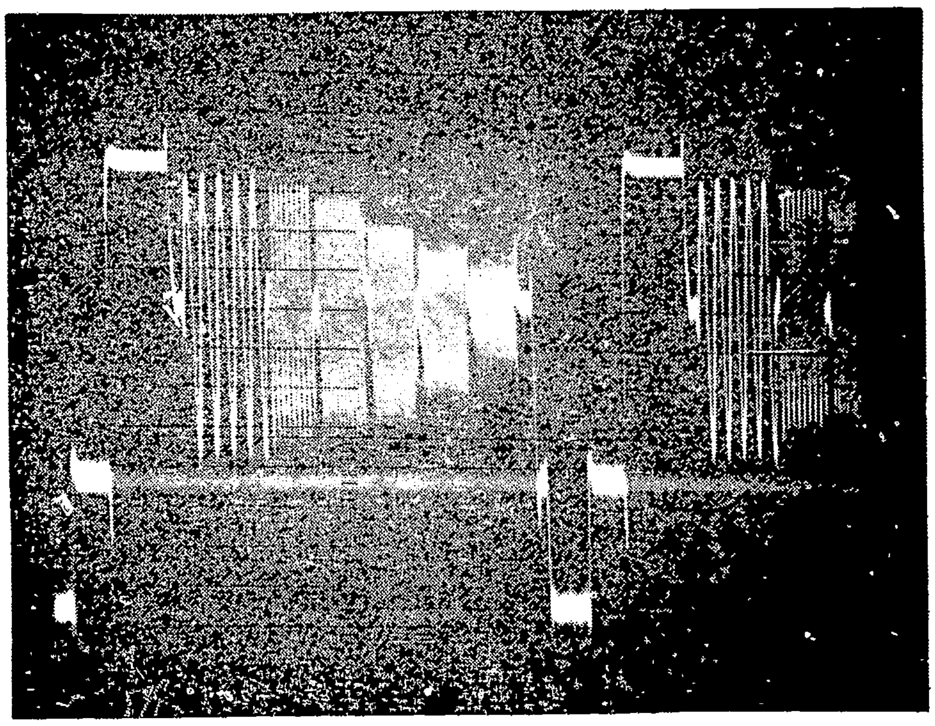

Fig. 38 - Tape Interchange

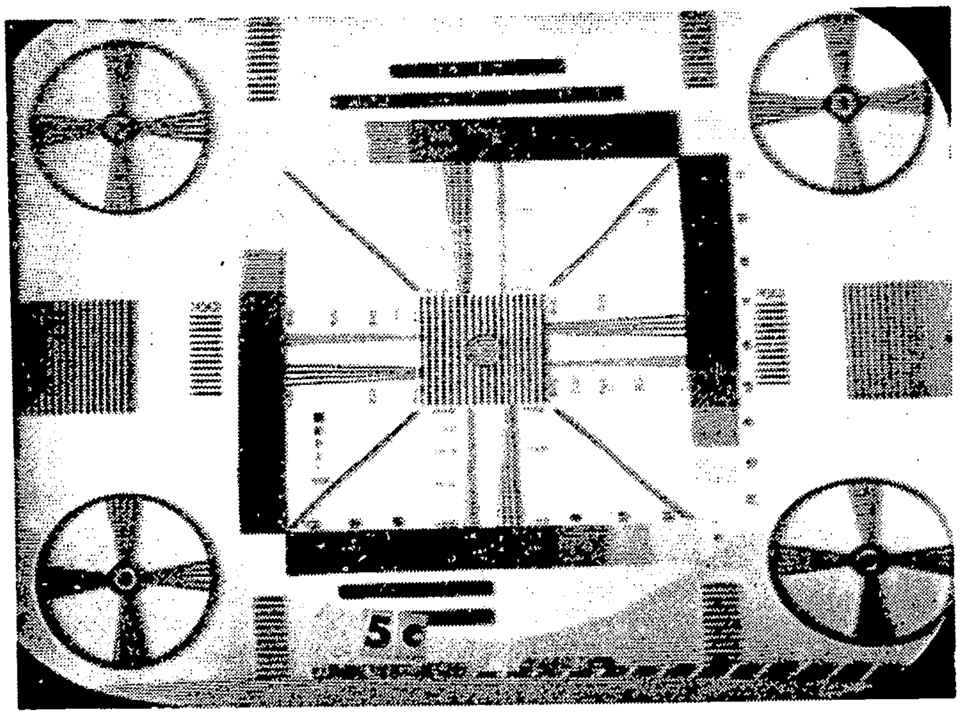

Fig. 39 - Second Generation Resolution

Figures 39 and 40 are the second generation pictures of the resolution chart and multiburst. The reproduced picture is quite satisfactory and the machine can be adjusted to eliminate most of the picture hook.

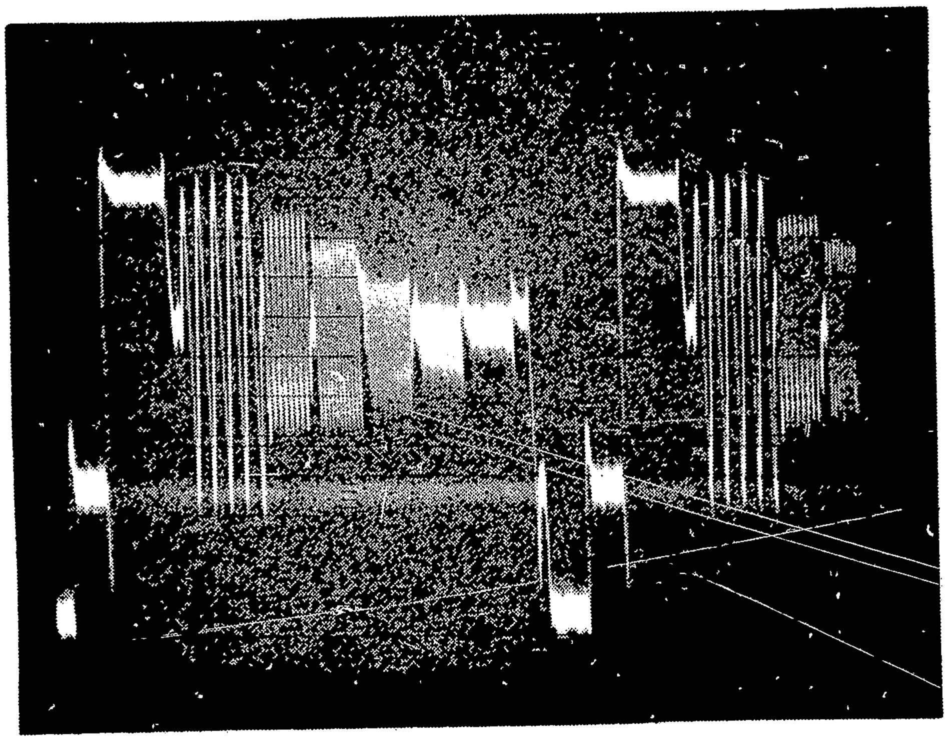

Fig. 40 - Second Generation Multiburst

The 3.6 MHz and 4.2 MHz bursts are badly distorted and the 2.0 MHz burst is down approximately 6 db below the 0.5 MHz frequency but only approximately 3 db below the original reference signal.

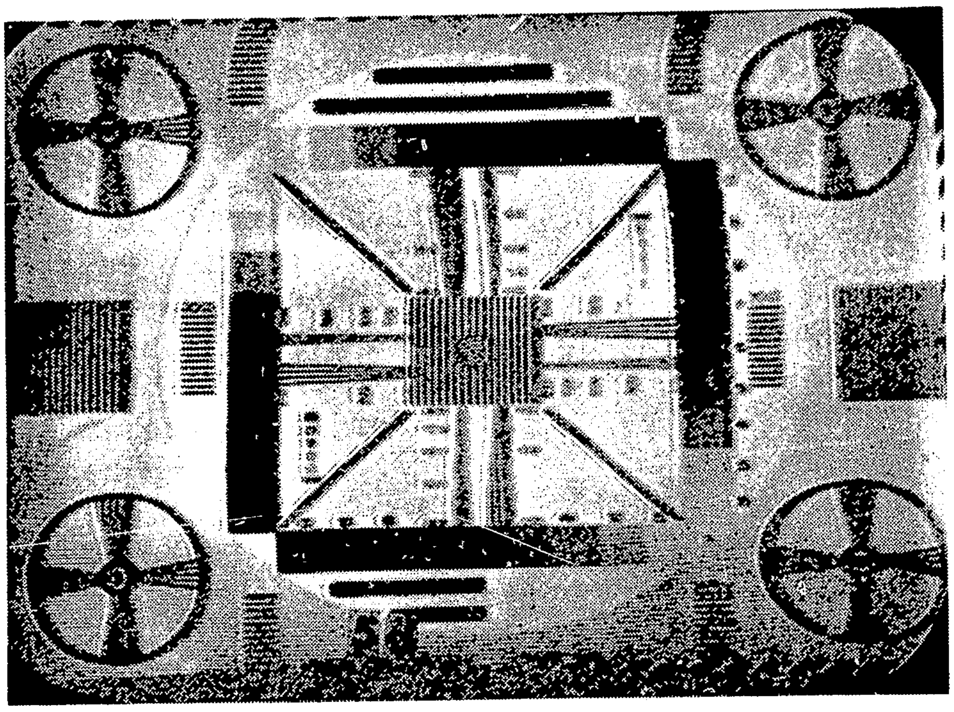

Fig. 41 - Third Generation Resolution

Figures 41 and 42 are the third generation resolution and multiburst pictures. The resolution chart shows some distortion and the additive effect of picture hook. The multiburst pattern shows excessive distortion in the 3.6 MHz and 4.2 MHz bursts with an exaggerated 0.5 MHz frequency as well as a general downward displacement of all of the bursts. This pattern clearly indicates some malfunctioning in the electronics or a misadjustment of the low frequency amplifiers in the equipment.

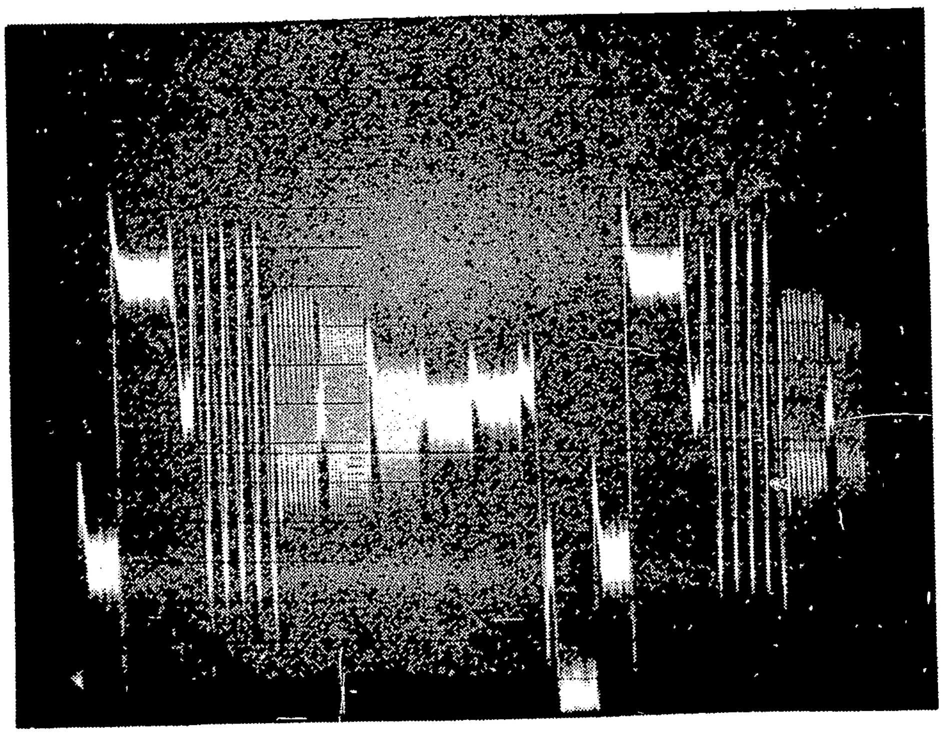

Fig. 42 - Third Generation Multiburst

End of Ampex VR-7000 series

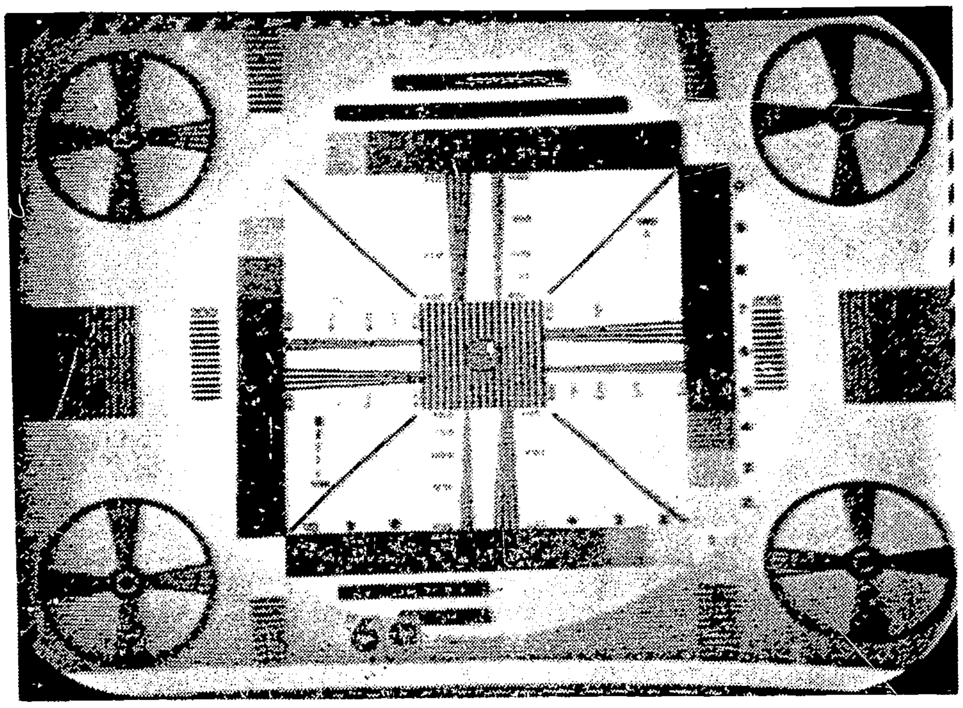

Fig. 43 - First Generation Resolution

Ampex VR-6000 Series

Figure 43 is a first generation resolution chart indicating excellent vertical linearity and approximately 250-line resolution in the center and corners of the pattern. The gray level is satisfactory.

