DOCUMENT RESUME

ED 107 062 EC 072 787

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TITLE Interactive Classroom TV System for the Handicapped.
SPONS AGENCY Social and Rehabilitation Service (DHEW), Washington, D.C.
REPORT NO R-1537-HEW
PUB DATE Jun 74
NOTE 52p.; For related information see ED 095 685 and EC 072 786

EDRS PRICE MF-$0.76 HC-$3.32 PLUS POSTAGE
DESCRIPTORS Adults; Aurally Handicapped; *Closed Circuit Television; Educable Mentally Handicapped; Elementary Education; Exceptional Child Education; *Instructional Media; *Partially Sighted; *Research Projects; Resource Centers; Television; Visually Handicapped
IDENTIFIERS *Low Vision Aids

ABSTRACT

One of a series on the visual information transfer problems of the partially sighted, the report describes an interactive, multicamera, multimonitor closed circuit television (CCTV) system that permits continuous visual communication between teacher and students in an elementary school resource room. The system (in use since November 1973) is the first known classroom CCTV system for the handicapped, and it enables students with severely impaired vision to read ordinary print, to write with a regular pen or pencil, to carry out operations requiring precise eye-hand coordination, and to see a teacher's written examples while listening to her verbal explanations. The system is reported to be helpful to educable mentally retarded and hearing impaired students and may also prove beneficial to similarly handicapped adults. Provided are sections on system components and design features, engineering considerations, and proof-testing the classroom TV system. Appendixes include technical information on system components; a description of nine performance tests (of intelligence, achievement, perception, and school attitude) administered to measure the effectiveness of the CCTV system; and entries from the teacher's log showing how the system has been used and describing associated problems and successes. (LH)

INTERACTIVE CLASSROOM TV SYSTEM FOR THE HANDICAPPED

PREPARED FOR THE DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

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R-1537-HEW
JUNE 1974

Rand
SANTA MONICA, CA 90406

The research described in this report was sponsored by the Department of Health, Education, and Welfare under Grant No. 14-P-55846/9. Reports of The Rand Corporation do not necessarily reflect the opinions or policies of the sponsors of Rand research.

Published by The Rand Corporation

PREFACE

This report is one of a series to study and try to solve the visual information transfer problems of the partially sighted. The research by members of the staff of The Rand Corporation is supported by a grant (14-P-55846/9) from the Social and Rehabilitation Service of the U.S. Department of Health, Education and Welfare.

The present study describes an interactive multicamera-multimonitor closed circuit TV system that was designed, fabricated, and assembled by the Rand project staff. This interactive CCTV system permits a teacher to be in continuous visual communication with her partially sighted students. The system has been installed and is being used in an elementary school resource room for handicapped children, under the jurisdiction of the Santa Monica Unified School District. Some of the students in the resource room are partially sighted; others are educable mentally retarded, profoundly deaf or partially hearing, or multiply handicapped.

Originally, the proof-testing of the CCTV system in the school was regarded as a means to determine whether (1) the system and its components operated reliably, (2) the features included in the design were useful and adequate, and (3) the teacher was able to operate the system with ease and without impairing her ability to teach. Response was enthusiastic, and although the system has been in use only since late November 1973, it has already proved helpful not only to the partially sighted students but also to the other handicapped children. We realize that data should also be gathered concerning each student's level of achievement, attitude toward himself and his schooling, eye-hand coordination, and attention span. Some of these data have already been collected, using various psychological and educational tests, but they were not analyzed in time for inclusion in this report. Together with the teacher's observations, such information should prove of considerable value in future decisions on how best to educate handicapped children. This report was written primarily for persons and organizations that are involved or interested in the primary education of partially sighted and other physically and mentally handicapped children or that are working on the development and manufacture of aids for that population. The instrumentation described here very likely will also be of value to adults who are similarly handicapped, and to those who serve that population.

ACKNOWLEDGMENTS

We are indebted to Dr. Frank D. Taylor, Assistant Superintendent/Special Services, Santa Monica Unified School District, and to Dr. Robert J. Stillwell, Supervisor of that school district's Special Education Program, for their enthusiastic support and generous cooperation. They have done everything in their power to establish and maintain a smooth and amiable working relationship between our project staff and members of their staff. Further, they initiated the suggestion that led to the joint decision to permit educable mentally retarded and hearing impaired children who are nonvisually impaired, as well as partially sighted children, to participate in the testing of the interactive classroom TV system. That suggestion may someday prove to be one of the most significant contributions in exploratory special education for the educable mentally retarded.

We also wish to thank Dr. O. Arthur Rosenthal, Educational Psychologist, Santa Monica Unified School District, for selecting and administering several test instruments to the students. Others whose help was very appreciated include Stephen G. Strand, who carried out the electronic fabrication of the classroom TV system and provided solutions to important technical problems; Angelo Makris, who was responsible for most of the system's mechanical construction; Michael E. P. Wallters for his help with the system wiring; and Scott Moore of Omega Associates, our major vendor, who took personal interest in our work and in what we are doing for the physically and mentally handicapped, and as a result gave generously of his time and assistance.

In the preparation of this report, the authors are grateful to Rudy Bretz and Dr. Gene H. Fisher for their thorough and constructive technical reviews, James A. Beavers for taking and processing the photographs that appear here, Eleanor T. Gernert for editing the manuscript and guiding it through the publication process, and Margaret Wray for patiently and accurately typing all the drafts.

CONTENTS

I. INTRODUCTION

During the past year the Rand project staff designed and fabricated a highly interactive teacher-student closed circuit TV system. This multicamera-multimonitor instrument is being proof-tested for its reliability and design rationality during the 1973-74 academic year in an elementary school resource room for partially sighted, mentally retarded, and hearing impaired school children.[1] The system permits the teacher and her handicapped students to be in *continuous visual communication with each other.* It was originally built to satisfy the need for continuous visual links between partially sighted students and their teachers, and in that capacity, the system has already shown great promise.[2] The system is being used primarily by partially sighted and/or educable mentally retarded students, some of whom have additional physical handicaps.

Although it is too early to make predictions concerning the long-range value of the system to the educable mentally retarded and to the teaching of these students, teacher observation to date indicates that the attention span of the educable mentally retarded students has increased considerably. However, there is not sufficient evidence as yet to make a definitive statement about the system's capacity to increase attention span over a long period of use.

The system is also being used in teaching deaf and partially hearing children. Their teacher reports to us that these children are enthusiastic about working with the system, and that she is finding it helpful in improving communications with them.[3]

For example, handicapped children are able to see their teacher's writing while she is at her desk or at a chalkboard. No longer is it necessary for her partially sighted students to ascertain what she has written *after* she has completed writing and *after* she has given an explanation of what she is writing. The ability to see what a teacher is writing *while she is actually writing and explaining what she is doing* is a vital factor in a student's ability to fully comprehend what is being taught.

In addition, the classroom TV system permits students, while seated in a comfortable and natural position, to work alone at camera-monitor stations. They can, for example, read *ordinary* printed and handwritten material, write with a pen or pencil, and carry on other operations that require precise eye-hand coordination.

Further, like the currently available individualized closed circuit TV systems for the partially sighted,[4] the classroom TV system's cameras and monitors also permit the control, by teacher and students, of image brightness contrast, polarity, and magnification to a far greater extent and with much greater ease than is possible with pure optical devices.[5] Although pure optical systems can provide the same

[1] After fabrication and experimental testing in our laboratory at Rand, the system was installed at Madison School, Santa Monica, in the classroom of Jadeane von der Lieth. Her observations appear throughout this report, and excerpts from her Teacher's Log from November 1973 to April 1974 are printed verbatim in App. F.

[2] In Ref. 1, Dr. S. M. Genensky carefully defined who the partially sighted are and estimated that about 305,000 of the 436,000 legally blind Americans are partially sighted, as well as about 1,330,000 Americans who are not legally blind.

[3] In Ref. 2, the authors estimated that there are about 180,000 partially sighted, 490,000 hearing impaired, and 2,100,000 educable mentally retarded Americans below the age of 21.

[4] These systems are based on previous research carried on at Rand.

[5] It should be understood that our teacher-student system is the first CCTV system for the handicapped that has ever been used by the teacher or students who are currently using it, and to our knowledge, it is the first system of its kind in the world.

degree of magnification as closed circuit TV systems, unlike the latter they must be kept at a rather precise distance from the viewed object to keep it in focus, especially at high magnifications. Further, unlike closed circuit TV systems, pure optical systems are incapable of reversing image contrast (i.e., turning black into white and white into black), and hence are unable to provide partially sighted users with an image of print that scatters less light and that provides illumination from the information rather than from the background on which it is printed. The absence of these two constraints on closed circuit TV systems makes them more attractive to the partially sighted than pure optical systems. Furthermore, focus problems and lack of contrast control are the cause of much of the fatigue experienced by partially sighted people when trying to read with the aid of pure optical devices for long periods of time. One other advantage of closed circuit TV systems over pure optical systems that has proven invaluable to the partially sighted is their ability to *enhance* both the brightness and contrast of a viewed object. With this capability and that of contrast reversal, the partially sighted are now able, for example, to view low-contrast printed or handwritten material in an image that is bright, has high contrast, and that minimizes glare.[6]

[6] For additional information on closed circuit TV systems for the partially sighted, the reader is referred to Refs. 3 through 10.

II. THE INTERACTIVE CLASSROOM TV SYSTEM

SYSTEM COMPONENTS

The classroom TV system has four stations, each consisting of (1) a black and white TV monitor and stand; (2) a down-pointing black and white TV camera that generates images with normal or reversed contrast (i.e., black on white or white on black) selected by a switch on the front or underface of the camera; (3) a 5 to 1 zoom lens with a close-up adapter;[1] (4) a heat shielded light source; (5) an X-Y Platform with adjustable margin stops in the x-direction and frictional control in the y-direction; and (6) a stand that accommodates the TV camera, the light source, and the X-Y Platform. In addition, each station is provided with a switch that permits its light source to be turned on or off, another switch that allows power to flow or to be cut off from all of the station's electrical components, and an amber light that when illuminated indicates that the image displayed on the station's monitor is also being displayed on the room monitor.

The system includes a ceiling-mounted room-viewing black and white TV camera equipped with a 10 to 1 zoom lens, a black and white room monitor, a cassette-type videotape recorder, a master control unit, a room camera control unit for the ceiling-mounted camera, and a teacher's channel selector.

Each of the camera-monitor stations is located on its own table. Three of these stations are specifically for use by students and the fourth is for use by the teacher, although it is sometimes used by a fourth student.

Figure 1 shows one of the three student stations, and Fig. 2 shows the teacher's station. In Fig. 2, note the videotape recorder to the left of the TV monitor and also the master control unit and the room camera control unit on the right of the desk supporting the camera and monitor stands. In the same photograph, the teacher's channel selector is shown to the left of the X-Y Platform and in front of the TV monitor.

HOW THE SYSTEM OPERATES

The master control unit[2] is located on the same table as the teacher's camera-monitor station. With it, the teacher is able to present on any one of the four desk-supported TV monitors, independently of what she presents on any other monitor, the following pictures: (1) a full screen image of what any one of the five TV cameras is viewing or a videotaped picture, (2) a horizontally split image of what any two of the five cameras are viewing or a videotaped picture and what any one of the five cameras is viewing, or (3) a full screen superposition of what any two of the five cameras are viewing or a taped image and what any one of the five cameras is viewing. With this capability the teacher is able to work simultaneously with as many as three students, and if she chooses to work with fewer than three, she will

[1] The zoom lens permits the user to vary the magnification of the image appearing on the TV monitor over some specific range by merely turning the appropriate ring on the lens. For example, a 5 to 1 zoom lens permits the user to vary the magnification of an image by as much as five times. The exact range over which magnification occurs is a function of many factors, including the lens construction, the monitor size, and whether supplementary lenses are used to change the limits of the magnification range or to permit the zoom lens to focus at shorter distances than it was originally constructed for.