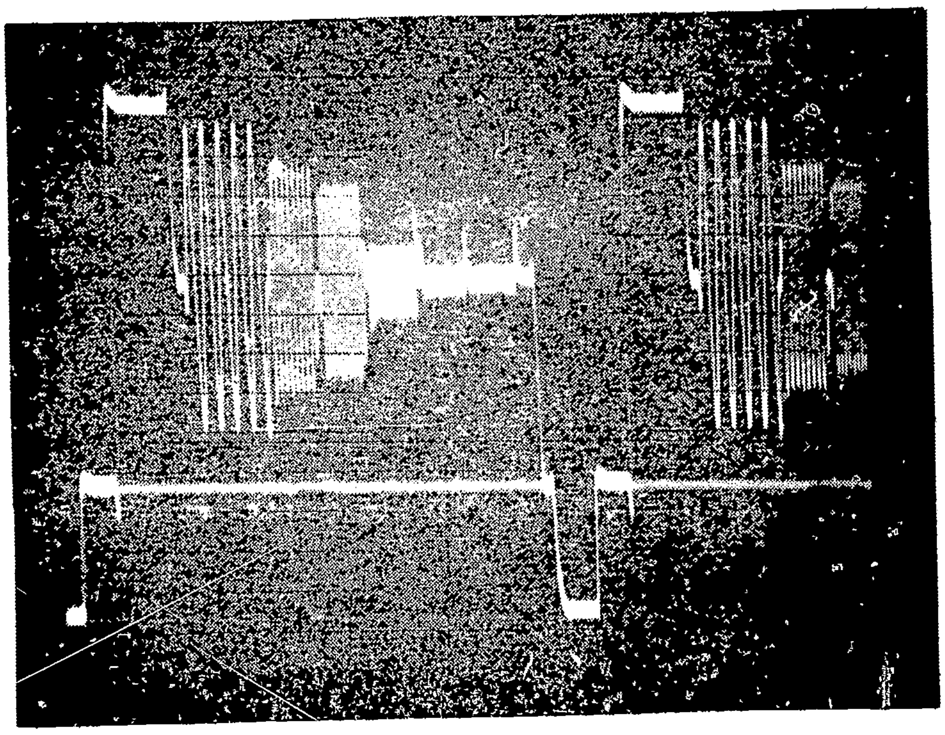

Fig. 44 - First Generation Multiburst

Figure 44 is the first generation multiburst and it shows almost perfect reproduction in the 0.5 MHz burst but 3 db down at the 1.5 MHz frequency and a signal that is almost masked by noise at 3.6 MHz and 4.2 MHz frequencies.

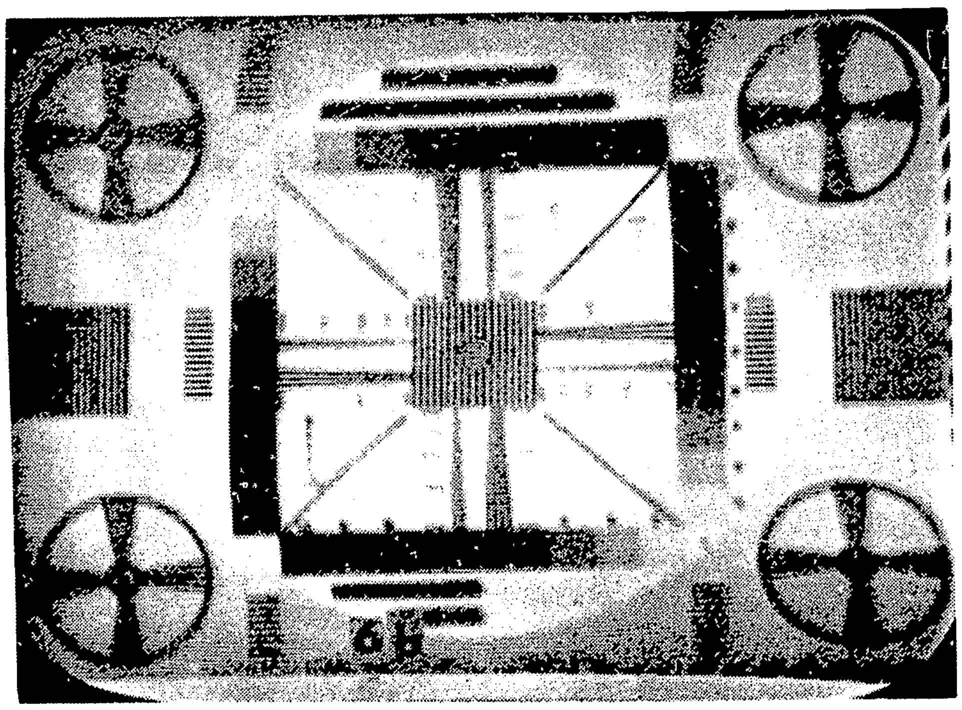

Fig. 45 - Tape Interchange

Figures 45 and 46 show the tape interchange capability of this model and, while the multiburst pattern is almost identical with that on the original machine, the resolution chart is less distinct in all areas. There are still 200 horizontal lines clearly visible in the center region.

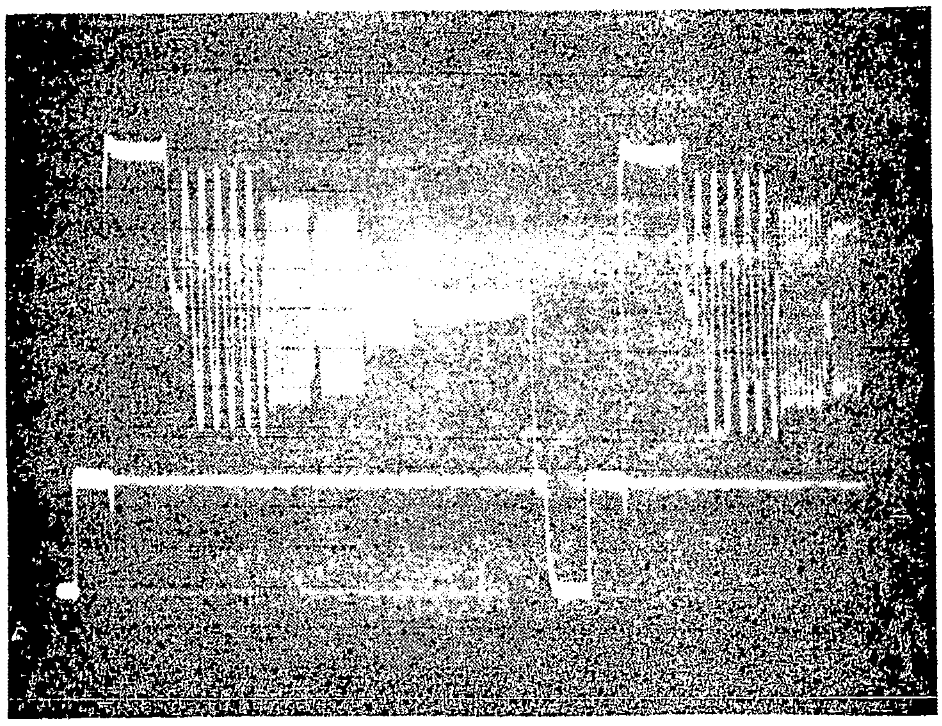

Fig. 46 - Tape Interchange

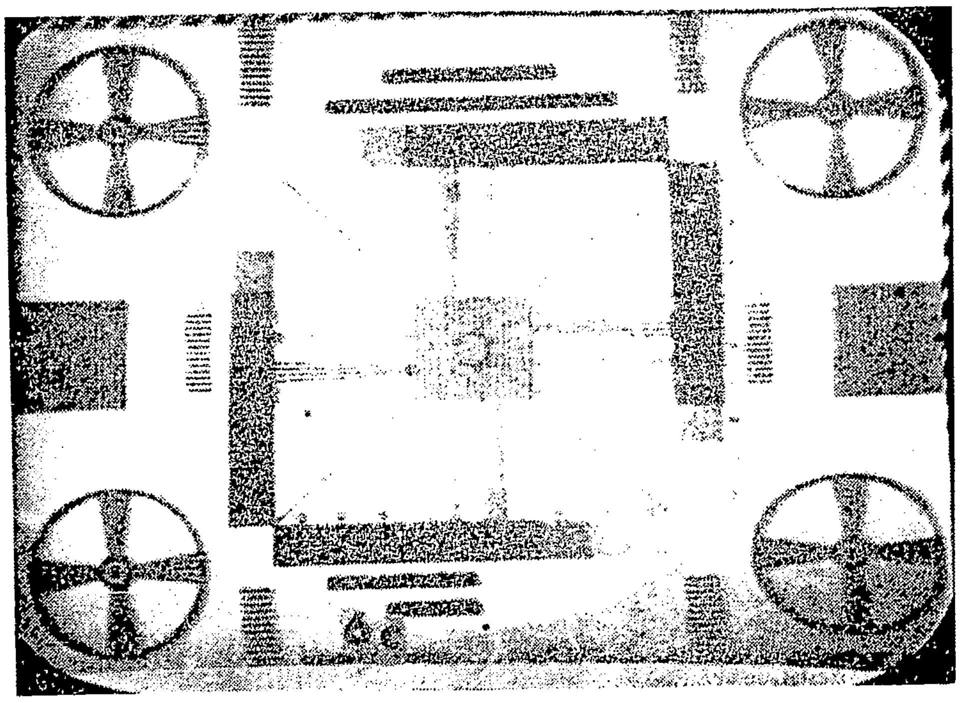

Fig. 47 - Second Generation Resolution

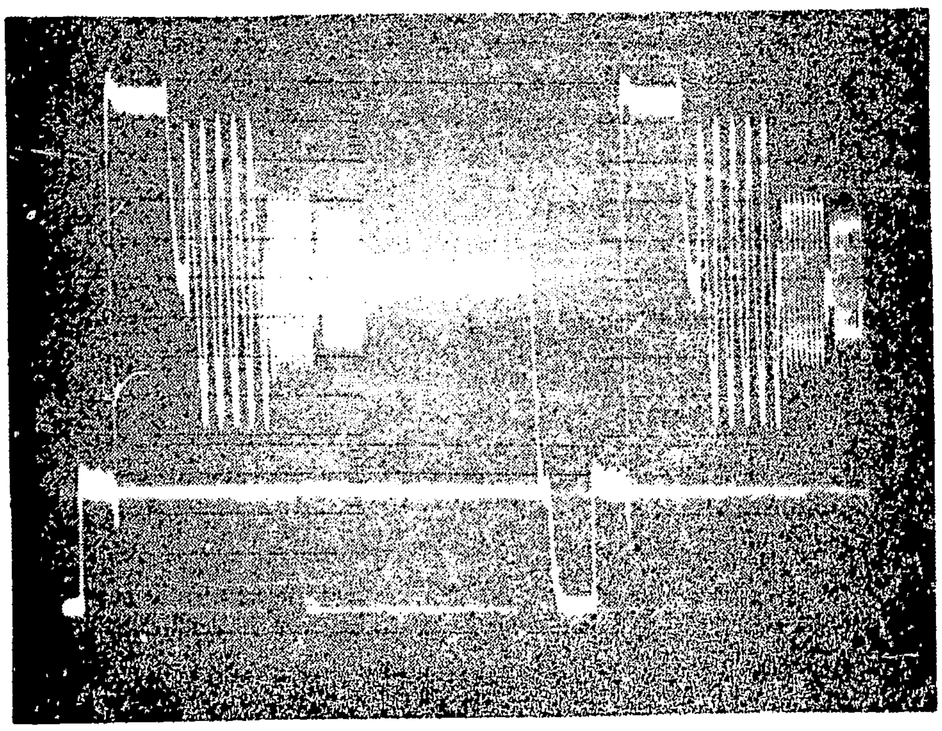

Fig. 48 - Second Generation Multiburst

Figures 47 and 48 are second generation resolution chart and multiburst pictures. The resolution chart still shows excellent linearity and 200 lines horizontal resolution in the center and corners. The multiburst picture shows the absence of the 3.2 MHz burst and the 1.5 MHz and 2.0 MHz bursts are down 6 and 8 db respectively. The sync pulses are still clear and distinct and show a remarkably low noise level or overshoot.