[2] See App. A for a detailed explanation of this unit.

still be able to assign tasks, using the classroom TV system, to students with whom she is not working. These tasks may involve the students working alone or with occasional observation or guidance from the teacher.

The examples given below are illustrative of what a classroom TV system can do, and each of the activities described has been carried out by the teacher, Ms. J. von der Lieth, in the elementary school resource room where our system is being proof-tested.

1a. Present on Student 1's monitor a full screen image of what his camera is viewing and ask him to place a book on his X-Y Platform and read by himself.

1b. Place a set of small pictures of various objects on her X-Y Platform, ask Students 2 and 3 to place sheets of blank paper on their respective X-Y Platforms, present on Student 2's monitor a superimposed image of what her (the teacher's) camera is viewing and of what his camera is looking at, and present on Student 3's monitor a superimposed image of what her camera is viewing and what his camera is looking at. She can then ask Students 2 and 3 to circle the pictures they see that begin with a particular letter and to write that letter next to the circled picture.

2a. Display a horizontally split image on the monitor on Student 1's desk of what his camera is viewing and of what the room-viewing camera is looking at. If, for example, the room-viewing camera is trained on a model of a famous ship, she can ask Student 1 to put a piece of blank paper on his X-Y Platform and draw a sketch of the ship or write an essay about it.

2b. Display a full screen image of a videotaped lesson on Student 2's monitor and ask him to view it by himself.

2c. Display on Student 3's monitor a full screen image of what the camera at his desk is looking at, ask him to place a book on his X-Y Platform, and then go to that student's desk and work directly with him.

3. Present a full screen image of what the room-viewing camera is looking at on all three student monitors and on her own monitor and use puppets or other props that are viewed by the room-viewing camera to help her tell a story. She might then ask the students questions based on the story, perhaps making use of the puppets or the chalkboard.

Using the teacher's channel selector,[3] the teacher can view individually but in any order on her own monitor what any of the students is seeing on his monitor, and, for instance, in example (1) above, she can watch what Students 2 or 3 are viewing on their monitors. Thus, she can point out mistakes to each of these students individually, without going to their desks. Likewise, if either student does something that the teacher believes needs reenforcing and that she is confident will not embarrass the child, she can display his success on other student monitors while complimenting his good work. Thus, the teacher can use the teacher's channel selector to occasionally observe the performance of students whom she has asked to work alone, and when necessary give them help or encouragement.

Figure 3a shows an enlarged image of the caricature of a bird on a student monitor. The image is the result of the room-viewing camera looking at a card containing the picture of the bird, which is located just above the center of the chalkboard. Figure 3b shows the same caricature except that here the contrast is reversed.

Figure 4a shows a split image on a student monitor. The upper half of the image comes from the room-viewing camera that is looking at two arithmetic problems on the chalkboard, and the lower half comes from a student camera viewing a pad of

[3] See App. C for a description of the function of each of the controls on this unit.

white paper, resting on an X-Y Platform, on which the answer to one problem has already been written and the answer to the other problem is being written. Figure 4b shows Ms. von der Lieth at a student station assisting the student with his reading. Note that the image of the reading material that he is viewing on the monitor is enlarged and reversed in contrast.

Figure 5a shows on a student monitor the superposition of a picture of a horse, which is located on the X-Y Platform at the teacher's station, on the contrast reversed image of a sheet of white paper that is resting on a student's X-Y Platform and on which the word "horse" has been written. Figure 5b shows on a student monitor a split image, the upper half of which is the picture of the horse that is located on the X-Y Platform at the teacher's station, and the lower half of which is the contrast reversed image of a sheet of paper that is resting on the X-Y Platform at a student station and on which the word "horse" is being written.

As pointed our earlier, the room camera control unit,[4] like the master control unit and the teacher's channel selector, is located on the teacher's desk. The teacher can cause the room-viewing camera to pan and tilt and present a positive or negative image (i.e., black on white or white on black) on one or more TV monitors. This unit also allows the teacher to control the opening of the zoom lens, bring objects into focus, and change the magnification provided by that lens. Figure 6 shows the room-viewing camera together with its 10 to 1 zoom lens suspended in a ceiling mount.

The videotape recorder is used by the teacher to record visual interactions such as those described above, to prepare taped lessons, and to display these lessons as well as other taped material.

The room monitor is used by nonvisually impaired students to see what is being displayed on one or more station monitors, especially when all of these monitors are being used by partially sighted students and/or the teacher. This permits the nonvisually impaired students to participate in the same group activities as the partially sighted students. Since the nonvisually impaired students can easily see what they are writing without having to bring their eyes close to the paper or the paper close to their eyes, they are able to watch the room monitor at a distance and when and if writing is called for, cope with it *visually* without any difficulty.[5]

DESIGN FEATURES

When we were designing the classroom TV system, we considered a large number of features and in many cases actually experimented with them in our laboratory. Some features were rejected because we found that their added value could not be justified from the standpoint of cost or utility, or could be accomplished by less costly means. For example, we explored the advisability of incorporating special effects equipment that would produce either an overlay of two images or a split image on a monitor screen divided horizontally, vertically, and/or diagonally. We found that for most activities expected to take place in a classroom the diagonal split was of little value, and the vertical split was distinctly inferior to the horizontal split. The success of most writing and reading activities depends more on maximizing the extent of information in the horizontal direction than in the vertical or

[4] See App. B for a description of the function of each of the controls on this unit.

[5] At least one of the educable mentally retarded but not visually impaired students prefers to sit at a table with a partially sighted student and share his station monitor. Since the classroom TV system's four stations are clustered together in a tight square and the other desks in the classroom are somewhat isolated from that square, this student's behavior may indicate a desire to be in a closer physical contact with the teacher and the partially sighted students.

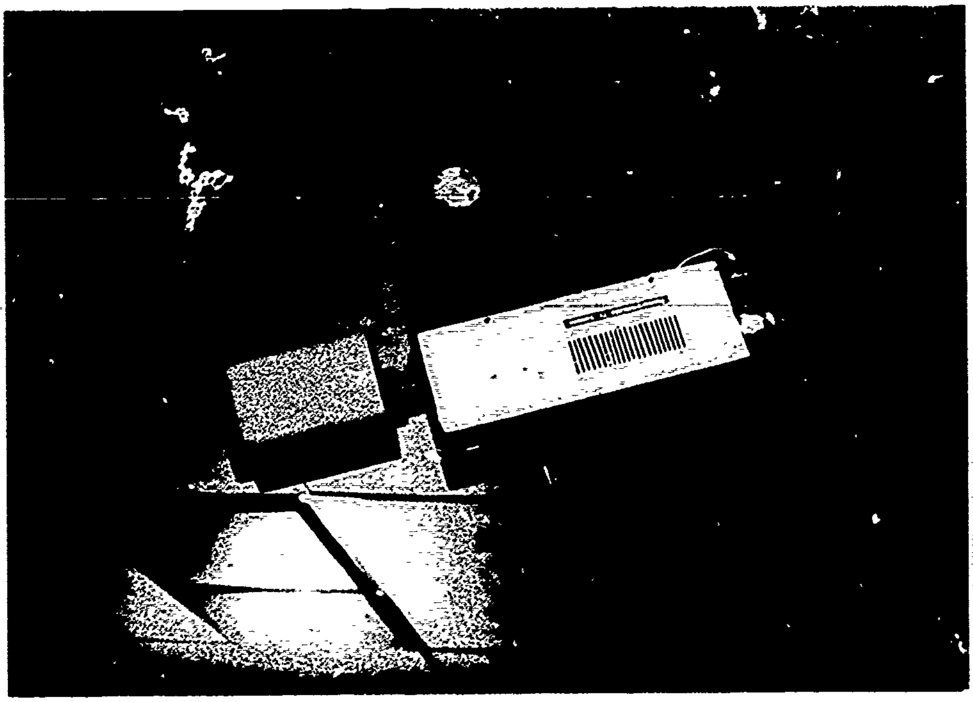

Fig. 6—The room-viewing camera

diagonal directions. We therefore decided to use cnly the horizontal split and the overlay special effects, thus simplifying instrument design and holding down costs.

Among the other features we considered and rejected were the use of color television, high-resolution cameras and monitors, and low-resolution TV equipment. Color TV was rejected on the grounds that (1) quality color is much more expensive than black and white, and (2) most of the materials used in the classroom can be seen at least as clearly with black and white TV as with color TV. High-resolution TV equipment not only would have increased system cost but also it did little or nothing to improve the ease with which most of the partially sighted can read and write with the aid of a closed circuit TV system. This is probably because most partially sighted people do not see details in letter construction, such as serifs. And yet, they can read printed and handwritten material and can write with pen or pencil with ease even when the image of that material is only sufficiently in focus to permit unambiguous recognition of individual alphanumeric symbols. Low-resolution TV equipment was rejected on the grounds that standard 525 line cameras and monitors are readily available, they provide better resolution than lower resolution equipment, and they are less costly.

The current classroom TV system was originally designed to provide two-way *visual* links between teacher and student and between student and student, and it did not include any special audio links. However, after the system had been installed and was operating in the classroom for about two months, it became apparent that at least a crude audio system would be helpful if, for example, it permitted the teacher to speak publicly with one or more students; allowed her to prepare videotapes with both visual and auditory components; permitted one or more students to listen to (via a speaker) as well as view videotaped material; and allowed a student to listen privately to such a tape recording using earphones. The audio system installed to accomplish these features is composed of two microphones (one for teacher-to-student communication and one for preparing videotape recordings), an amplifier, a speaker, and a set of earphones.

Although we make no claim that the precise mix of features that will prove to be of greatest value to handicapped children and their teacher is incorporated into the design of the current classroom T[illegible] we believe that we have included all or nearly all of the features to m[illegible] ne goal—to enable the teacher to establish and maintain continuous visual communication with her handicapped students.

III. SYSTEM ENGINEERING CONSIDERATIONS

OVERVIEW

When we decided to build the interactive classroom TV system, several basic decisions were made, reflected in its design and component parts, that were motivated by the fact that our project funds only permitted us to allocate about five months to designing the system, purchasing equipment, and carrying out construction. One such decision was to purchase whatever parts were needed and available commercially rather than to design and fabricate them ourselves, even though the latter course might have yielded parts that were better suited to our needs. Another decision was where to locate the electronic equipment. Ideally, we would have placed the electronics associated with the master control unit and the room camera control unit inside those units and connected the teacher's channel selector by cable to the master control unit. Project constraints, however, led us instead to locate all electronic equipment in a central cabinet, connected by cables to the master control unit, the room camera control unit, and the teacher's channel selector. This arrangement unfortunately increased the overall size of the system.

The major design problems faced and overcome in this effort were (1) the development of a basic control concept that the projected user could understand readily, enabling him to operate the system with ease; and (2) the development of appropriate special effects circuitry. The control concept finally incorporated into the system design evolved as a result of experience gained, using various control console patterns laid out on paper. These were used to operate an imaginary but concretely conceived classroom TV system, and to discover design flaws that should be excluded from the final design. This process not only led to the design of the present master control unit, but also to the design and inclusion in the overall system of the teacher's channel selector, which is playing a key role in the successful operation of the system.

The special effects equipment was developed along lines suggested by Stanley Patterson[1] in a conversation with Dr. Harold Petersen. The original objective was to explore the possibility of buying a low-cost special effects circuit that had only the limited capability we sought, namely, the ability to split an image equally and horizontally and to superimpose two images. Such a circuit was not available, but Patterson suggested a basic circuit approach which we tried; the circuit was built at Rand and proved to be successful. That circuit and a description of its operation is included in App. G.