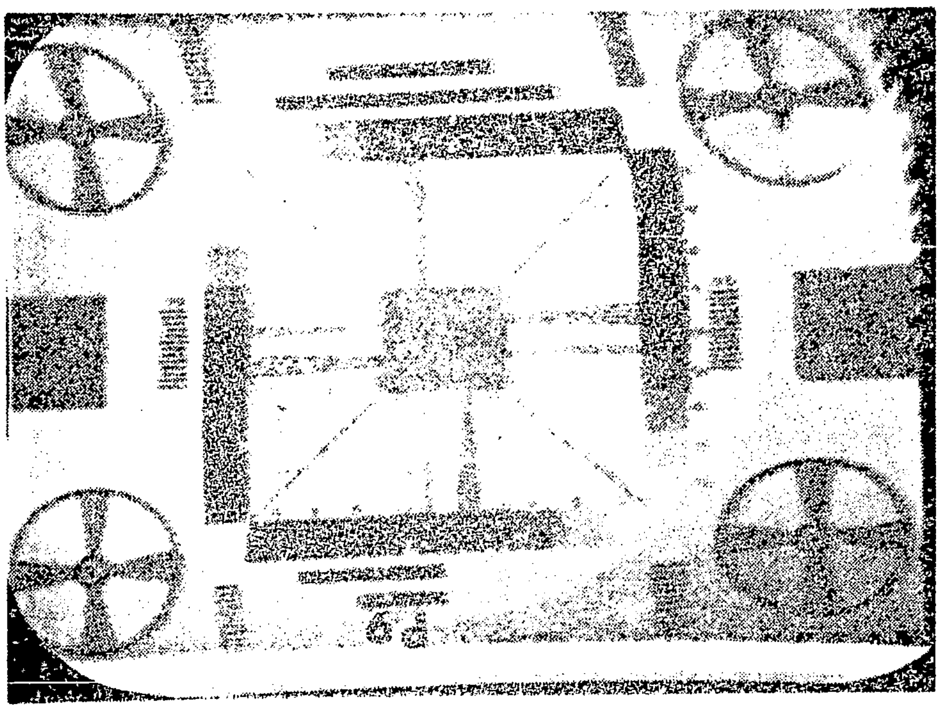

Fig. 49 - Third Generation Resolution

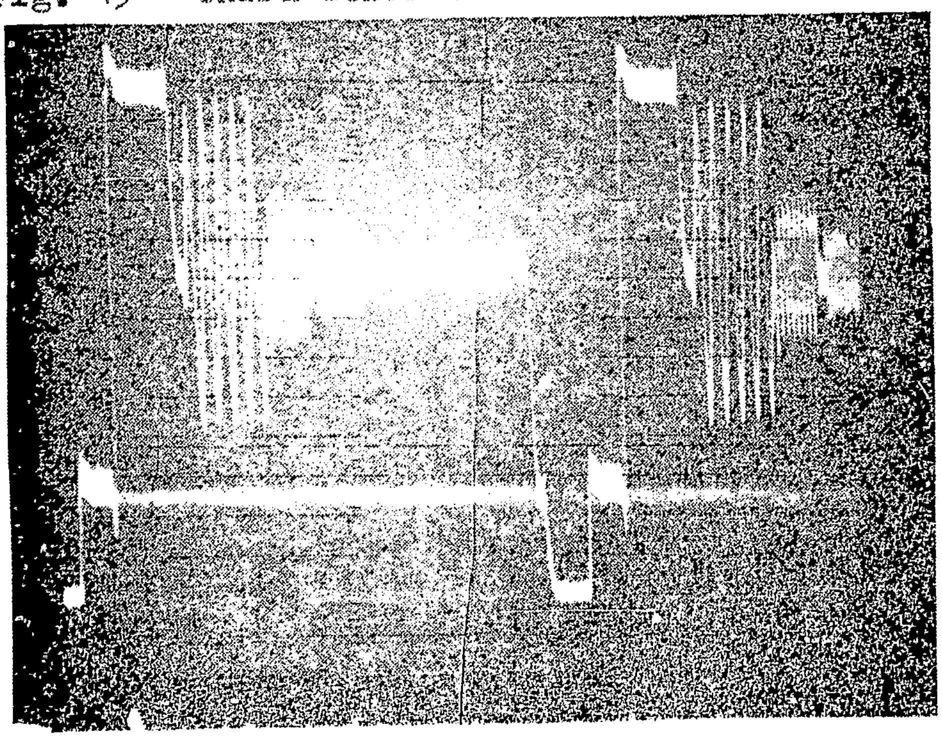

Fig. 50 - Third Generation Multiburst

Figures 49 and 50, the third generation resolution chart and multiburst, show a continuing deterioration of the picture quality and frequency response. The horizontal resolution is now less than 200 lines. The amplitude of the 0.5 MHz signal continues to remain normal and there is almost no displacement of the center line of the multiburst signal. The noise level and overshoot characteristics are entirely satisfactory. The third generation would, however, yield picture quality that lacks detail. Figure 49 shows the missing lines produced by lack of contact between the head and the tape due to the omega wrap feature as a white bar at the bottom of the picture.

End of Ampex VR-6000 series

Wollensak VTR-150 Series

Figure 51 is the first generation resolution chart of the Wollensak VTR-150. The resolution is less than 200 lines. The variation in black level may be attributed to uneven head-to-tape contact.

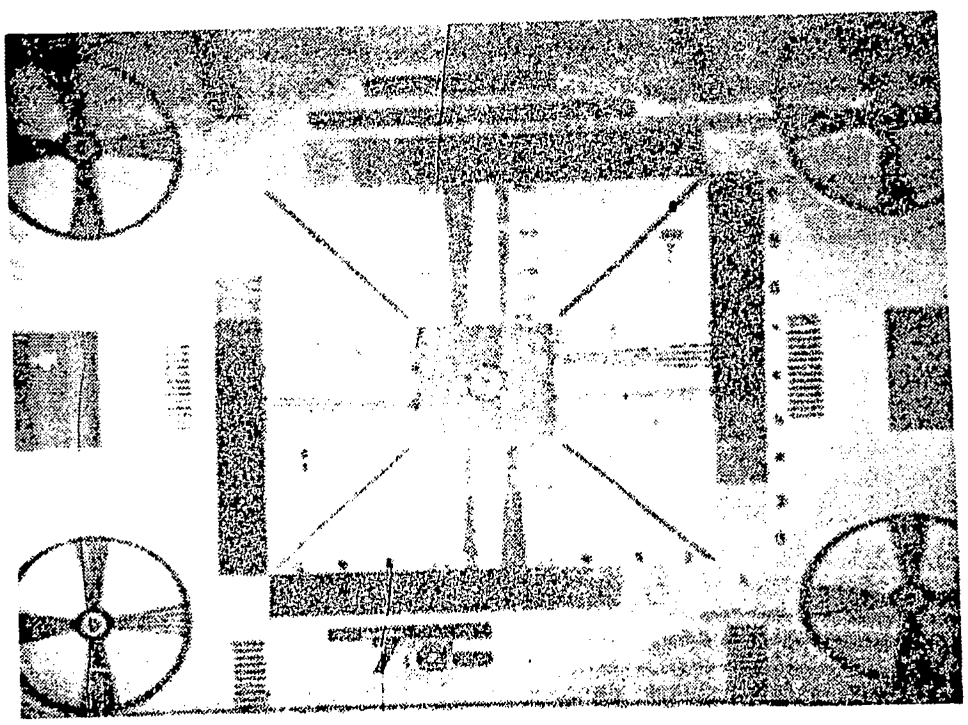

Fig. 51 - First Generation Resolution

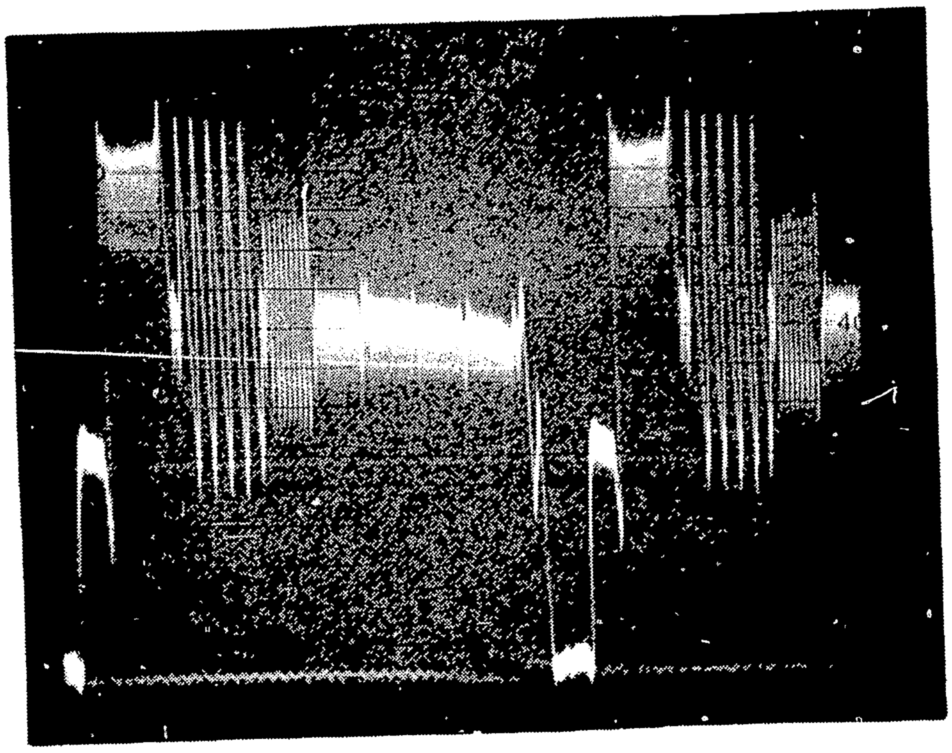

Fig. 52 - First Generation Multiburst

Figure 52, the first generation multiburst, shows a great deal of noise on the white flag with a displacement of the horizontal elements of the sync pulses. Additionally, the relationship between the base line, white flag, and black level are seriously distorted. The reproduction of the 0.5 MHz signal is accented while the 1.5 MHz burst is down by 6 db. The remainder of the burst frequencies are masked with noise.

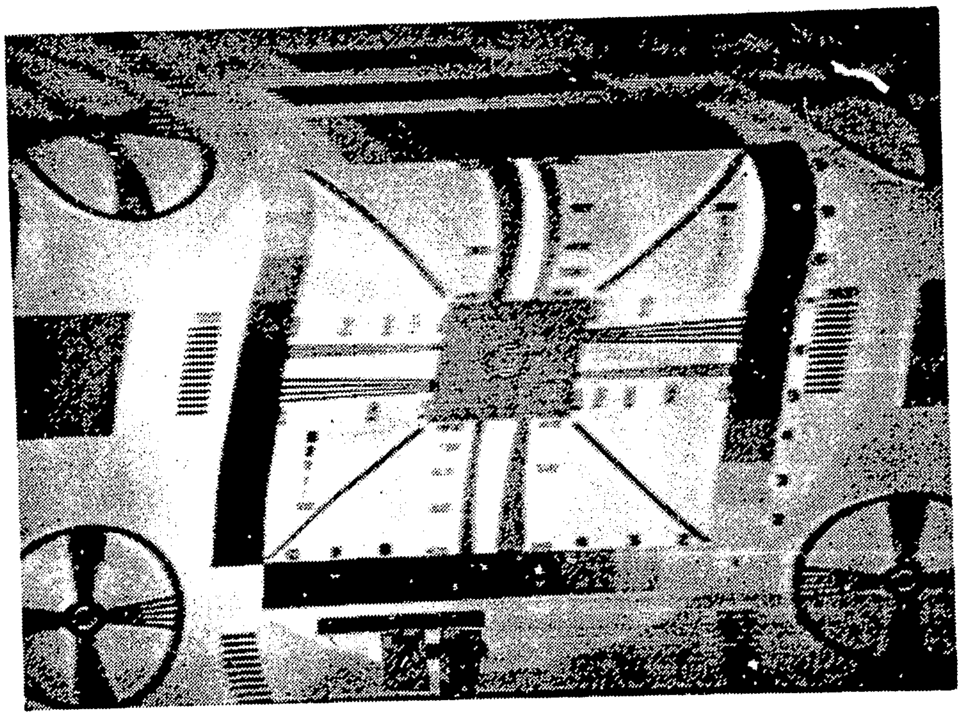

Fig. 53 - Tape Interchange

Figures 53 and 54 are an attempt to interchange the tape to a second machine. The Wollensak VTR-150 does not have a tension control and relies entirely on the friction produced by a felt pad rubbing against the tape as it passes through the first guide. The picture distortion could be decreased by varying the friction produced by the felt pad. The friction is evidently consistent enough to record and play back but it is likely that tapes held for a long period of time would not properly play back because of the change in friction with time by this kind of a device. The same high noise level on the white flag in Figure 52 also present in Figure 54 indicates that the noise is produced either on record or is inherent in both machines.