SYNCHRONIZATION

The successful operation of television special effects depends on the synchronization of all input equipment, including cameras and videotape recorders. That is, all such equipment must be sending out signals at any one time that are from the same portion of their respective pictures. This is accomplished by sending two control signals from a central source to each camera to force it into synchronization with the other cameras. However, this cannot be accomplished with most of the cameras

[1] Alma Engineering, San Diego, California.

used in ordinary CCTV systems because generally they cannot be externally synchronized. We were fortunate to find a relatively high-quality and inexpensive camera with the required capability, the Shibaden HV 40S. However, we were unable to find an inexpensive videotape recorder that could be brought into synchronization with external sources. Therefore, we designed the classroom TV system so that when it was operating in the videotape playback mode, all of its components were brought into synchronization with the videotape recorder. We used the Grass Valley Group Model 940H video-processing amplifier and its companion, the 950H sync-generator. As long as no video sync signal appears at the input of the 940H, synchronizing signals are generated internally by the 950H, and they are used to drive the system's cameras and special effects logic. Once video originates from the videotape recorder, video sync signals appear at the input of the processing amplifier. The 940H-950H then locks to those signals and keeps the entire system in synchronization with the videotape recorder. Details on necessary synchronizing interlocks are given in App. H.

When playing back from the videotape recorder, we also wished to use the special effects capability with the cameras. We were warned that this might be difficult to do with a relatively inexpensive tape recorder because the mechanical wow and flutter in its tape drive system would cause changes in the horizontal synchronizing frequency and appear as an annoying waving of vertical lines in the monitor image. Fortunately, we had had prior experience with this problem and solved it by reducing the value of two capacitors in the horizontal frequency control circuit of each monitor programmed for use in the system. As a consequence, there is now almost no visible shiver and shake in the image on any of the monitors. We also observed that since all the system's cameras were to be synchronized to the videotape recorder in the playback mode, the wow and flutter caused a similar effect in the image operated by the cameras. This was corrected by a similar change in the horizontal frequency control circuit of each camera. Only very critical observation can detect the wiggle that remains, and most observers are not able to determine when the system is using the videotape recorder for sync.

SAFETY

All cabling in the system carries only low voltage (6 volts) for control purposes, and video signals are 1 volt or less. All 115-volt ac power lines, etc., are connected to a separate grounded enclosure. This separation can be noted in Fig. 1 where the box on the left rear of the camera stand contains the video and control connection to the station, and the box on the right rear contains all the power connections. Plugs are in the rear of that box to discourage inquisitive fingers. All power distribution is carried via three-wire grounding-type connectors, although the illuminator required some modification to accomplish this.

In addition, since the illuminator becomes quite hot, a heat shield was designed and incorporated that permits the user to adjust the direction of the light source and to touch any part of the shield without discomfort.

Each monitor is equipped with an integrally bonded heavy glass implosion shield. All the TV monitors programmed for use in the classroom TV system have been thoroughly checked by a responsible testing firm. This is to ensure that the monitors present no x-radiation hazard to anyone seated very close to the face plate for long periods of time. A copy of the letter from J. L. Shepherd and Associates, dated September 28, 1973, attesting to the safety of all the monitors that have been programmed for use in the classroom TV system, is reproduced in App. D.

Even the X-Y Platforms were modified to lessen as much as possible the danger of minor injuries, such as a pinched finger.

SIGNAL EQUALIZATION

In addition to requiring synchronization of all cameras, we found it very important to maintain equal signal levels from all sources to prevent one signal from dominating another. Thus, we hoped to avoid the possibility that a user might lose the image on his screen because of a weak signal. To ensure nearly equal signal levels, we have provided, to the degree possible, equal light levels from the illuminators and have adjusted the four desk cameras so they produce approximately equal output signals. In addition, the input trimmers in the electronics cabinet are adjusted so that each video input signal to the special effects circuitry is of exactly the same value when each camera is viewing identical patterns with the same settings (zoom, focus, and f-stop) on each lens. After the classroom TV system was assembled and in operation in our laboratory, we discovered that it was not advisable to depend on users to adjust the camera lens aperture accurately. We therefore added a mechanical limit to the aperture control on each of the desk camera lenses. Although some adjustment is still possible, it is limited at present to f-stops between f-4 and f-5.6. This is adequate for viewing a wide range of paper colors and backgrounds.[2] We did not choose to restrict similarly the range of openings available with the room-viewing camera. However, by adjusting the lens opening of that camera, via the room camera control unit, the teacher can produce on any monitor a split or superimposed image, one of whose components is generated by the room-viewing camera, that is well balanced and does justice to the image produced by each input source. All of the changes mentioned above have worked out well in the classroom environment.

Another difficulty that became apparent during early simulations with the room-viewing camera is what we have chosen to call "the white shirt problem." It manifests itself when, for example, the room-viewing camera is trained on a chalkboard, its lens is adjusted to produce a clear and sharp image of an area of interest on the chalkboard, and then someone wearing a white shirt or other light-colored garment enters the picture. This produces a serious degradation in the image contrast of the material on the chalkboard, so serious in fact that the material may become completely invisible. This problem was ameliorated by using a room camera that had a white peak limiting circuit and by adjusting that circuit to reject white signals that would have a tendency to overwhelm the viewed scene.

Since the room camera is not easily accessible, we provided a remote on/off switch for it, and also one for the regulation of contrast reversal. Power to the camera is turned on or off by a relay located in the ceiling near the camera. Reversal of the image contrast is carried out in a circuit contained in the switching system input board (for details, see App. I), and selection of contrast is accomplished by a reed relay on that board. Both types of relays are controlled by their respective switches on the room camera control unit.

[2] Credit for first observing this problem and proposing the limited f-stop solution is due to Stephen Strand.

IV. PROOF-TESTING THE CLASSROOM TV SYSTEM

As described earlier in this report, the interactive classroom TV system is being proof-tested in a resource room for physically and mentally handicapped elementary school children in Santa Monica, California, during the academic year 1973-74. This testing is providing valuable data concerning how such a system can be used and what features it should have to meet the needs of the teacher and her handicapped students. Initially, we regarded the proof-testing of the system as a means to determine whether (1) the system and its components operated reliably, (2) the features included in the design were useful and adequate, and (3) the teacher was able to operate the system with ease and without impairing her ability to teach. Subsequently, the enthusiastic response to the system by the teacher and her students has led us to recognize that data should also be gathered concerning each student's level of achievement, attitude toward himself and his schooling, eye-hand coordination, and attention span. Some of these data have already been collected, using various psychological and educational tests or instruments, but they were not analyzed in time for inclusion in this report. A description of the instruments that have been administered is given in App. E.

If additional funding can be obtained, we will continue to collect data during the academic years 1974-75 and 1975-76. These data, together with information obtained by the Santa Monica Unified School District before the installation of the classroom TV system in the Madison School, will provide us with a quantitative base to gain some insight as to how the classroom TV system is helping the students in Ms. von der Lieth's classroom. Since it is almost impossible to find a control group that has the same physical and mental characteristics and handicaps as those of the children in our class, we have decided to use a sort of "Lagrangian" approach, namely, to collect data on each child over time and, whenever possible, to compare his progress before and after being taught with the help of the classroom TV system. If it turns out that we can obtain reliable data on children who closely approximate individual children in our class, we will compare their educational progress with that of the appropriate students in Ms. von der Lieth's classroom and try to ascertain whether there is a significant difference. These data, together with those contained in the daily log kept by Ms. von der Lieth, will help us judge the strengths and weaknesses of teaching with the aid of a classroom TV system. The information contained in the log, as well as that which we acquire in conversations with Ms. von der Lieth and her students and from our first-hand observations in her classroom, will help us develop modifications in system design that should be incorporated into future classroom TV systems.

Ms. von der Lieth not only uses the classroom TV system to maintain continuous visual communication while teaching, but also to develop teaching techniques appropriate for use with the system and tailored to the needs of her specific students.

Appendix F contains excerpts from Ms. von der Lieth's daily log. Actual names have been replaced with capital letters in these excerpts.

Experience with the classroom TV system indicates that equipment breakdown occurs very infrequently.[1] However, project personnel are needed fairly often during the first month or two after the system is installed and operating to assist the teacher with small problems—problems that deal with human uncertainty as to

[1] Since it was installed in Ms. von der Lieth's classroom in late November 1973, the system has only been out of operation one day.

how to operate the equipment rather than with the performance of the equipment itself.

Members of our project staff meet at least once every two weeks with the teacher to keep abreast of how the experiment is progressing and to learn what problems, if any, have been encountered and how our staff might help to alleviate them. The school system has a free hand in designing the curriculum and in selecting and presenting course material. However, qualified members of our staff, when requested, assist in adapting materials for use with the classroom TV system. For example, because much oversized material is currently in use in classrooms and resource rooms for the partially sighted, it is sometimes advisable to reduce that material to normal or even smaller dimensions when using it in conjunction with our system.

The fact that our classroom TV system is being used by elementary school children and not by children at another educational level is fortuitous. Children at the elementary level probably can benefit most from it because (1) handicapped students at this educational level tend to spend more time in classrooms or resource rooms for the handicapped than those who are in junior high school or senior high school; (2) more control can be maintained over the educational environment at this level than at more advanced educational levels; (3) basic skills are taught at this level which, if thoroughly learned, give a student a sound basis for progressing to higher educational levels and if poorly learned will tend to handicap him educationally for many years and perhaps throughout his entire educational experience; and (4) less effort need be spent in assisting students to adjust to the altered educational environment created by the use of a classroom TV system at this level than at more advanced levels.

All the participating students and some of their parents and guardians have visited our RANDSIGHT Ⓣ[2] research facility at Rand, Santa Monica. This was arranged so that (1) we could become acquainted with these people; (2) they could learn first-hand about our research and our attitudes about handicapped children; (3) we could give students personal instruction on how to operate a closed circuit TV system and use it to best advantage for both reading and writing; and (4) we could make measurements, particularly with respect to visual acuity, size, and geometry of visual field and color perception and gather other data needed to evaluate the results of the classroom experiment. All data collected during these visits are treated in the strictest confidence and used only in ways where the privacy and anonymity of the students and their families are protected.

[2] RANDSIGHT is the Certification Mark of The Rand Corporation. It is a closed circuit TV (CCTV) system developed at Rand that enables many persons with severely impaired vision to read, write, and perform other operations requiring precise eye-hand coordination. Neither Rand nor the project staff has any financial interest in any company that manufactures, distributes, or sells this visual aid for the partially sighted.

V. SPECULATIVE REMARKS

Although it is too early to judge the success of our interactive classroom TV system on the basis of data collected through psychological and educational instruments administered periodically over a meaningful time span, teacher observation indicates that the system is certainly proving to be of value in teaching partially sighted students. Also, there are indications that it appears to be of help to hearing impaired and educable mentally retarded students.[1] There is no indication to date that student interest in and enthusiasm toward the classroom TV system are beginning to wane. We had thought that this might take place particularly among those students who are not visually impaired, because they were not expected to find the visual link that the system provides to be as important as it would be to the partially sighted. Even so we are not yet ready to speculate on the effect that classroom TV systems may have on the education of nonvisually impaired handicapped children. We will reserve judgment regarding those children until more test data have been gathered and analyzed.

We probably should take the same position relative to the partially sighted, but here the situation is different. We do not need the results of psychological and educational instruments to observe that with the classroom TV system, partially sighted students are able to be in continuous visual contact with their teacher in ways that commonly occur in classrooms for "normal" children. Even here, though, the validity of what we are about to say depends to some extent on how well partially sighted elementary school children learn basic skills with the aid of an interactive system. The decision as to how well they are able to perform with it should be based on the results obtained with test instruments as well as the personal observation of visual interactions between teacher and students with and without the help of the system. If we assume that our personal observations regarding the benefit of a classroom TV system are in fact supported by results obtained from test instruments, we can make some conjectures at this time: Relative to elementary education involving the acquisition of basic skills, e.g., reading, writing, and arithmetic, it *may* prove advisable to place partially sighted students in classrooms of their own and, in those classrooms, to thoroughly teach them the basic skills with the aid of classroom TV systems. Simultaneously, it would be advantageous to instruct them on how to obtain the maximum benefit from the complete range of other visual aids, such as binoculars, monoculars, and telescopic spectacles, which they may be able to use to establish and maintain visual communication with their teachers when they have acquired the basic skills and have shifted into classes primarily for nonhandicapped children.[2]

[1] Ms. von der Lieth conjectures that the small field of view of a TV camera, compared with that of the human eye, may be indirectly responsible for some of the progress her students are making in arithmetic, for example. She points out that they have become more aware of fractional parts and their relation to the whole since they have had to view, on their TV monitors, two or more parts of various pictures, for example, pictures of familiar animals (especially at large magnifications) to determine with a reasonable degree of certainty the content of the overall picture. She also conjectures that the strong affinity her students have shown toward using the classroom TV system may be due, at least in part, to the fact that when they are seated at their stations, they are less distracted and more comfortably constrained than they would be in an ordinary classroom. Although all of her students share this attraction toward and feeling of security with the system, these manifestations appear to be more pronounced among the educable mentally retarded.

[2] The eyes of partially sighted students should not only be examined periodically by an ophthalmologist but they should also be examined periodically by a qualified clinician (an opthalmologist or optome-

We recognize that suggesting that it might be advisable to have special classrooms for partially sighted students, even for only the early years of elementary education, may be viewed as a retrogressive suggestion; however, if our classroom TV system proves as successful in educating the partially sighted as we think it will, then we believe that currently accepted theories regarding the early education of the partially sighted may need reexamination. When the decision was made to move partially sighted children from special classes into integrated classes with "normals," our nation's practical technological sophistication was not as high as it is today, and hence there is reason to believe that in the light of current practical technology a modification of that decision might be appropriate.[3] Although we agree that decisions as to how we should educate our children should not be made lightly, we believe that they should be made in the light of current knowledge and with the full realization that the body of knowledge changes with time, and hence a decision that appeared to be right yesterday may not be appropriate today.

trist) who is equipped to determine whether one or more of the wide variety of optical and electro-optical aids currently available may be of benefit to such students.

[3] This statement is not only true regarding the education of partially sighted children, but is also valid regarding the education of other handicapped children. For example, the successful development in the 1960s of electro-optical to tactile reading aids, such as the Optacon, brought into question the applicability of decisions made prior to the 1960s to refrain from teaching the functionally blind how to read ordinary printed or handwritten correspondence, magazine articles, and other short pieces of conventional written material.

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Appendix A

THE MASTER CONTROL UNIT

The master control unit can be viewed as consisting of four horizontal control strips plus two OFF buttons, one of which is located at the base of the column of buttons labeled RM/MON (Room Monitor) and the other at the base of the column of buttons labeled either RECORD or REC (see Fig. 7).

Each control strip consists of a two-row six-column cluster of twelve buttons followed by a single row consisting, from left to right, of a cluster of two buttons labeled SPLIT and OVERLAY, a single button labeled RM/MON, and a single button labeled either RECORD or REC. The top row of the two-row six-column cluster consists of buttons labeled, from left to right, S-1 (Student 1), S-2 (Student 2), S-3 (Student 3), T (Teacher), RM (Room-Viewing Camera), VTR (Videotape Recorder). The bottom row of each cluster is identical with the top row in content and ordering.

The buttons of the topmost (or first) control strip are used to select the image that is displayed on Student 1's monitor (and that may also be replicated on the room monitor or recorded on videotape).

The buttons of the next two control strips are used to select the image on Student 2's and Student 3's monitors and those on the fourth strip the image on the teacher's monitor (when the C-T button[1] is also depressed).

In what follows, an explanation is given of the function of each of the labeled buttons.

S-1 Buttons marked S-1 control the display of the image being generated by the camera at Student 1's desk. S-1 buttons are grouped in pairs, one directly above the other. When both the button marked SPLIT and the top button of the S-1 pair in the same control strip are depressed, the top half of the image generated by the camera at Student 1's desk is displayed on the station monitor governed by that control strip. When the bottom button of that S-1 pair is depressed, the bottom half of that image is displayed on the monitor. For example, by depressing the RM button in the top row and the S-1 button in the bottom row, it is possible to show on a station monitor the upper half of what the room camera is viewing on the top half of the screen and the bottom half of what the camera at Student 1's desk is viewing on the bottom half of the screen.

When the button marked OVERLAY and either but not both of the S-1 pair in the same control strip are depressed, the entire image being generated by the camera at Student 1's desk is displayed on the station monitor governed by that control strip, superimposed on the entire image being displayed as a result of a non-S-1 button being depressed in the other row. For example, if in the first two-by-six array the S-1 button is depressed in the top row and the T button in the bottom, then the resulting image

[1] Described in App. C.

will consist of the superposition of the images generated by Student 1's camera and the teacher's camera.

When both of the S-1 buttons in one control strip are depressed, the entire image being generated by the camera at Student 1's desk is displayed on the same monitor as above and is superimposed upon itself. We recommend that the latter superposition be avoided unless the resulting high contrast image proves to be essential to successful viewing by a partially sighted user.

If neither the SPLIT nor OVERLAY buttons in a particular control strip is depressed, the image on the station monitor governed by that control strip will be a whole screen image of whatever has been selected in that strip's top row of buttons. For example, if in the third two-by-six array the S-1 button is depressed in the top row, a whole screen image of what Student 1's camera is viewing will be displayed on Student 3's monitor.

S-2 — The comments on S-1 buttons are applicable to S-2 buttons if we substitute "S-2" for "S-1," and "Student 2's" for "Student 1's "

S-3 — The comments on S-1 buttons are applicable to S-3 buttons if we substitute "S-3" for "S-1" and "Student 3's" for "Student 1's."

T — In this case, we substitute "T" for "S-1" and "teacher's" for "Student 1's" in the comments on S-1 buttons.

RM — Here the substitutions are "RM" for "S-1" and "room-viewing camera" for "camera at Student 1's desk."

VTR — We substitute "VTR" for "S-1" and "videotape recorder" for "camera at Student 1's desk."

SPLIT — As described in the comments on S-1 buttons, when the button marked SPLIT is depressed, a horizontally split image of what is selected in the two-by-six button array appears on the station monitor associated with that control strip.

OVERLAY — As described in the comments on S-1 buttons, when the button labeled OVERLAY is depressed, the image of what is selected in the top row of the two-by-six array is superimposed on what is selected in the bottom row. The superposition of those two images is displayed on the station monitor governed by that control strip.

RM/MON — Each of these buttons when depressed displays on the room monitor the information being displayed on the station monitor governed by the same control strip. See the comments under S-1 buttons.

OFF — When the OFF button at the foot of the column of RM/MON buttons is depressed, all the RM buttons return to their up positions, and no image will appear on the room monitor.

RECORD or REC — Each of these buttons when depressed causes the videotape recorder to record the picture that has been selected by the control strip occupied by the depressed RECORD or REC button. However, recording will not begin unless the videotape recorder is turned on and set to "record."

When recording from any channel, the room monitor is automatically switched to display the output from the videotape recorder. This provides a check on the recording process. Further, when any RECORD or REC button is depressed, all of the VTR buttons in the two-by-six arrays are made inoperative.

OFF

When the OFF button at the bottom of the column of the RECORD or REC buttons is depressed, all the RECORD or REC buttons return to their up positions, and no signal will be fed to the videotape recorder.

Appendix B

THE ROOM CAMERA CONTROL UNIT

The room camera control unit governs the operation of the room-viewing camera. This control is carried out via a lever arm (called a "joy stick"), several switches, and a knob projecting from the upper face of the control unit (see Fig. 8).

The most prominent feature on the upper face of the control unit is a lever arm set in a circular depression near the top and center. The joy stick controls the pan and tilt of the room-viewing camera. When pushed to the right, the room-viewing camera rotates to the right, and when pushed to the left, the camera rotates left. When it is moved toward the top edge of the control unit, the camera rotates upward, and when it is moved toward the bottom edge, the camera rotates downward. When we say that the camera rotates in a particular direction, we mean that its front or lens-end moves in that direction. The speed of rotation in any of these directions is proportional to how far the lever is pushed in that direction.

When operating the control unit, caution should be exercised to avoid permitting light to fall on the camera's vidicon tube, because this may result in permanent damage to the tube. Thus, it is particularly important to avoid under any circumstances pointing the camera in the direction of the sun, and to avoid directing it toward bright fluorescent lights or toward a daylight scene unless the iris of the camera's lens is sufficiently closed (stopped down).

Just below the joy stick is a row of three switches labeled from left to right IRIS, FOCUS, and ZOOM. These switches can be pushed from their normal central "off" position toward either the top or bottom edges of the control unit.

When the IRIS switch is pushed upward, the iris in the zoom lens opens, permitting more light to enter the room-viewing camera; when pushed down, the iris in the zoom lens closes. When viewing a dark scene, it may be advisable to increase the opening in the iris, and when viewing a bright scene, to decrease that opening.

When the switch labeled FOCUS is moved downward, the camera focuses toward more distant objects; and when it is moved upward, it focuses more clearly on nearby objects. By manipulating this control, the camera can be made to focus sharply on any object more than four feet from the exposed end of its zoom lens.

When the switch marked ZOOM is moved upward, the image of any given object is magnified, and when it is moved downward, the image is minified. Using this technique the zoom lens can be controlled remotely over its entire 10 to 1 zooming range. Thus, if on a particular monitor screen, the image of the teacher's face is 1 centimeter wide when the zoom lens is set at the minimum of its magnification range, that image will be 10 centimeters wide when the lens is zoomed in to the maximum of its range.

Below the row containing the IRIS, FOCUS, and ZOOM switches is another row of controls: a two-position switch labeled POS (positive) above, NEG (negative) below; a circular knob labeled SPEED; and a switch labeled POWER. The POS/NEG switch is used to reverse contrast in the image generated by the room-viewing camera. When that switch is in the POS position, the image coming from the room camera has a conventional gray scale—white objects are white and black objects are black. When the switch is in the NEG position, the image has a reversed gray scale—white objects appear to be black and black objects to be white.

The knob labeled SPEED controls the speed with which the iris in the zoom lens opens and closes, the rate at which the zoom lens changes focus, and the speed with which the lens zooms, i.e., changes its magnification. Each of these three operations is actually activated as previously described by its appropriate switch, IRIS, FOCUS, or ZOOM.

The switch labeled POWER turns the room-viewing camera and its remote camera control unit on or off. When the power switch is on, a red light is illuminated just above the switch.

Appendix C

THE TEACHER'S CHANNEL SELECTOR

The teacher's channel selector consists of four buttons arranged in a single row and labeled, from left to right, C-1, C-2, C-3, and C-T. Given below is an explanation of what each of these buttons do when depressed:

C-1	The image that is displayed on Student 1's monitor is replicated on the teacher's monitor.
C-2	The image displayed on Student 2's monitor is repiicated on the teacher's monitor.
C-3	The image displayed on Student 3's monitor is replicated on the teacher's monitor.
C-T	The image programmed by control strip 4 is displayed on the teacher's monitor.

Appendix D

COPY OF SHEPHERD LETTER REPORTING ON X-RAY MEASUREMENTS

JL SHEPHERD and Associates

703 So. Pacific Avenue, Glendale, California 91204 • 213/245-0187

Irradiation Equipment • *Counting Systems* • *Nuclear Applications*

September 28, 1973

Rand Corporation
1700 Main Street
Santa Monica, California 90406

R E P O R T

MEASUREMENT OF X-RAYS ASSOCIATED WITH CLOSED CIRCUIT VIDEO MONITORS

The equipment checked was as follows:

Model	SNA-9C	Serial	244247
	SNA-14C		244549
	SNA-17C		244711
	SNA-17C		244740
	SNA-14C		244564
	SNA-17C		248494
	SNA-17C		248385

Instrumentation:

The instrumentation used to measure the emergent radiation from the above listed units was a Shepherd and Associates USM-1A rate meter, complete with SP-12 GM p robe with window thickness of 1.4 mg/cm^2 and a window diameter of one square inch. The efficiency of the SP-12 probe is 2.5% as measured against a ^{55}Fe (5.9 kev. photon energy standard manufactured by Isotope Products Laboratories, with calibration traceable to National Bureau of Standards.)