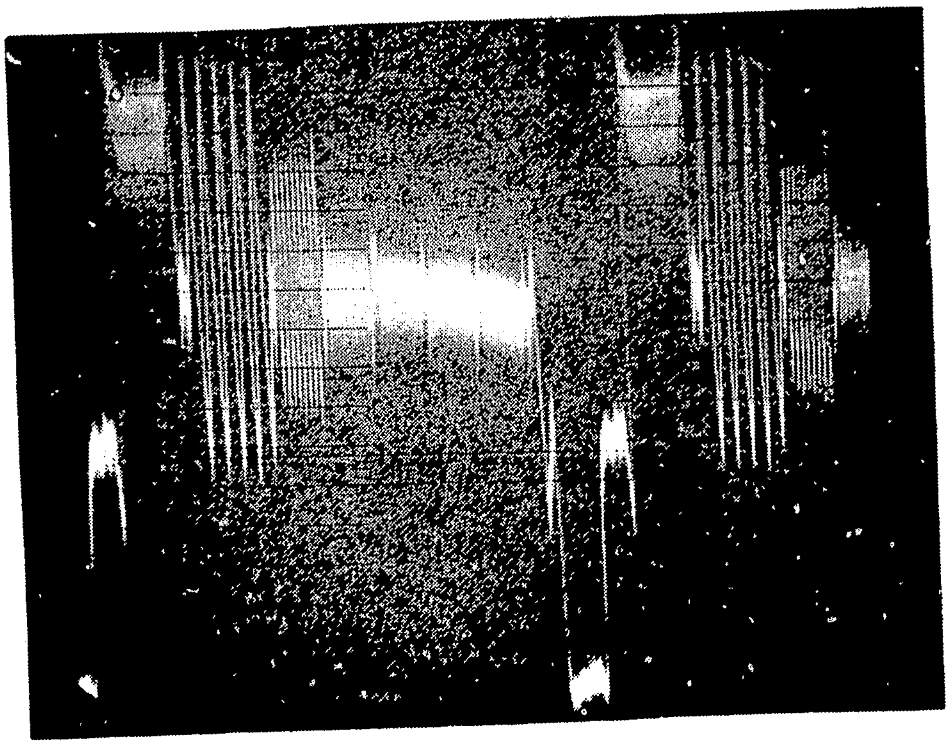

Fig. 54 - Tape Interchange

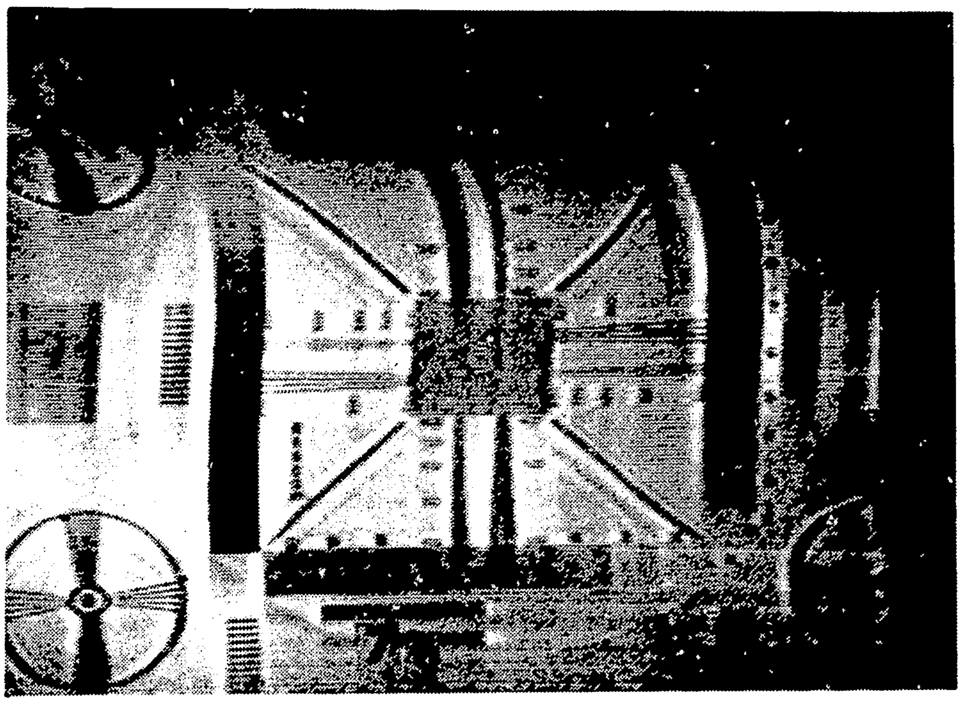

Fig. 55 - Second Generation Resolution

Figure 55 is the second generation of the resolution chart and it shows both distortion and missing lines at the top of the picture due to loss of head-to-tape contact. More lines are missing in this machine than in some of the other tape recorders and this effect increases with the third generation, Figure 57.

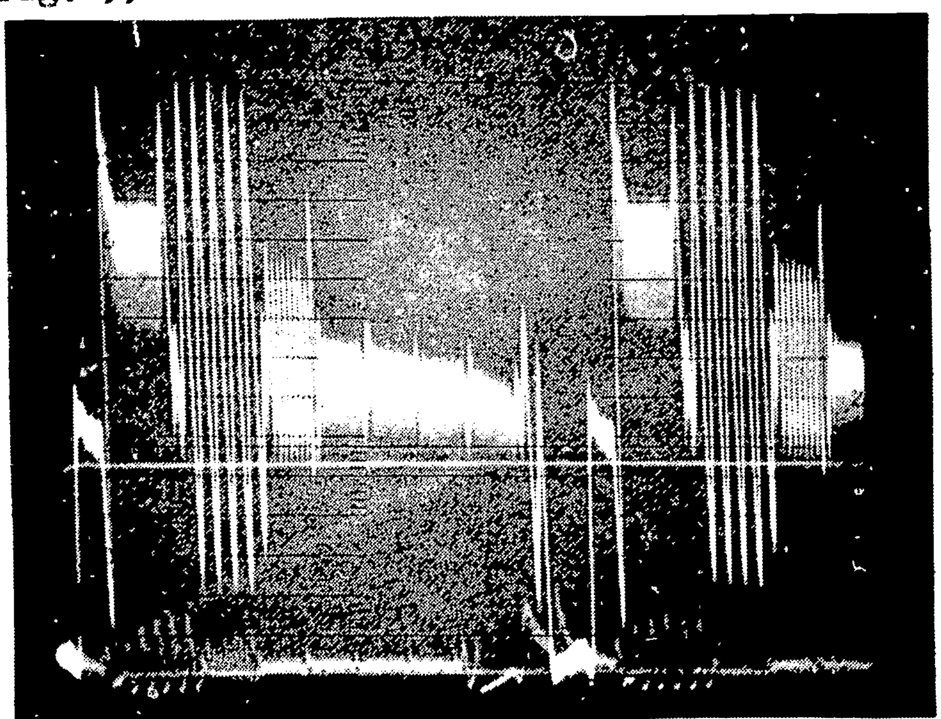

Fig. 56 - Second Generation Multiburst

Figure 56 shows that the peaking at 0.5 MHz is excessive as this level has increased by approximately 6 db. The noise level and phase distortion continues to worsen as can be seen by the white flag and the droop in the signal level of the noise blanked last four multibursts.

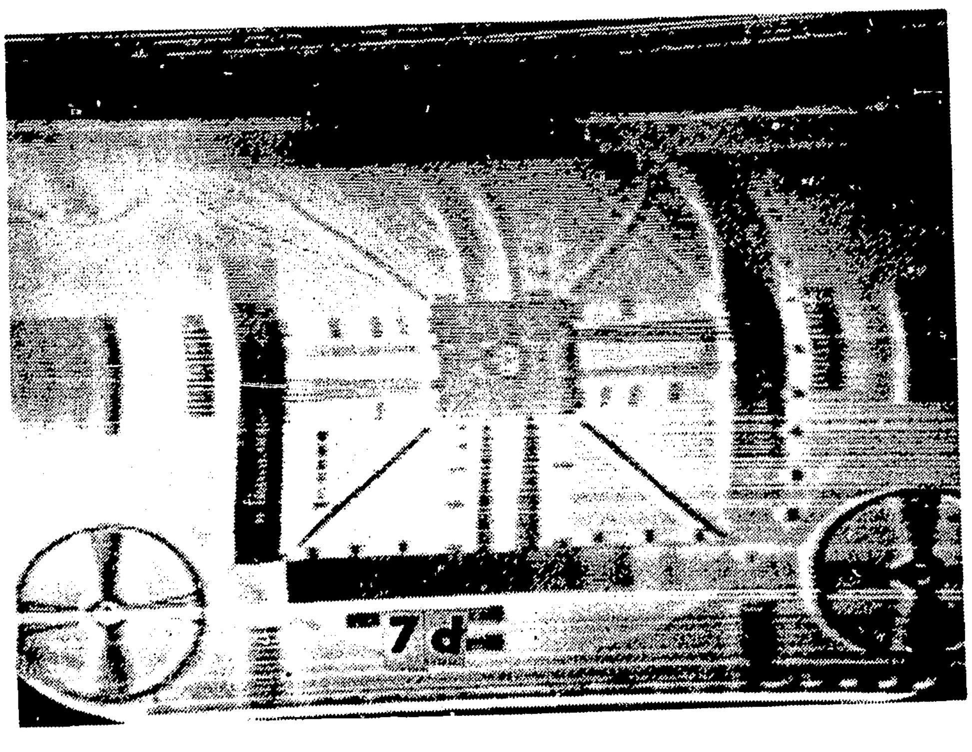

Fig. 57 - Third Generation Resolution

Figure 57 is the third generation and it can be seen that this picture is virtually unuseable. The loss of additional horizontal lines at the top of the picture has now obliterated half of the upper corner circles.

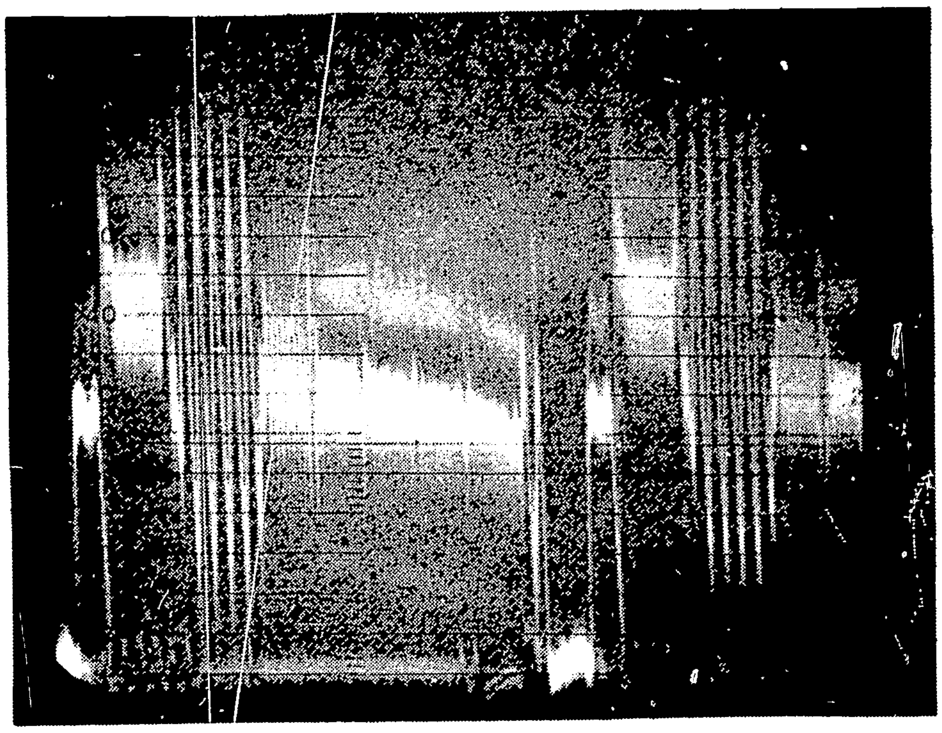

Fig. 58 - Third Generation Multiburst

Figure 58 shows a deterioration of the sync pulses and extraneous noise that produces the poor picture quality.

End of Wollensak VTR-150 series

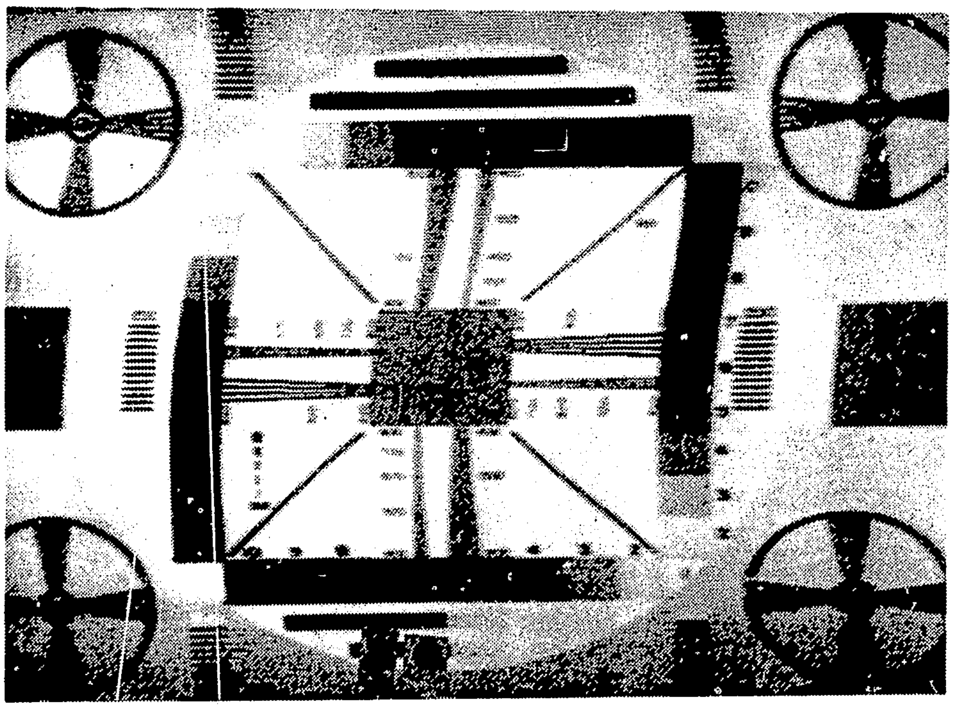

Fig. 59 - First Generation Resolution

Concord VTR-600 Series

Figure 59, the first generation resolution chart for the Concord VTR-600, is quite satisfactory for a half-inch machine. The horizontal resolution is less than 200 lines as can be seen by the absence of vertical lines in the center scale and the right and left edge resolution lines. The upper half of the resolution chart shows both a right and left curve that could not be corrected by the tension control.