Measurements:

No detectable radiation was found at any point on any unit. The sensitivity of the instrument was such that 80 counts per minute net count rate above background could easily be determined. Each unit was scanned with 100% coverage on all six surfaces. In addition, backs were removed from the instruments and a survey made on all accessible internal parts.

82 counts per minute net (per square inch - the area of the detector - and a detector efficiency of 2.5%) represents a radiation field of 0.00032 mr/hr for 19 kev. X-rays.

Conclusions:

We can conclude that the external radiation levels at the surface of all instruments was significantly less than 5% above normal background. This means that an individual with his face pressed against the front plate of the monitor for an average of 16.8 hours per week for a one year period would receive significantly less than 0.5% additional radiation above normal background to the eyes or other vital organs.

J. L. Shepherd, Health Physicist

JLS:cp

Appendix E

PERFORMANCE TESTS

To measure the effectiveness of our interactive classroom TV system in the Madison School, Santa Monica, California, the following nine instruments were administered to the physically handicapped and mentally retarded children. These instruments were used to assess ability, achievement, perception, attitude, and behavior. They were given in February 1974 and again in June.

MEASURES OF INTELLIGENCE

Verbal Opposites (from the Detroit Tests of Learning Aptitude). A measure of verbal ability, in which the subject is required to furnish the opposite of a series of words.

Slosson Intelligence Test. A verbal measure of intellectual functioning that correlates highly with such instruments as Stanford-Binet and Wechsler. The test measures an individual's vocabulary, level of information, fund of information, logical thinking, problem-solving ability, immediate auditory memory, and aspects of perceptual motor functioning.

Goodenough-Harris Draw a Man Test. A nonverbal measure of intellectual maturity. Although human figure drawings have been interpreted psychodynamically by clinicians, this test was used here only as an intelligence measure. The individual's drawing ability is not under consideration, but rather his concept of the human body.

ACHIEVEMENT TEST

Wide Range Achievement Test. The most widely used measure of academic achievement, with norms for all ages from preschool level to college graduate level. Three areas are covered: reading, spelling, and arithmetic. Raw, grade placement, percentile, and standard scores are reported.

PERCEPTION TESTS

Wepman Auditory Discrimination Test. A measure of hearing accuracy. The test determines the ability to recognize differences existing between phonemes used in English speech. The child is asked to listen to the examiner read pairs of words and to indicate whether the words read are the same (a single word repeated) or different (two different words).

Berry and Buktenica Visual Motor Integration Test. A measure of a child's visual-motor ability. The test measures the degree to which visual perception and motor behavior are integrated through a series of 24 geometric forms to be copied with pencil and paper.

SCHOOL ATTITUDE MEASURES

Child School Attitude Survey (Behavior Rating Scales). An instrument designed to measure the student's feelings toward his school program, i.e., what things he likes and dislikes about school and what things teachers can do to make school more enjoyable. Each child is given an answer sheet with a series of paired names. Twenty-six statements are presented one at a time with the instruction "Circle the name of the student you are most like or feel most like."

Burks' Behavior Rating Scale. A 5-point observation scale indicating maladaptive behaviors in the vegetative-autonomic area (hyperactive and restless), the perceptual-discriminative area (confusion in spelling and writing), and the social-emotional area (often tells bizarre stories). The higher the score, the more deviant the behavior.

Madison Plan Placement Inventory. A teacher rating developed for deciding on the most appropriate placement in the Santa Monica Unified School District Learning Center. The instrument indicates the degree of readiness for regular classroom functioning.

Appendix F

TEACHER'S LOG, NOVEMBER 1973–APRIL 1974

The entries below are taken from the log in which Ms. J. von der Lieth records daily how she and her students have used the current interactive classroom TV system, what problems they have encountered, and what successes they have had. Capital letters have been substituted for student and other names where the entry contained such names. A brief description of each child and adult mentioned in the entries follows and should make those entries more meaningful to the reader.

A is 6 years old and partially sighted. The visual acuity in his better eye is about 20/1200.[1]

B is 8 years old. He is partially sighted, speech impaired, and educable mentally retarded. The visual acuity in his better eye is 20/80.

C is 9 years old. She is partially sighted and shows the effects of cerebral palsy on her right side. The visual acuity in her better eye is about 20/160.

D is 11 years old. He is educable mentally retarded.

E is 12 years old. She is educable mentally retarded.

F is 9 years old. She is functionally deaf.

G is a student teacher of the visually handicapped.

H is 8 years old. She is profoundly deaf.

J is 9 years old. She is partially hearing.

K is 11 years old. He is functionally blind.

L is 7 years old. She is educable mentally retarded and educationally handicapped.

M is a volunteer teacher's aid.

TEACHER'S LOG

11-26-73: First day of operation.

11-28-73: Most of my students can read independently now—and are able to maneuver their X-Y Platform while reading. I still need to work directly with B, D, and E on how to center their material and maneuver the platform.

11-29-73: The room camera is working out well. I use it all the time—for puppet shows, board work, and lessons in front of the class.

11-30-73: I videotaped a lesson today, and it worked perfectly. I played it back for the class to see—they loved it. I'm trying something new with A. He has been having trouble participating in our art lessons, mainly because he can't see what he is doing. I tried letting him use his CCTV, and now he can see what he is cutting and drawing. He seemed to feel more successful and is anxious to continue using the CCTV.

[1] Visual acuity is usually expressed as a nondimensional ordered pair of two positive integers. The second member of the ordered pair gives the furthest distance at which a "normally sighted" person can resolve a test symbol of a given size and style. The first member of the ordered pair gives the furthest distance at which the tested subject can resolve the same test symbols. For example, 20/1200 can be interpreted to mean that symbols of a given size and style that a "normally sighted" person can just resolve at 1200 feet cannot be resolved by the subject at more than 20 feet.

A is beginning to realize how useful his CCTV is. I had to move him to the art center for a group activity and he made the comment that he couldn't do the task without his TV—he's probably right.

12-3-73: We tried a great lesson. I brought in labels from some cans and jars. I enlarged them enough so the class could read them. I'll bet they never were able to read them before—these machines are fantastic. Anyway, we discussed the contents and ingredients. I asked them to find the weight in ounces. Afterward, we drew pictures of the labels, and I'm going to have them paste them on their own cans. They enjoyed this.

The CCTV enables my class to do so much. A can now use scissors more proficiently—and is able to see what he is cutting.

Fantastic! We tried lots of new things—tracing Santa Claus using sticker books under the lens. Even A could see what he was doing.

12-5-73: A relatively good day. We had lots of activity. The class is doing amazingly well. All of them can read with the X-Y Platform. I keep questioning them on how to operate their CCTV system so they can learn how to use the system independently.

12-7-73: I used the room camera and blackboard to explain the concepts "in the box," "on the box," and "under the box." Dumbo (a puppet) assisted the class. They *watched* Dumbo place a plastic toy in the box, on the box, or under the box. Eventually, they wrote the phrases on their own paper—according to where they saw Dumbo place the toy.

We tried another lesson. The class was given a piece of paper with different parts of a face to cut out and paste on an outline of a face. A, with the assistance of his machine, could actually see some of the smaller pieces and could cut them out and place them in their proper place. Even my slower students feel more comfortable using the CCTV to do this task.

12-11-73: A fun lesson—Reading Train. I made a train on the blackboard with words written in the cars. As the room camera followed the train (words), the train appeared to move forward or backward. It proved to be very successful.

1-14-74: C has been working very hard. She is learning division now, so I've been using the split image with her. It works well, because she can see the problem and do the work on her monitor. I also use the split image with D and C when they are practicing their multiplications. I use my screen to write the following:

	4	8	10	6	3	2
× 2						

Then C and D write out the problem or answer on their screen $2 \times 4 = 8$, etc. It saves me time because I don't have to copy the complete problem. You can also use an overlay with the same chart.

1-18-74: I used the videotape machine today and we taped a sequence similar to yesterday's lessons. After a half-hour, I played it back. It was so exciting for the class, because we now have sound with the video; and now they can hear themselves! It was a good lesson, and you could hear their responses clearly.

I also worked with F today. She came in for a reading lesson, and I used one of the puppets. She loved it and I even let her come up in front of the room camera and work Dumbo. Because she is deaf, she needs intensive drill in speech patterns and phonetic sounds, and the puppet is a great motivational device (so are the machines).

I found out something useful when I played back the tape. Many times my directions and instructions to the class are not explicit. This is something I had not realized, and something which I'd like to improve. The audio portion of the videotape may prove significant in helping students and teachers become better.

1-21-74: We practiced some handwriting and I noticed that my handwriting sheets are not printed dark enough and consequently the image is not reproduced.

1-25-74: Today during reading, B refused to read. It was only after I suggested that we use the CCTV that he enthusiastically changed his mind. He read for 20 minutes without stopping and seemed to enjoy it. I feel the machine is an important motivational instrument for D and it allows D to see his results immediately. He can feel successful with the machine, and it enables him to share his ideas and answers with the rest of the class. D and E especially need close interaction with other people.

1-28-74: We started a unit on animals and the class seems very excited about it. I read them a story using the CCTV and I realize the importance of having sound. The whole class can hear me now and I don't have to stand while I read the story. (I used to have to stand when we didn't have the microphone, because no one could hear me sitting down—hidden down under all the machines.) I showed them the pictures, and afterward I let them trace some of the pictures of the animals.

1-29-74: I let D monitor the control box today during phonics. He did very well, and he paid close attention to not only his task but also our phonics lesson. This may prove to be a very conducive situation for D since he usually has difficulty working in small groups.

1-30-74: The class earned some free time so they decided to play games using their machines.

C and A read independently today and they both did very well. A loves to read and is now able to select a book from the library and read it using his CCTV.

2-4-74: During math, I put 4 problems on the board, and then I had individual students come up and work the problems. I used the room camera—it's a great way to keep everyone involved and, also, individualizes their math.

2-5-74: During phonics, I let B work the remote control (of the room camera) and he was fantastic. He was able to maneuver the controls and I didn't have to give him very many directions.

2-7-74: A has progressed very quickly in reading. He has finished *Around the City* and he is now using the Bookmark Series. D is also using a new reading book.

2-8-74: I have tried keeping D at the machine for longer periods. He is able to concentrate on his work more easily, and does not tend to get out of his seat as often.

. . . we tried something very interesting. I showed the class different pictures of animals from a variety of food containers. We discussed how an animal can look quite different in one picture, and in the next picture the artist's rendition of the same animal may just resemble what we imagine it to look like. Is that confusing? Anyway, animals look dissimilar in different pictures, so we decided to make composite animals! I had the class draw pictures of animals that were a combination of two animals, such as snake-rabbit, kangaroo-mouse. The children would draw an animal that had characteristics from both animals. Some of the class used their machines, and the sighted students drew their pictures at their desks.

I use C as a helper once in a while. She works well with both B and A and they seem to respond to her.

2-14-74: I worked individually with each student today, and I'm so pleased with everyone's enthusiasm and cooperation. We found that the split image works well with both C and A because with it I can correct their problems immediately.

2-15-74: G came today and I spent some time with her explaining the CCTV system. She is picking it up very quickly. I gave her a few minutes to work on the machines by herself, while I worked individually with A and B.

2-19-74: H came in today. We worked on handwriting and I had her write the two letters c and b. Then we drew pictures of objects that began with these letters. She used the machine, and as she drew the pictures she remembered to look into the monitor.

2-20-74: During math, C played a multiplication game (using her CCTV).

We had a group lesson today, and A worked the remote control. He enjoys it so much, and he still concentrates on his phonics lesson.

F came in today, and we worked on a lesson about "opposites and alikes." I would say two words and F would repeat them and then say if they were opposite or alike. Then we tried a game where I would say a word, and F would tell me the opposite of it. She did very well and she was able to respond correctly most of the time. We've also been working on certain sounds that she had trouble with.