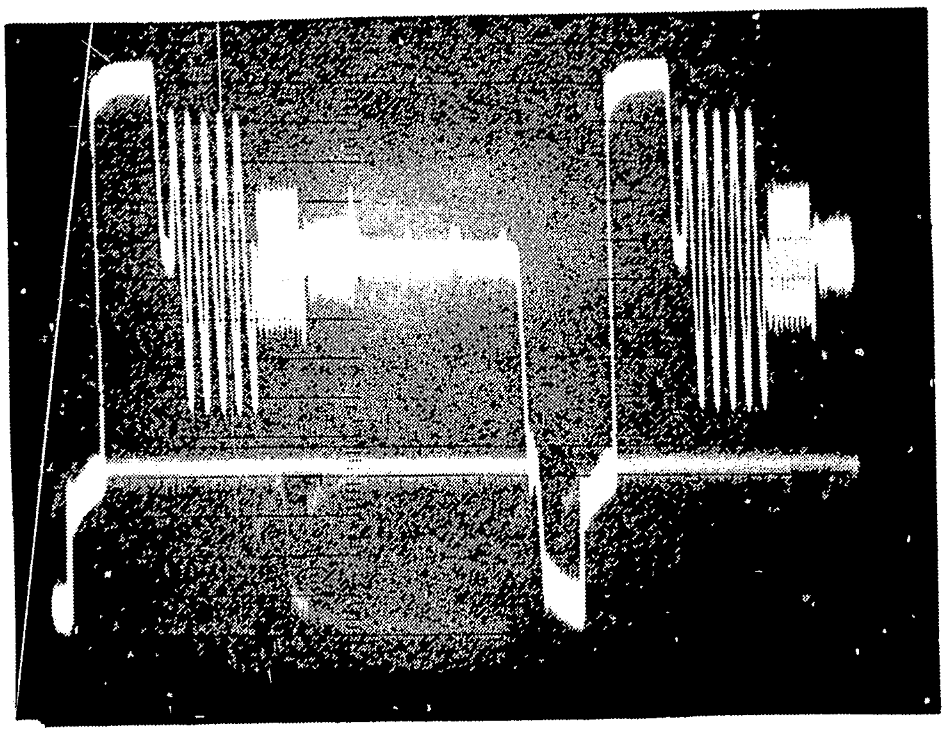

Fig. 60 - First Generation Multiburst

The first generation sync pulses show no signal beyond 2.0 MHz and the signal at this point is down by approximately 12 db. The signal at 1.5 MHz is down approximately 6 db and there is phase distortion on the white flag and sync pulses.

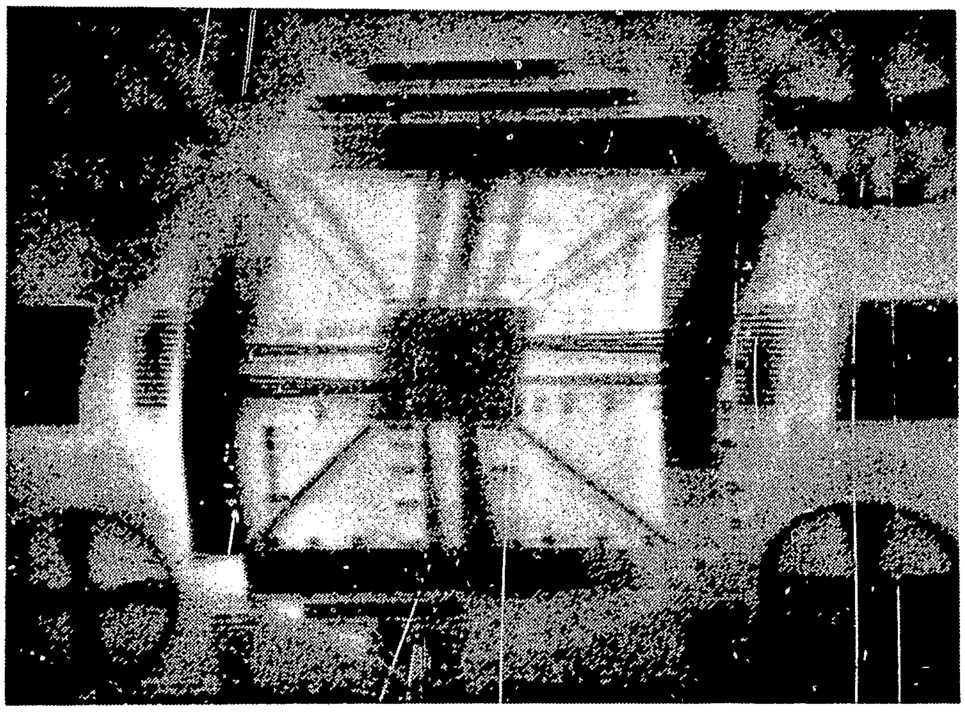

Fig. 61 - Tape Interchange

Figure 61 shows the resolution chart on a tape interchange playback. The apparent double exposure on the portion of this picture is produced by the two heads and the fact that either the adjustment is not perfect or the tension varies for each of the heads.

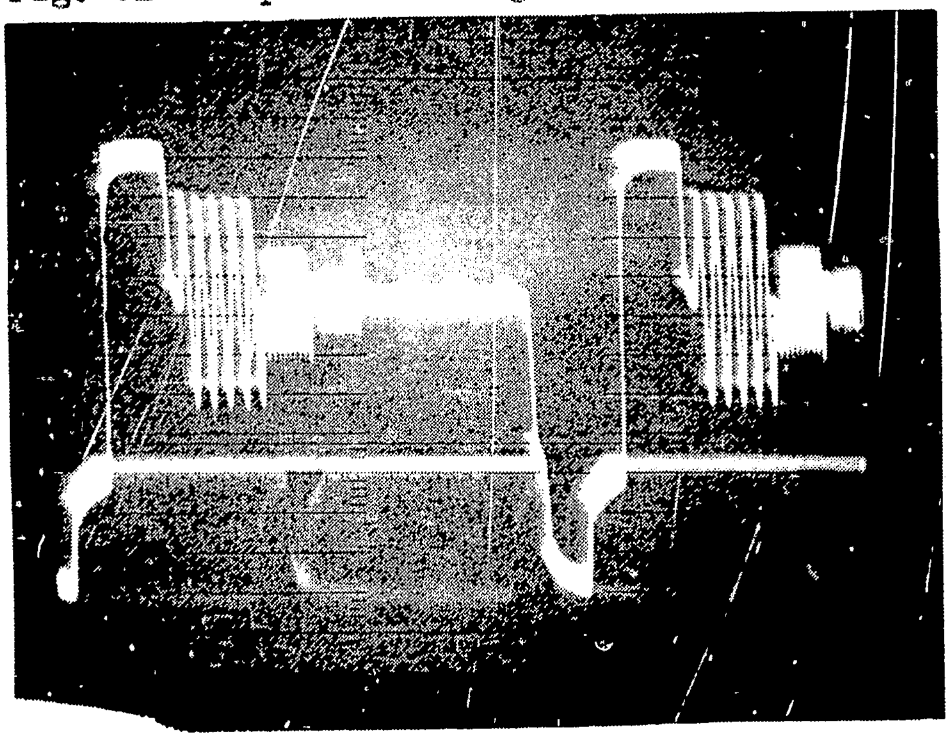

Fig. 62 - Tape Interchange

Figure 62 shows a frequency response that is very similar to the response found on the original machine.

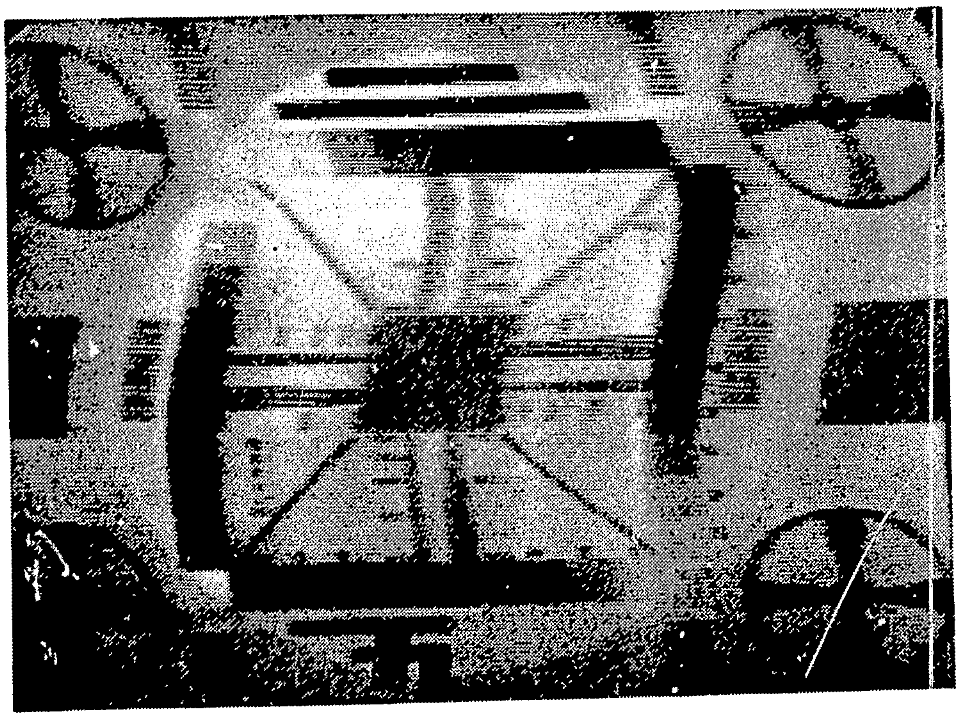

Fig. 63 - Second Generation Resolution

The second generation resolution chart shows an increased double hook on the upper portion of the picture but does not exhibit the double exposure effect of Figure 61. A tape made on Machine No. 2 would reproduce satisfactorily while it would not satisfactorily play back a tape made on Machine No. 1.

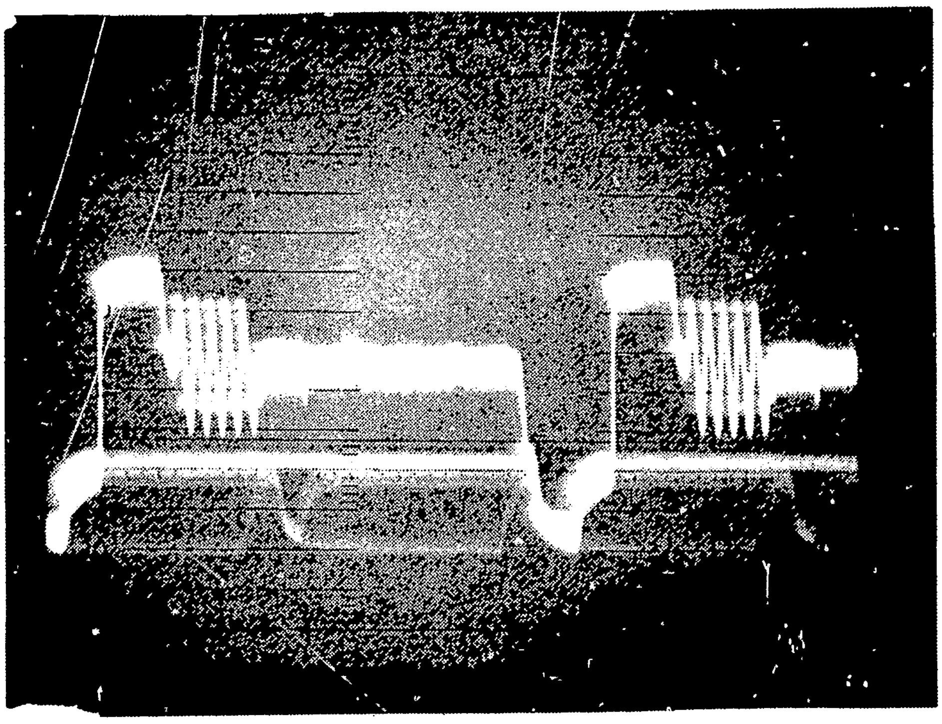

Fig. 64 - Second Generation Multiburst

Figure 64, the second generation multiburst, shows a deterioration of all but the 0.5 MHz burst. A small amount of signal in the 1.5 MHz frequency can be detected but the remaining multiburst frequencies are masked by noise.

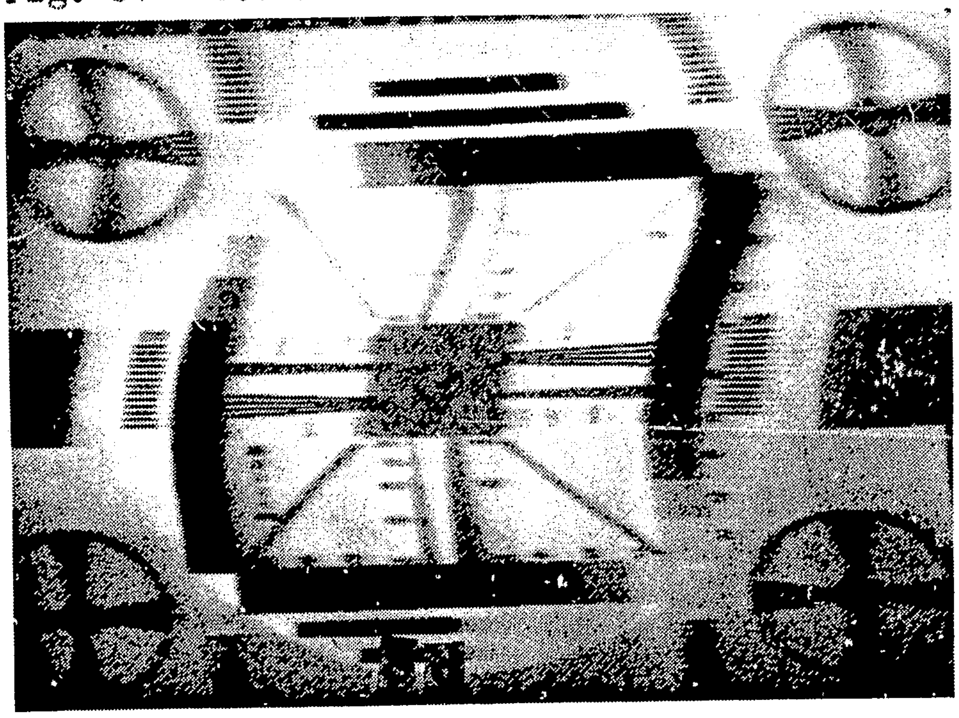

Fig. 65 - Third Generation Resolution

Figures 65 and 66 show the third generation resolution chart and multiburst amplitudes. The third generation picture produced on this machine would be very unsatisfactory as the vertical distortion has increased and the horizontal resolution is probably no greater than 150 lines. The sync pulses and white flag are by now so distorted that they are hardly recognizable. The type of distortion shown is low-frequency phase distortion and lack of high-frequency amplitude.

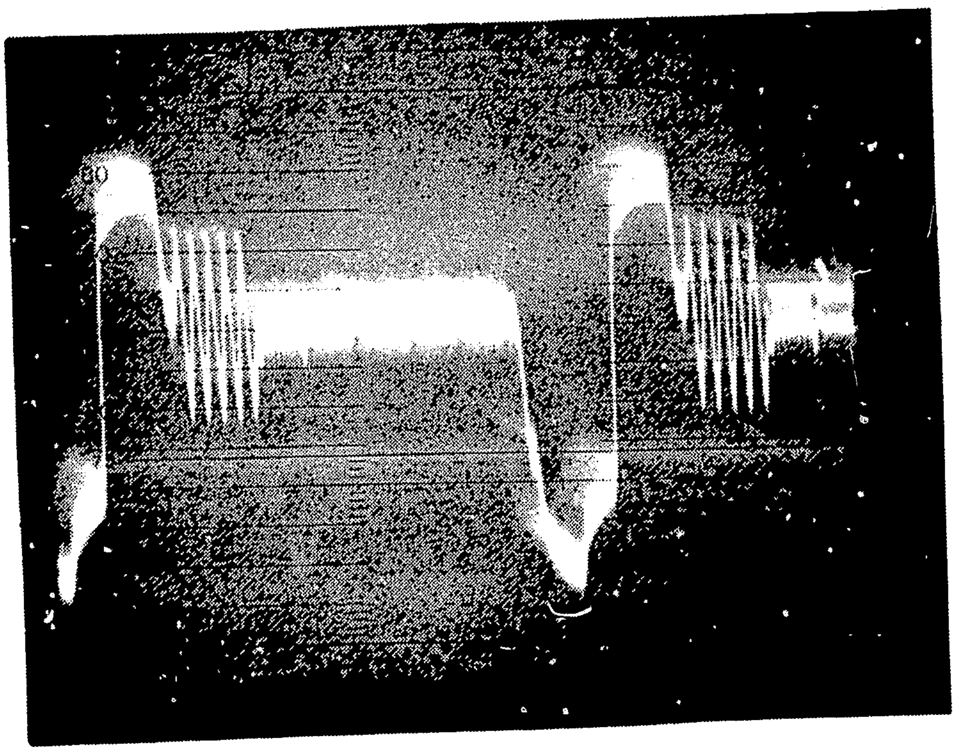

Fig. 66 - Third Generation Multiburst

End of Concord VTR-600 series

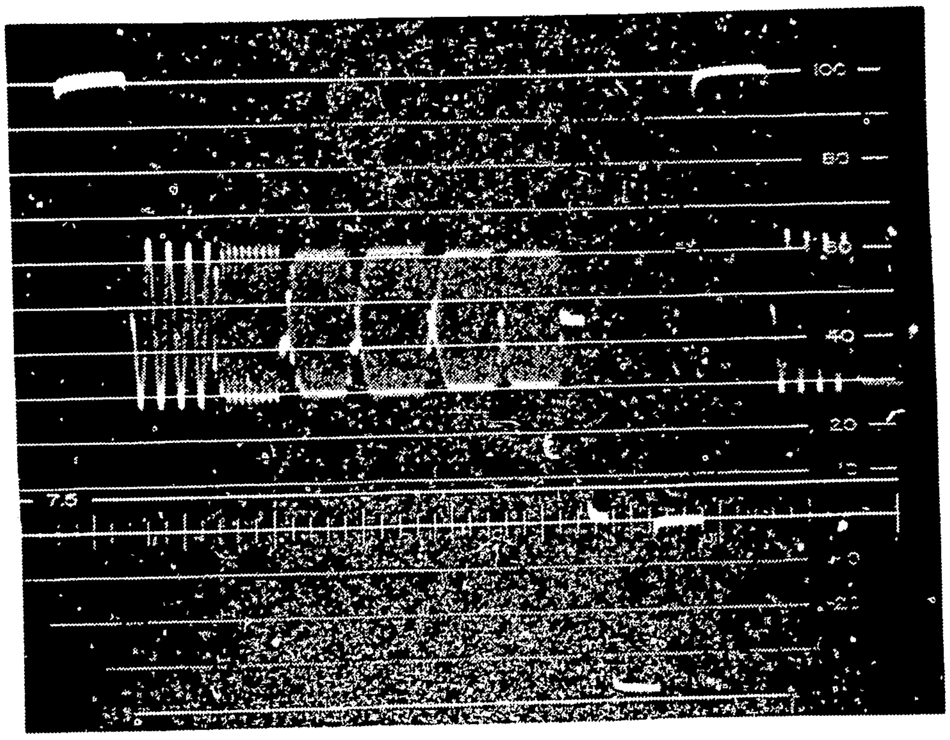

Fig. 67 - Multiburst Standard for Craig 6401

Craig 6401 Series

Figure 67 is the multiburst sequence used on the Craig 6401 machine. This machine was not available when the other tape recorders were tested and a different multiburst generator, waveform oscilloscope, and resolution chart were used. Note that the multiburst standard amplitudes are different from those in the previous series.

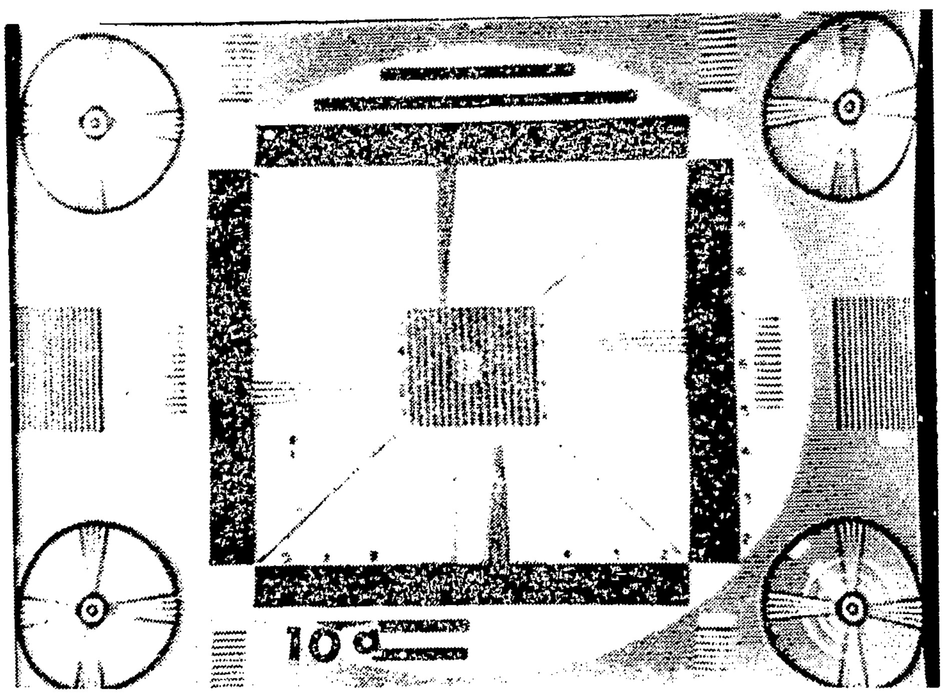

Fig. 68 - First Generation Resolution

Figure 68 shows the resolution chart with solid bars rather than the shades-of-gray scale. The horizontal resolution is well in excess of 200 lines and the vertical linearity is excellent.

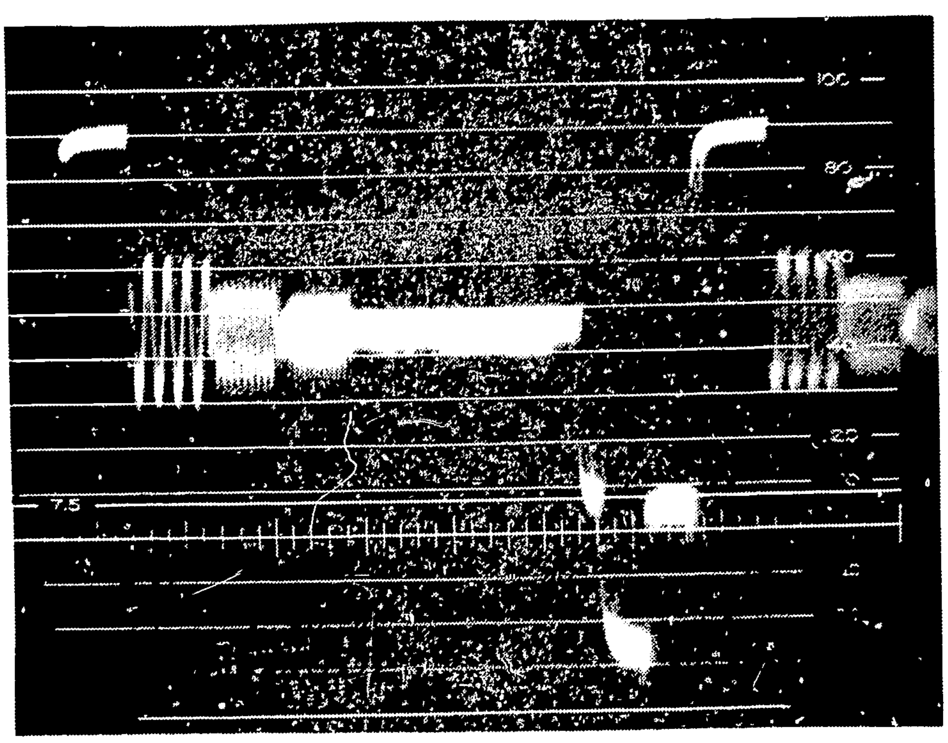

Fig. 69 - First Generation Multiburst

Figure 69, the first generation multiburst picture, shows a 2.0 MHz frequency down by not more than 6 db. The 0.5 MHz burst is almost identical to the input frequency.