2-22-74: H worked at my station and I tried the game "opposite or alike" with her that I played with F on 2-20-74 and with J on 2-21-74. H understood how to play the game, and she could answer some of the questions. I also checked her out on the CCTV to see if she knew how to turn on the light source. She could perform most of the tasks, but for a moment she mixed up the brightness and contrast control knobs.

For our math lessons we did a group activity on fractions. I used the room camera to focus on the board, and I had the class come to the board and work on some problems involving "sections" (or fractional parts) of a pie, for example, 1/4, 1/2, 3/4, 2/3, 1/3. For a follow-up task, I had the class do a worksheet on the topic.

2-25-74: Today I read a story about the circus. Afterward, I had each student draw a picture about the story and write his own story. When they were finished, they shared their work with the rest of the class via their TV.

During math I showed the class samples of some clocks on their CCTV. I had made them out of paper plates and some of them have animals, suns, or snowmen in the background. Afterward, the class began to make their own clocks.

Phonics: We played a word game using flash cards. C worked the remote control of the room camera. I had each student come up, one at a time, and hold up a picture, and when a student knew the word that went with the picture, he would raise his hand.

2-27-74: During math, E complained that she couldn't do her work. I moved her to my monitor, and she completed every problem correctly! Many times she feels alienated from the group because her regular seat is separated from the rest of the class. Once she is moved to one of the monitors, she feels that she is part of the class and will finish her work.

We played hang-man during phonics. I thought of the words, and I would ask each student, one at a time, to guess a letter. I used the room camera focused on the board, so the class could see the letters and words.

2-28-74: We used the room camera to focus on the puppet stage, and K gave us a short puppet show about the Three Fives. He did a great job, and the rest of the class watched on their monitors. I had no idea how successful the puppet stage would be!

I sent A to the learning center to work on a puzzle, and then I realized he couldn't see the pieces and couldn't distinguish between the parts of the puzzle. We moved the puzzle to his monitor, and he was able to complete the puzzle.

3-1-74: G came today. She seems a little timid about using the machines. I guess they seem overwhelming, especially since she only works on the machines once a week. I reassured her that they are very simple to maneuver and I let her work with A on my monitor so she can get used to the system. A was very helpful, and he showed G how to maneuver the X-Y Platform during reading and writing.

3-4-74: We tried something interesting today. I found a ladybug on the playground, and we decided to watch the bug under A's camera lens. It proved to be quite exciting, and we could see the bug so clearly.

F came to our room today. I let her play some of the word games by herself. I wanted to see if she could work independently on the CCTV. She can work by herself and she remembers to watch the monitor while she reads and writes.

3-5-74: A, B, E, and I played a word game on the CCTV. I would write the beginning sound of a word and each student would try to figure out the word. When we finally filled in the blanks to complete the word, it would show up on my monitor.

The class worked in their workbooks and I am so impressed with B's progress. He is able to complete four pages in his workbook at one sitting independently, and this is quite an improvement from what he was able to do previously. In the beginning of the year, he couldn't complete one page by himself before he became restless and frustrated.

3-6-74: During storywriting, we shared a book on animals. Afterward, we began to draw some of the animals on butcher paper. We used A's camera to look at certain animals, then the class would draw them. If there wasn't a picture of an animal one of the students wanted to draw, I had them look up the name of the animal they wanted to draw in our (picture) dictionary. This gave the class a chance to practice their dictionary skills.

I let A maneuver the remote control during phonics. We reviewed the ar/ir/er/ur/or sounds. A seems to concentrate longer when he is in control of the room camera. He feels that he has a responsibility to the class, and he works very hard to maneuver the room camera correctly.

3-7-74: I taped a lesson this morning on one of the stories we've been reading. The videotape machine is working perfectly and the class seems to enjoy viewing the tape of the book on their monitors.

During math I used my monitor to show two adjacent even or odd numbers. Then I had the class write the number that comes between them. All of the children could do this. B was so proud of himself when he got all of the problems of this type right.

3-8-74: We played a word game where the class thought of words that began with b, r, and c. They shared, one at a time, their word with the aid of the machine. B worked the controls and he is becoming quite proficient.

3-13-74: Some of the class have difficulty in telling time, and when such a student doesn't know the answer, I just push a button and he can view his classmate's correct answer. *This is something that you can't do in a regular classroom.*

3-18-74: C ran the control box during phonics. I asked the class to make sounds with one of the short vowels and a consonant, for example, "ap." Then the students, one at a time, came up to the board and made up their own combinations.

H came to our class today and I let her view a story on the videotape. Afterward, I asked her questions about the story.

3-19-74: I let E maneuver the room camera—she always feels so good about herself when she has a responsibility and can run the control box.

3-21-74: We showed a group of visitors some of the things we do using the CCTV. We had some good group activities using our clocks. I had the class fill in the correct time after viewing a clock. They did very well.

3-22-74: I was absent, but the class helped the substitute use the CCTV. They showed her how to focus the lens and which buttons to push.

I feel they can work independently now, and they are able to maneuver their own system.

3-25-74: The class finished their animal pictures. They learned how to make animals from an egg shape. A used his monitor to view the animals and then he would draw from memory.

3-26-74: F came in the room today. She read a story on the machines and afterward I asked her questions about the story. She responds quickly when she knows the answer, but if she doesn't know the answer she becomes very restless. Her attention span is very short, and she becomes frustrated when she can't recite a word or answer. The machines seem to hold her attention, but she is not able to work independently at this time.

3-27-74: I let the class use the puppets during reading. We've been reading a story about a giant and some magicians so the class wanted to act out certain parts of the book. I used the CCTV room camera to focus on the puppet stage, and some of the students preferred to watch the show via their own monitor.

Math: I have put together a workbook for each student so that during math III they can work on problems that represent their level of work. It also provides extra drill and practice on certain concepts they are studying. Each student can work independently in his book using the CCTV.

3-28-74: We have a new girl in the class—L. She's an EMR/EH, and seems to be very slow. She is a nonreader and is doing basic readiness tasks. I introduced her to the machines and she seemed very motivated and caught on very quickly. She knows how to turn the machine on and off and she can adjust the contrast/brightness knobs. I have not taught her how to maneuver the X-Y Platform as yet.

3-29-74: During reading, I used an initial consonant task. The class had to place the correct initial consonant in the box after viewing a picture of an object. I let the members of the class view each other's answers and it proved to be extremely helpful to our new student L. She doesn't know the alphabet yet and can only write one letter, the letter P.

4-2-74: During handwriting, I had most of the class practice the letter r. L used my monitor and I wrote the letter a. She has great difficulty in forming her letters, and I'm not going to have her begin handwriting until she becomes more proficient in carrying out discrimination. matching, and recognition tasks. She does, however, seem to respond to the machines in a positive way, but her attention span is very short—about 1 minute.

E was having a rough day so I let her work at one of the stations all day. She calmed down and she was able to participate during phonics.

4-3-74: M, a volunteer who has offered to help us, came today. I had her work with A, E, and B. I showed her a few things on the CCTV, but I didn't explain the system to her. I wanted her to become acquainted with the class before I went into detail about the CCTV.

4-5-74: L is doing better. She seems to understand how the machines work but her retention is very low. She has managed to remember some of the basics about how to turn the CCTV on and off.

Appendix G

SPECIAL EFFECTS CIRCUIT

This appendix describes in detail the special effects circuit and the camera selector circuits controlled by each two rows of six buttons labeled S-1, S-2, S-3, T, RM, and VTR that the teacher uses to select what will be seen on her monitor or on one of the student monitors. Since the system has what can be thought of as four independent channels, the circuitry we are referring to is repeated for each channel.

In Fig. 9 we have shown, schematically, the arrangement for selection of sources by each of the two-by-six arrays of buttons that are located on the master control console and connected by cable to the appropriate points in the electronics cabinet. The upper half of the circuitry in Fig. 9 will be referred to as video select 1 and the lower half of that circuitry will be called video select 2. When a button in the upper row, for example, an S-1 button, is pushed, the closing of that contact supplies 5 volts to the coil of the relay to which it is connected. Closure of the relay contact allows the video signal from the camera at Student 1's station to be carried to the input of the field effect transistor (FET) switch (Signetics DG 187). Each row of six pushbuttons is mechanically interlocked so that only one button in a row may be down at a time. Video select 2 operates in the same manner but is controlled by the lower row of the two-by-six array of pushbuttons for each channel. Since the six pushbuttons in each row are mechanically interlocked to prevent more than one button being down at a time, only one source will be selected for video select 1 and only one (though it may be different) for video select 2.

The selected signals then pass through the FET switch if it is enabled by the special effect control signals. Assume both switch 1 and switch 2 are enabled as when the overlay special effect is chosen as shown in Fig. 9. Appendix I contains a description of how the special effect control signals are generated. In this case, each video signal is applied to the input of its own "Darlington"-type amplifier D1 or D2 as shown in Fig. 10. The outputs of D1 and D2 are tied together through the two 200-ohm resistors and the 100-ohm balance control. The signal from the wiper of the balance control that contains the sum of the two video signals is then applied to the high input impedance of D3. The output signal from D3 is coupled through a capacitor to a gain control potentiometer followed by the amplifier section A to make up for the signal loss up to this point as well as the loss in the output amplifier.

The horizontal drive signal is inverted and used to control the dc level of the signal at the base of the output drive transistor to a value determined by the set-up potentiometer.

The signal from the drive transistor controls two separate output transistors. The output from the upper one shown in Fig. 10 is connected directly through a coaxial cable to the television monitor associated with the channel being controlled. The other output is routed to the "output" board (see App. H for details concerning that board) where it may be directed to the teacher's monitor, the room monitor or the videotape recorder, or any combination thereof.

We have explained how the overlay effect is achieved, namely, by adding together the two selected signals that were allowed to pass through their respective FET switches. Suppose we were to turn switch 2 off by removing its control signal. Internally the FET switch 2 will then, in effect, open the switch (shown in Fig. 9) connected to pins 1 and 2 and will close the switch shown connecting pins 9 and 10.

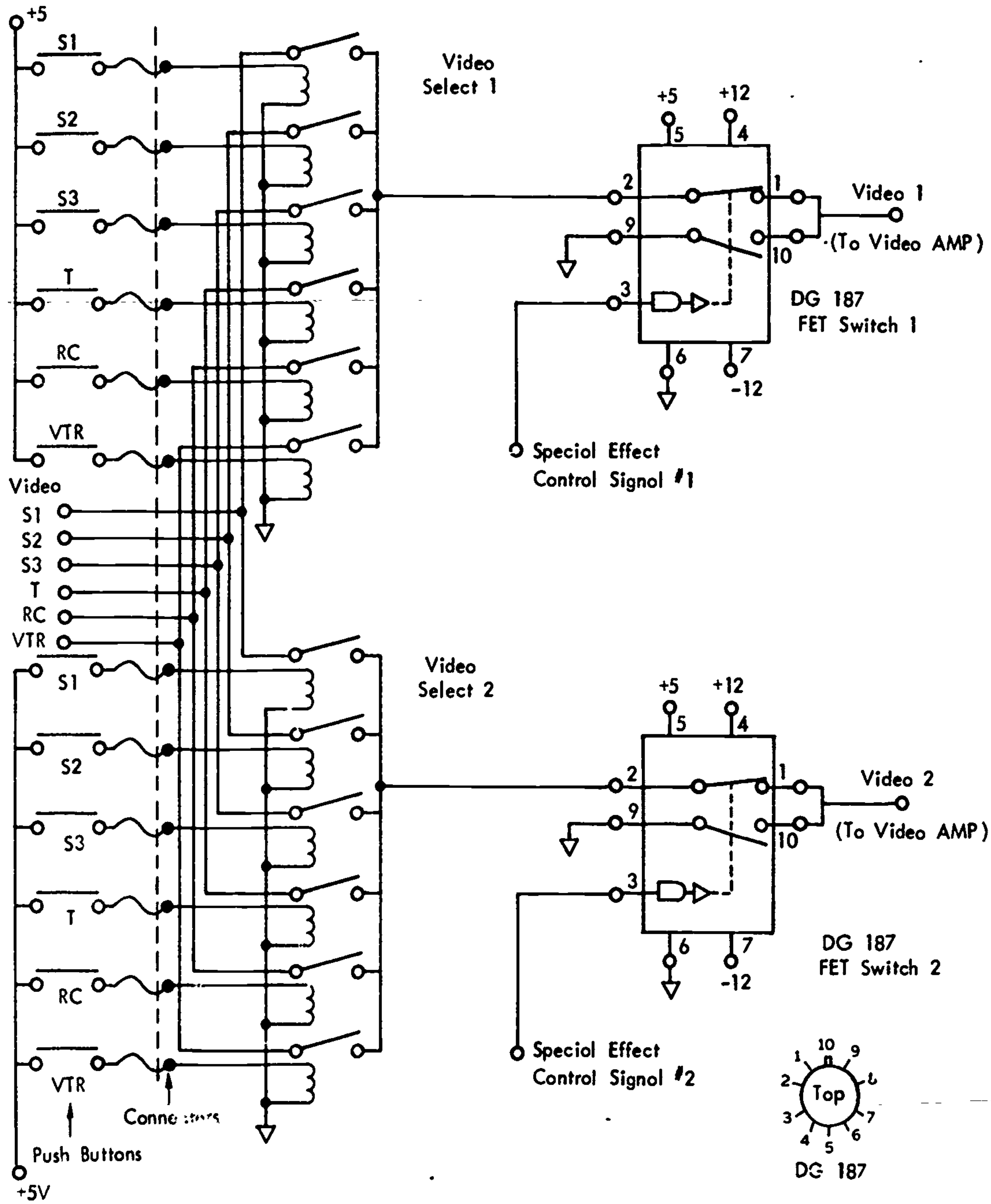

Fig. 9—Video select section of channel board

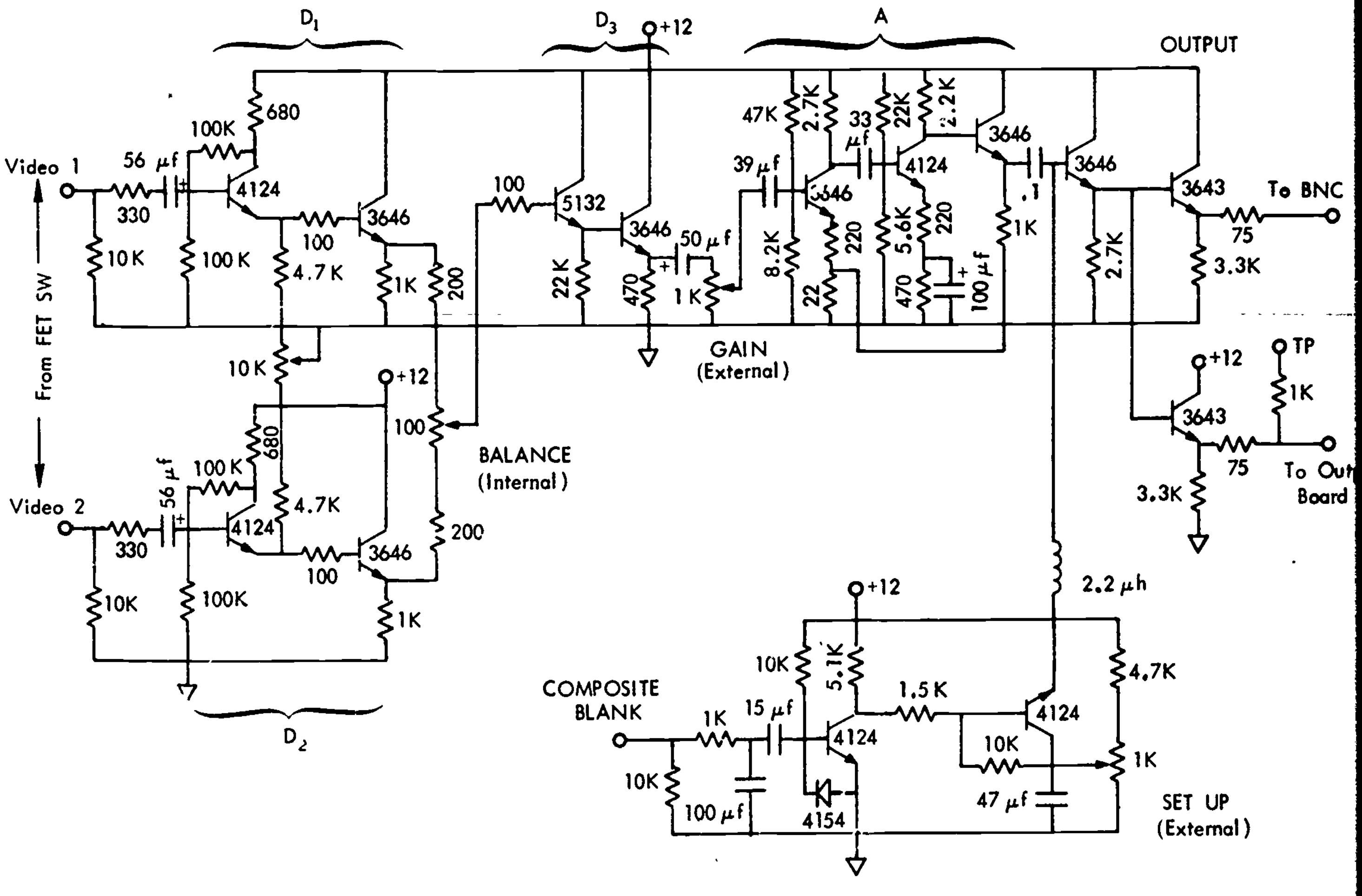

Fig. 10—Video mixer and amplifier section of channel board

Now, instead of seeing video signals from video select 2, the output of FET switch 2 is connected to ground through pin 9. Remembering that the effect of the following electronics is to add the signals from both video 1 and video 2 shown in Fig. 9, we are now adding the video signal from 1 to the absence of a signal from 2. The result is that the output sent to a monitor, etc., will contain only the signal chosen by video select 1.

Of course, if we now turn FET 2 on and turn FET 1 off, the monitor will receive only the signal selected by video select 2. Since the picture on a monitor is painted line by line starting from the top of the screen, if we start out at the top with only video 1 signals present (i.e., FET switch 1 "on" and FET switch 2 "off") and then when the picture is half way down from the top we reverse the situation (i.e., 1 "off" and 2 "on"), we will obtain a split screen image. Of course, when the picture is completed and painting begins at the top again, the switches must be reversed so that the signal source is again from video select 1. (The FET switches used can be turned off or on in a very small fraction of a microsecond and, if desired, could be used to provide a screen that is split by a vertical line. However, this effect was not deemed necessary to the classroom TV system and has not been provided. But it could be added at small expense.) The logic used to generate the special effect control signals is explained in App. I.

FOUR CHANNELS

We have just described how the special effects for one channel are accomplished. To provide four independent channels, the circuitry to the right of the dashed line marked "connectors" in Fig. 9 and all of Fig. 10 was duplicated on five separate (four operational and one spare) plug-in circuit boards that could be plugged into a set of four sockets in a plug-in rack within the electronics cabinet. The control wiring from the control console was then attached as appropriate to activate the video select relays. Each channel is controlled by the circuits plugged into its particular location. These circuit boards may be interchanged with no effect on the performance of the system and, as mentioned above, one is available as a spare for quick substitution should one of the others fail while in operation.

CIRCUIT PERFORMANCE

The circuit shown in Figs. 9 and 10 can provide output signals of up to 2 volts into a 75-ohm load without saturation. In one test, a color signal from the videotape recorder was sent through one of the channels to a color monitor we had borrowed for test purposes. The color quality resulting from this test was as good as that which occurred when the VTR was driving the monitor directly. A split screen presentation combining a color with a black and white picture resulted in no apparent color degradation. In the overlay mode, a black and white picture with a large white background tended to wash out the color scene. However, in this case, the use of negative contrast in the black and white camera eliminated most of the desaturation effect.

Appendix H

SYSTEM OUTPUT AND INTERLOCK BOARD

Appendix G described the special effect board for each of the system's four channels. Each of these is designed to control the image that appears on a station monitor. As pointed out in App. G, one of the two identical but separate outputs from each channel board is connected directly by cable to the station monitor associated with that channel; the other output is connected by internal wiring to the output board. We will now describe how the output board controls what appears on the teacher's monitor and on the room monitor and what is sent to be recorded by the videotape recorder. In addition, certain synchronizing interlocks required for VTR operation in both the record and playback mode will be discussed.

TEACHER'S CHANNEL SELECTOR

As mentioned in the body of this report, the teacher's channel selector enables the teacher to quickly see the image available on any one of the four channels by merely depressing the appropriate pushbutton. The upper set of four switches shown schematically in Fig. 11 corresponds to the four pushbuttons on the teacher's channel selector. The video signal from each of the four special effect channels is brought, via internal wiring in the electronics cabinet, to the four points labeled video 1, 2, 3, and T, respectively, shown slightly to the right of the switches in Fig. 11. Each is terminated by a 75-ohm resistor at that point.

If a pushbutton, C-1 for example, is depressed (mechanical interlocks allow only one of the four buttons to be depressed at any time), the coil of its associated reed relay is energized. This closes its contact and connects the signal on video 1 to the input of the output amplifier that drives the coaxial cable connected to the teacher's monitor. If the teacher then selects any other channel, say C-3, the mechanical interlock will release C-1, thereby de-energizing its relay, and on closure of the contact for C-3 will energize its reed relay sending the video from channel 3 to the teacher's monitor.

ROOM MONITOR CONTROL

The room monitor control buttons located on the master control console allow the teacher to control what appears on the room monitor in a manner very similar to that used in the teacher's channel selector. Thus, if the teacher selects the room monitor button corresponding to channel 1 on the master control console, the mechanical interlock releases any previous selection and the relay for channel 1 will close, sending channel 1 video to the room monitor output amplifier.

The one exception to this rule occurs when a REC or RECORD button on the master control console is depressed. In this case, the room monitor will automatically display the output of the recorder while it is recording. This was done to provide the teacher with a visual check on whether the recording process is proceeding as expected. For example, if she forgets to put the videotape recorder into its RECORD