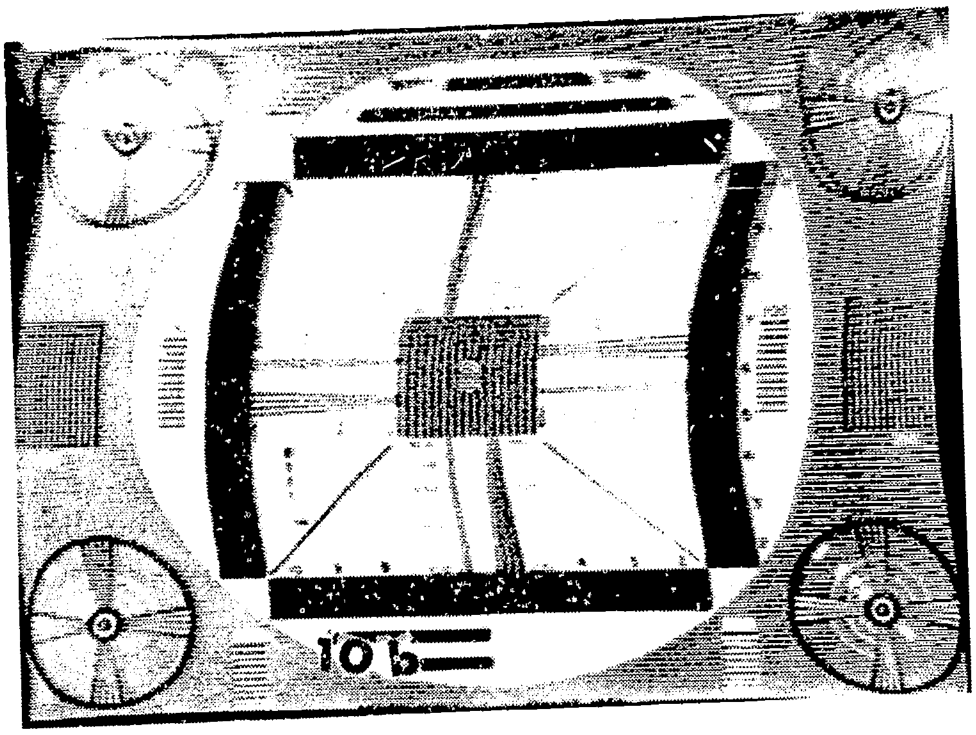

Fig. 70 - Tape Interchange

Figure 70, the resolution chart tape interchange picture, shows again the effect produced by the two record-playback heads in the Craig 6401 machine. This causes the apparent double exposure on the upper half of the picture indicating that difficulties will be experienced on playback of tapes made on other machines.

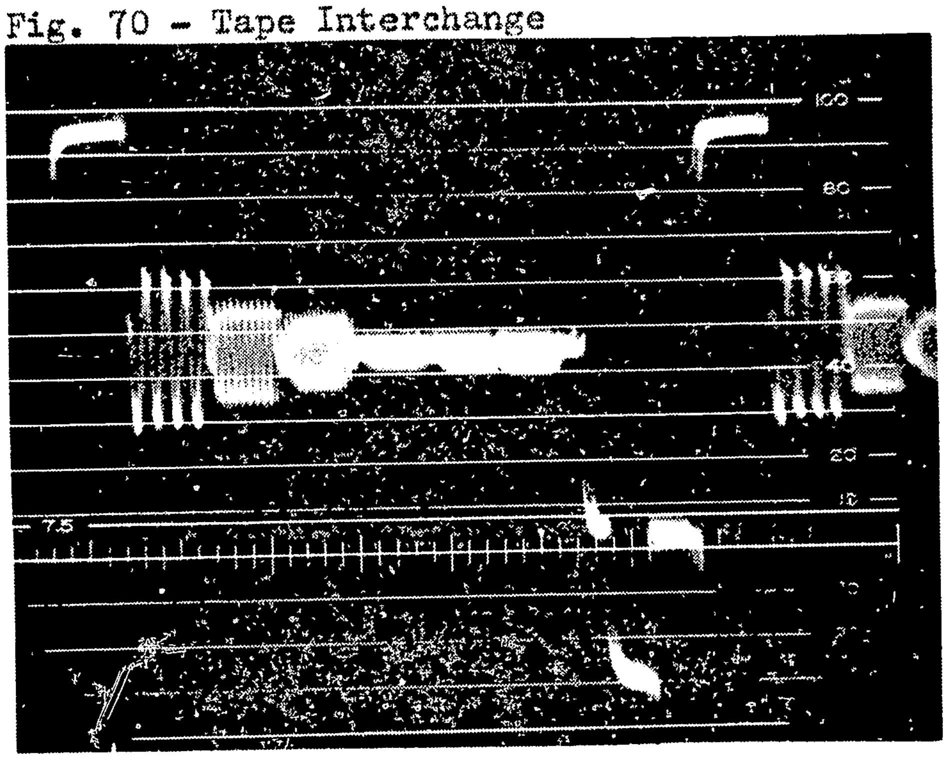

Fig. 71 - Tape Interchange

Figure 71 shows almost the identical frequency response as on the original machine but again with a slight frequency displacement produced by the two record-playback heads.

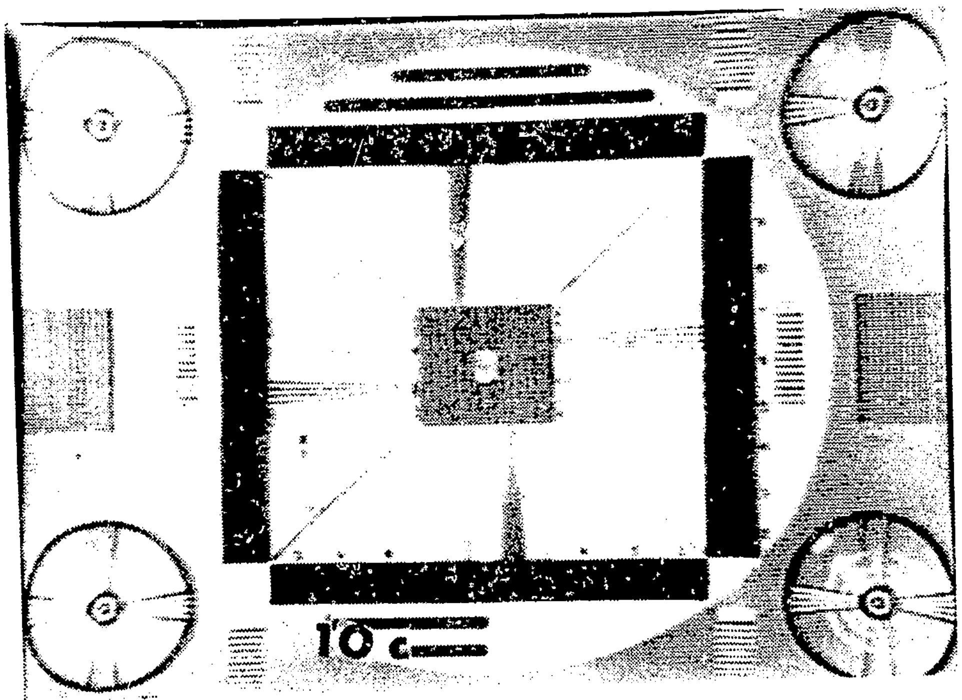

Fig. 72 - Second Generation Resolution

Figure 72, the second generation resolution chart, continues to show in excess of 200 lines in the center and all four corners of the picture. While this resolution is not satisfactory for exacting applications, the second generation has deteriorated very little.

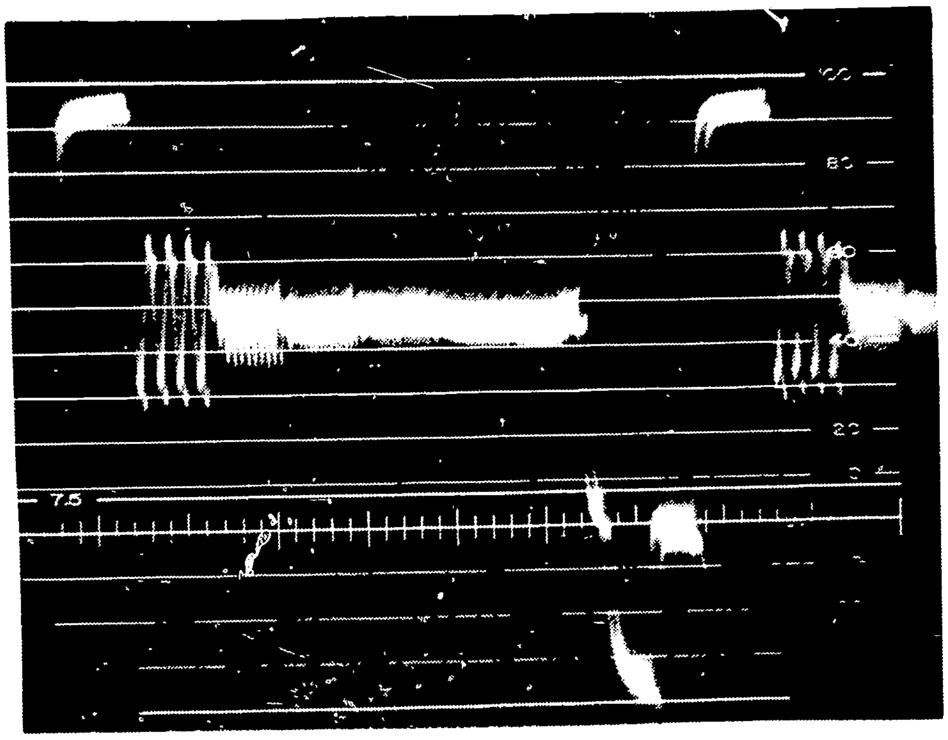

Fig. 73 - Second Generation Multiburst

Figure 73 shows a marked degeneration of the sync pulses and decrease in all but the 0.5 MHz frequency. The small signal in the 1.5 MHz frequency is responsible for reproducing the 200-line resolution in the picture.

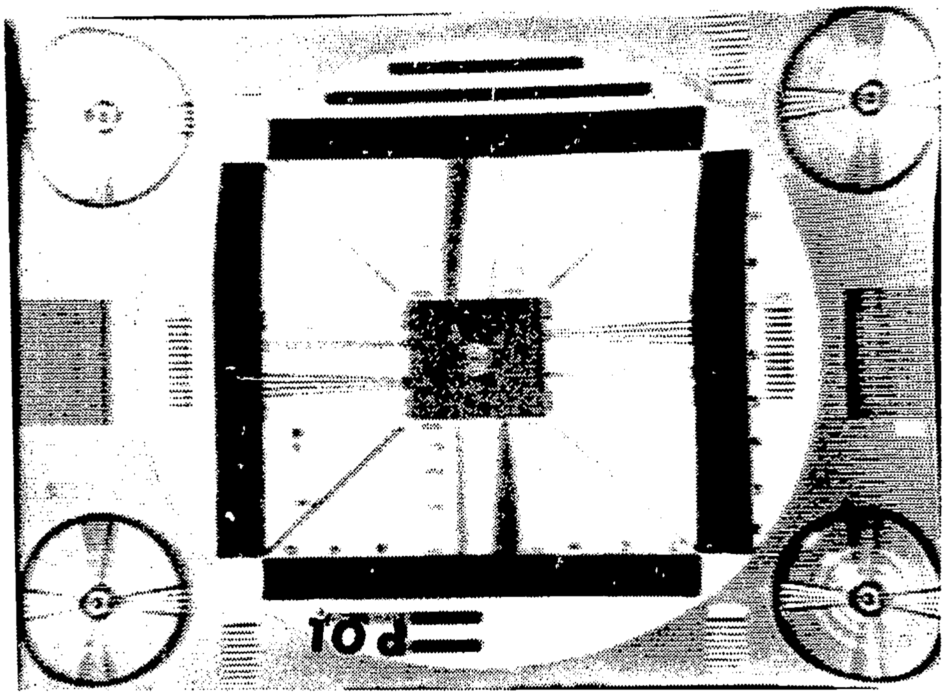

Fig. 74 - Third Generation Resolution

Figure 74 is the third generation resolution chart produced on this machine. The vertical linearity continues to be excellent and except for frequency response which results in loss of resolution, the third generation tape produced is quite satisfactory.

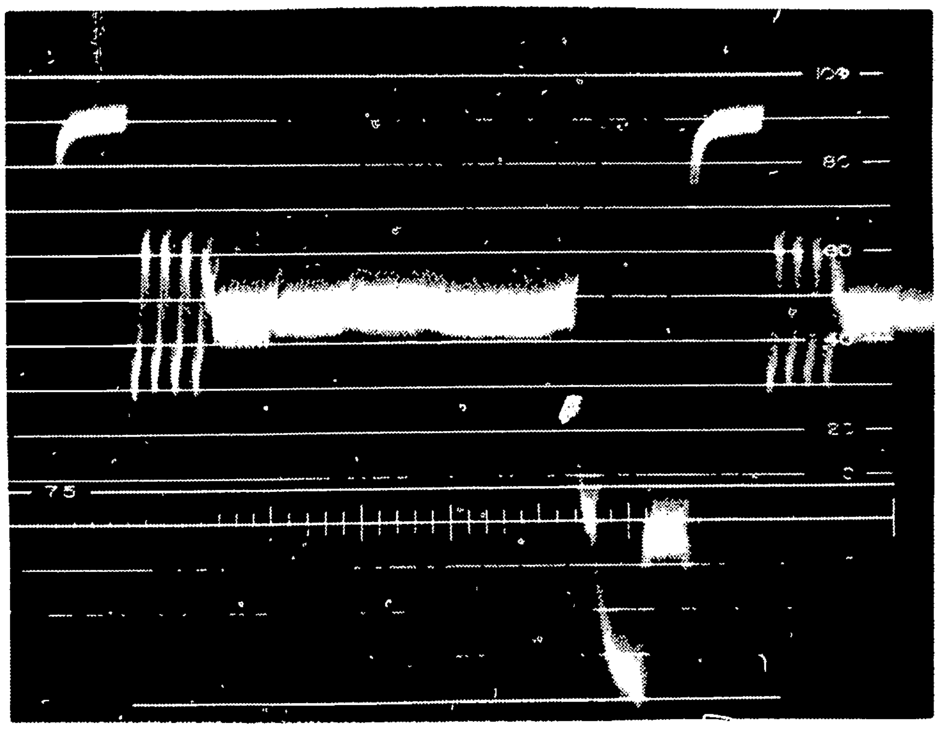

Fig. 75 - Third Generation Multiburst

Figure 75 shows a continued degeneration of the sync pulses and white flag. The noise, however, has not increased out of proportion and this results in the high quality resolution chart picture. The machine can be adjusted to produce very favorable vertical linearity.

End of Craig 6401 series

Equipment Reliability

All video tape recorders tested employ solid-state circuitry and low voltage power supply. Heat produced in the system is very low due to the low signal levels and power supply voltages in the system. Virtually all transistors are now of the silicon variety. The low voltages place little strain on capacitors and resistors and all of these factors result in high reliability. A properly engineered solid-state system should perform as well after ten years of continual use as it performs in the initial stages.

The mechanical reliability involves many more complex factors. A tape recorder that relies on a multiplicity of rubber belts, friction drives, and other wearing surfaces may be expected to require frequent attention. Rubber or neoprene belts exhibit fatigue characteristics which result in increase of slippage and malfunctioning. Felt pads when used for brakes on rotating equipment glaze and lose their stopping ability. Devices that rely heavily on friction points for their operation need frequent adjustment and in the absence of proper admustments the circuits jerk, grab, or otherwise mishandle the video tape.

Video tape is made with a very strong mylar base but frequent jerks on the tape and improper tension will cause the tape to deform with the resulting misfit contact with the recording heads. Most of the video tape machines have recorded tracks on both edges of the tape as well as in the center section. A tape that has stretched or is otherwise deformed will make contact with certain of the heads but may have inadequate contact with some other head. Video tape recorders equipped with multiple motor drives instead of a belt-driven transport and with braking accomplished by electrical means are generally more reliable than those depending on belts or friction for these functions.

Tape Guides

The tape guides are used to align the tape for the most satisfactory contact with the recording heads. The most satisfactory tape guide is a rotating one which usually exhibits a minimum of friction with respect to the tape. This is especially important when the guide makes contact with the oxide surface of the video tape.

The non-rotating tape guides consist of various configurations of bars or stationary spools. In some instances, the tape guide is adjustable, which permits the operator to correctly align the tape. By the same token, it is also possible to misalign the tape by having the guides too close together in which event the top or bottom edge of the tape is scratched. Too loose a guide will allow the tape to rise above or float below the proper position. In the hands of a layman, the adjustable guides are probably undesirable. In any event, guides should be examined carefully after every few hours of operation for signs of oxide and tape material that may have been removed from the video tape by the guide during operation.

Since video tape recorders are to have the capability of playing all tapes produced on the identical make and/or model, the tape transport system must not be misadjusted as this will seriously reduce the interchangeability of tape.

Cleanliness

Utmost care must be used to keep the video tape and the tape transport system of the video tape recorder immaculately clean. Video tapes on lifetime tests in carefully controlled environments are capable of 4,000 to 10,000 passes. The same video tape used in questionable locations often has deteriorated to uselessness after 100 to 400 passes.

A common fault in video tape is a microscopic irregularity in the magnetic coating of the tape. This causes a drop-out or a momentary white line on the picture monitor. This irregularity may be a function of the manufacturing process but specks of dust, cigarette ashes, sand, cloth fibers, and the like will produce the same effect. A tape guide may produce a sliver of polyester which can deposit on the tape, and this chip, causing the head to lose contact with the tape, will result in a momentary drop-out.

Periodic thorough cleaning of the entire tape transport and the various heads is most essential for satisfactory video tape machine operation. The entire transport should be cleaned before each recording or playback. Each of the several guides should be carefully wiped with an approved cleaner and all of the head assemblies should be cleaned to remove specks of oxide and other debris that can clog the heads. Microscopic specks of oxide may form a bridge in the video tape head which will make the head inoperative for either record or playback. This irregularity is quickly observed on playback but, unfortunately, cannot be detected on record. It is, therefore, essential that all parts of the tape recorder assembly be immaculately clean to avoid head build-up.

The oxide material used in the fabrication of video tape is an iron oxide; one of the hardest and most abrasive materials found in nature. The binder used in the manufacture of the video tape causes the oxide to build up on the guides and on the heads. Such build-up can ruin the entire video tape in one pass on the machine by irreparably scratching it.

It is doubtful that anyone except a trained technician can properly maintain a video tape recorder.

Cleaning Solution

The use of a good cleaning solution is mandatory. This will help remove oxide and debris deposits from all tape guides and heads. Due to the chemical characteristic of the tape and of the binder used in the manufacture, only a few common cleaners are satisfactory for this purpose. Freon TF is recommended by the majority of video tape manufacturers. Freon TF is highly volatile and the operator must work very fast to remove the oxide before the freon is evaporated.

Those portions of the transport that do not contain rubber may be cleaned with xylene or a mixture of 98% xylene and 2%, 75%-25% aerosol-glycerin. This material must not come in contact with the video tape or rubber but is effective on metal guides and easier to use then freon.

Rubber guides may be cleaned by use of methyl alcohol. Great care must be exercised that all surfaces moistened with methyl alcohol are thoroughly and completely dry before the video tape is again threaded through the machine.

Tape Tension

A certain amount of tape tension must be applied to the moving tape so that a proper tip penetration is maintained during the motion of the head across the tape. Most video tape recorders have a fixed tension control on record and a variable tension control on playback. The playback tension control is adjusted for optimum picture quality which usually occurs when the picture exhibits a minimum "hook" characteristic. The Wollensak VTR-150 uses a simple nonadjustable felt pad for the tension control; and in the particular model tested, the quality of the resultant picture would have improved had the control been variable. Similarly, the fixed tension control on recording on some machines made it nearly impossible to correct for the picture hook when the tape was played back on a different machine. Evidently, some method of standardizing the record tape tension would be desirable in order to insure the maximum tape interchangeability.

Tape Interchangeability

All of the machines tested in this project worked satisfactorily with respect to interchanging tape with a machine of the identical make and model. Admittedly, the best results are always obtained when the tape is played back on the same machine used for recording because the head alignment on record and playback is then exact. On machines that have no playback tension adjust, difficulty can be experienced in interchanging tapes. A playback tension adjust should, therefore, be required to insure interchangeability of tape from machine to machine.

Standard Tape Format

Several groups of machines now use a common tape format. Foremost in this is the Ampex VR-7000 series where the same format is used on the machines used in this test, the Ampex VR-6000, Ampex VR-7000, and Ampex VR-7500. Additionally, Ampex has introduced the Ampex VR-5000 and the Ampex VR7800 in the identical tape format. The Ampex VR-7800, with a full complement of accessories, is capable of excellent color and a tape made on the Ampex VR-7800 may be played back on any of the other machines. Similarly, tapes made on any of the Ampex one-inch format machines may be played back on any other type. For example, the test identified as 4-6-a is a recording made on Ampex VR-7500 (low band) and played back on the economy Ampex VR-6000 machines.

The versatility of the Ampex one-onch format lies in the fact that a single high quality machine like the Ampex VR-7500 can be used for recording purposes and the production of copies. These copies can be played back on the economy Ampex VR-5000 machine in the classroom. The Ampex one-inch format is used on Raytheon Model RR-750 and Raytheon Model RR-700 machines. These machines appear to be identical with Ampex VR-7500 and Ampex VR-7000 and the interchangeability of tapes extend to these models.

The Sony EV-200 is available as a package unit under several other popular trademarks including General Electric and RCA. Tapes made on any of these machines are capable of playback on any other of the same group.

The Raytheon machines, amnufactured by Ampex, as well as the RCA and General Electric machines manufactured by Sony, were not tested in this project because of their relationship to the parent company.

Tape Costs

The per-hour cost of video tape is an important consideration. While distributors have certain latitudes in establishing quantity-price break, the following list cost of tape is illustrative of the difference in tape cost:

half-inch tape, 60 minutes	$40.00
one-inch tape, 60 minutes	60.00
two-inch tape, 60 minutes	75.00

Groupings Among Tape Recorders

There appear to be three natural groupings in the helical scan video tape recorders. These groupings are apparent in picture quality, price range, and possible useage. The groupings are as follows:

1. The first group is generally in the $4,000 to $8,000 price range. This equipment appears useable for broadcast purposes provided that certain precautions are taken. The picture quality is such that the third generation tape still is clearly useable. Of machines tested in this project, the Sony PV-120-U and the Ampex VR-7500 (high band) would probably fall in this group.

2. The second group of machines would fall in the $2,000 to $4.000 price range. These machines did not exhibit the necessary time base stability required for broadcast and had more problems with picture hook as well as a degraded picture quality. The sync pulses were not sharply reproduced; and, in some instances, there was marked deterioration of the recorded material. The machines, however, should find acceptance in school systems for closed-circuit programing where editing and making copies of the material are not a prime prerequisite. The machines that fall in this group are the Ampex VR-7000 and the Sony EV-200.

3. The third group of machines would fall in the $1,000 price range and these machines should be limited to record and playback. These machines typically are of the half-inch format and are economical in tape consumption. The machines likewise are useful for dubbing from a more professional model. The machines in this group are Ampex VR-6000, Sony SV-300, Concord VTR-600, Wollensak VTR-150, and Craig 6401.

TABLE 1

SELECTED STATISTICS OF THE TEST RECORDERS

TEST NO.	NAME OF MACHINE	PRICE	NO. OF VIDEO HEADS	HEAD VELOCITY	TAPE WIDTH	TAPE SPEED	TAPE COST PER HOUR
1	Sony EV-200	$ 3,350	2	590 ips	1 in.	7.8 ips	$ 60.00
2	Sony SV-300	980	2	425	1/2	7.5	40.00
3	Sony PV-120-U	8,950	2	740	2	4.25	75.00
4	Ampex VR-7500	3,995	1	1000	1	9.6	60.00
5	Ampex VR-7000	3,450	1	1000	1	9.6	60.00
6	Ampex VR-6000	1,595	1	1000	1	9.6	60.00
7	Wollensak VTR-150	1,495	1	180	1/2	7.5	40.00
8	Concord VTR-600	1,150	2	484	1/2	12	40.00
9	Panasonic 204						
	(Only one Panasonic 204 machine was available and the test was abandoned)						
10	Craig 6401	1,035	2	545	1/2	9.5	50.00

ACKNOWLEDGEMENT
OF
VTR EQUIPMENT USED IN PROJECT

Video Tape Recorders Tested:	Furnished By:
Ampex VR-6000, Serial No. 4124 Ampex VR-6000, Serial No. 4141 Ampex VR-7000, Serial No. 4189 Ampex VR-7000, Serial No. 4454 Ampex VR-7500, Serial No. 1869 Ampex VR-7500, Serial No. 1872	Ward/Davis Associates 3921 East Bayshore Palo Alto, California 94303
Concord VTR-600-1, Serial No. 1999 Concord VTR-600-1, Serial No. 2017	Campbell Engineering 814 East 14th Street Oakland, California 94606
Craig Model 6401, Serial No. 690098 Craig Model 6401, Serial No. 690095	Video Products Sales Craig Panorama Inc. 2302 East 15th Street Los Angeles, California 90021
Sony EV-200, Serial No. 1985 Sony EV-200, Serial No. 1874 Sony SV-300, Serial No. 1119 Sony SV-300, Serial No. 1276 Sony PV-120-U, Serial No. 2656 Sony PV-120-U, Serial No. 2233	Sony Corporation 926 Industrial Avenue Palo Alto, California 94303
Wollensak VTR-150 Wollensak VTR-150	Minnesota Mining and Manufacturing Company 320 Shaw Road South San Francisco, California 94080

Video Tape Used:	Furnished By:
3M Tape	Minnesota Mining and Manufacturing Company 320 Shaw Road South San Francisco, California 94080
Ampex Tape	Ward/Davis Associates 3921 East Bayshore Palo Alto, California 94303
Memorex Tape	Video-Educational Distributors 312 Brokaw Road, Suite 8 Santa Clara, California 95050
Sony Tape	Com-Tel Engineering Corporation 1472 Oddstad Drive Redwood City, California 94063

Test Equipment Used:	Furnished By:
Telchrome Test Signal Generator Model 3508-C2, Serial No. 717 Manufactured by Telemet Company, Amityville, New York	Telemet Company 3841 South Main Street Santa Ana, California 92705
Telemation Broadcast Synchronizing Generator Model TSG-2000, Serial No. 201	Telemation, Inc. 2275 South West Temple Salt Lake City, Utah 84115
Conrac Picture Monitor Model CNB8/C Model No. 123849 Manufactured by Conrac Division, Covina, California	Reeves Electronics 405 Sherman Avenue Palo Alto, California
Hewlett-Packard Oscilloscope Camera, Model 197A Serial No. 730-01126	Neely Enterprises 1101 Embarcadero Road Palo Alto, California 94303
Hewlett-Packard TV Waveform Oscilloscope Model No. 191A	Neely Enterprises 1101 Embarcadero Road Palo Alto, California
Blonder-Tongue Vidicon Camera Model No. TTVC-16-SN Serial No. 1335	Manufactured by Blonder-Tongue Labs, Newark, New Jersey
Speed Graphic Plate Camera	
Pan X Film	
Polaroid Type 107 Film	

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