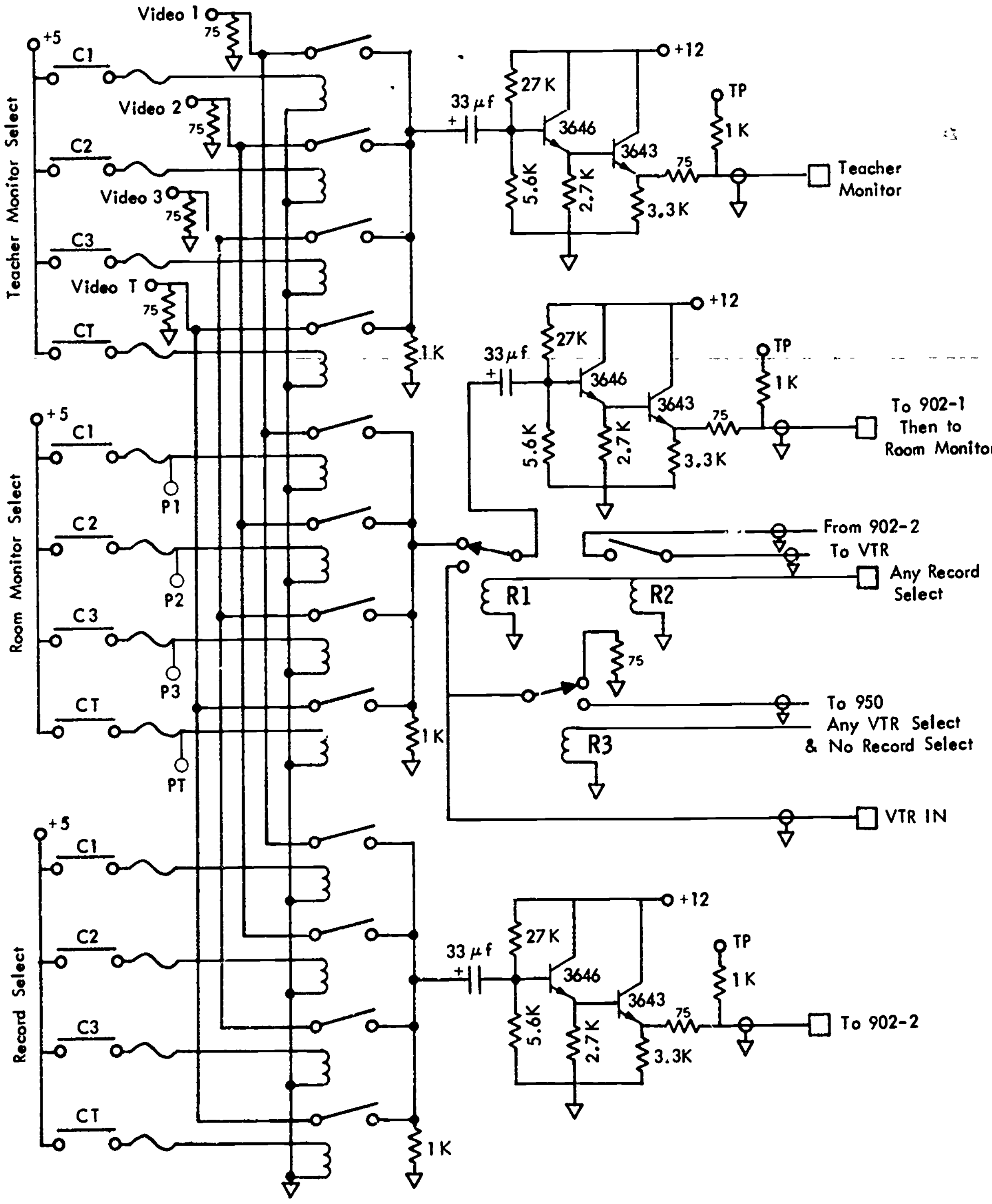

Fig. 11—Output board

mode and if it is operating in the playback mode, the room monitor will show the previous recording on the tape rather than the activity she intends to record.

This automatic switching to the videotape output is accomplished by wiring a separate set of contacts on the four REC or RECORD buttons on the main control console in such a way that if any REC or RECORD button is depressed, a control line, which we will call "any record select," is energized. This line or wire is brought to the output board and, as shown in Fig. 11, will energize the double pole relay R1. This changes the signal sent to the room monitor from the source selected by the room monitor select buttons on the master control console to the videotape recorder output that is connected to the point labeled VTR IN in Fig. 11.

The room monitor output amplifier does not go directly to the room monitor but is internally connected to the input of a video distribution amplifier, model 902 manufactured by the Grass Valley Group, referred to in Fig. 11 as 902-1. The 902-1 provides independent control of video gain and dc level and adds composite sync to the output signal. One of the 902-1's four outputs is connected by coaxial cable to the room monitor. The other three are at the moment unused but could drive other room monitors if additional ones were added to the system.

It was felt desirable to let the student know when the image on his screen is also being displayed on the room monitor where others can view it. A privacy light, mounted on the rear left of each station camera stand, turns on whenever that particular channel is connected to the room monitor. This is accomplished by connecting the privacy lights of Students 1, 2, and 3 and that of the teacher, respectively, to the points P1, P2, P3, and PT in Fig. 11. Whenever the appropriate RM/MON pushbutton is depressed, the corresponding privacy light is turned on.

RECORD CONTROL

The technique for selecting the signal to be recorded is almost identical with that used to select the appropriate room monitor source. A particular REC or RECORD button energizes its associated reed relay to send the selected signal to another video distribution amplifier, 902-2. There, a video sync signal is added, and video gain and dc level may be set. Since 902-2 adds sync even if there is no video signal, and the videotape recorder will always pass its input signal through (with delay) to its output unless it is actually playing back a recording, two additional interlocks were found to be necessary. Without these interlocks, the 940-950H synchronizing system, which is generating its own sync signals when the videotape is not playing back a recording, might see its own signals delayed by going through the recorder and hence attempt to lock the system to them. This would result in a total breakdown of system synchronization.

The reed relay R2 in Fig. 11, which is normally open, will not pass any signal to the videotape recorder unless the "any record select" line is energized. This is necessary but not sufficient to prevent trouble because a REC or RECORD button might inadvertently be left depressed, leading to confusion of the 940-950H synchronizer. Since the latter wants to see the recorder output only when a VTR select is active, one approach to solving this problem might be to prevent any signal from reaching the 940-950H unless a VTR select is active. However, suppose both a VTR select and a REC or RECORD select are left depressed on the main control console. Until playback of an actual recording has taken place, the 940-950H would still see its own delayed and confusing sync signals. The solution to this problem is to wire a set of contacts on the pushbuttons to energize relay R3 only if one or more of the VTR buttons is depressed and no REC or RECORD buttons are depressed. As shown in Fig. 11, when "any VTR select and NO RECORD select" is energized, R3 will switch the output of the VTR to the 940-950H. The 75-ohm resistor is necessary to properly terminate the recorder when its output is not going to the 940-950H.

GENERAL COMMENTS

Although several different functions are performed on the output board, we find no major interaction between them. The test points TP shown in Fig. 11 are brought out to the front test panel to aid in testing the system without removing the plug-in circuit boards.

Appendix I

INPUT AND LOGIC BOARD

In the input and logic board, several different functions are performed:

- The special effects control signals for each of the system's four channels are generated.
- Contrast reversal for the room camera is provided and the desired contrast selected.
- Provision is made for the adjustment of all video input signals to the same level.
- Several necessary control pulses are generated.

SPECIAL EFFECTS CONTROL

The required special effects control signals are generated by digital logic rather than by analog techniques (1) to avoid the jumping up and down between two horizontal scan lines of the location of the dividing line of the horizontal split, and (2) to ensure that the split does not occur somewhere near the middle of the horizontal scan line. These undesirable effects occurred with the low-cost commercial screen splitter that we used during the simulation of a two-station interactive system before designing and building the classroom TV system. The digital approach inherently eliminates both of the unwanted effects.

Figure 12 shows the details of the digital logic used to generate the special effects control signals. We will not describe them in detail, but will provide an overview of their principles of operation. The vertical synchronizing signal that tells the monitors and cameras to go back up to the top of the picture and start scanning over again is used for two purposes. It resets the output of a flip-flop (No. 7 in Fig. 12) to the zero state, and at the same time resets a counter (11 and 12 in Fig. 12) to a value determined by the connections to pins 9, 10, 14, and 15 of counters 11 and 12. Thus, this count could be set to a value of 130. Once this has been done, each time a horizontal drive pulse occurs (which tells the cameras and monitors to go back to the extreme left of the picture and start toward the right), the value in the counter is decreased by one. When this value is zero and tries to go negative, an output pulse is generated which, through an "and" gate (9), sets the flip-flop (7) to the one state where it remains until it is reset to the zero state. The latter takes place when the vertical synchronizing pulse occurs again, and the entire process is repeated. Thus, the output from flip-flop (7), which we might call the "master split screen control signal," avoids the problems mentioned above.

The logic needed to generate the special effects control signals required for each one of the four channels is contained in the upper half of Fig. 12. The SPLIT and OVERLAY buttons located on the master control console are connected so that when the former is depressed it grounds the point labeled SPLIT and when the latter is depressed it grounds the one labeled OVERLAY, as shown on the left portion of the dashed part of Fig. 12.

If SPLIT for channel T, for example, is depressed, the circuits shown in the figure allow the "and" gate (4) to conduct the master split screen control signal to its

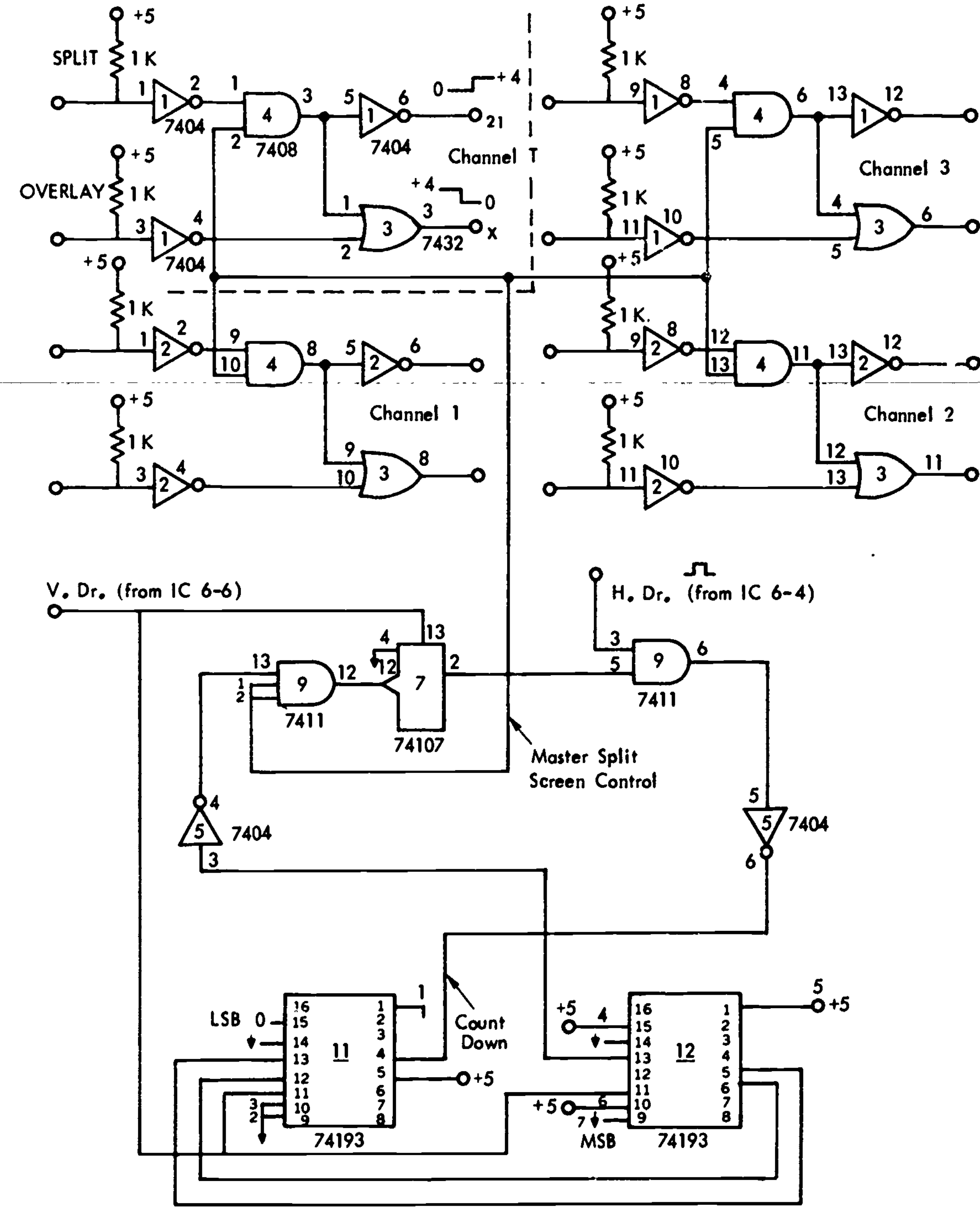

Fig. 12—Logic section of input board

output. There the signal follows two paths. Along the upper path, it inverts the logical value, i.e., a one becomes a zero and vice versa. Along the lower one it passes through a logical "or," which has the effect of making the output one if the value on either pin 1 or 2 is a one. Since the OVERLAY button cannot be closed if the SPLIT is selected (they are mechanically interlocked), the value at pin 2 of the "or" is a zero in this case, and hence the output of the "or" is the same as that of the master split screen control signal. The two outputs labeled x and 21 are applied to the two FET switches in the special effects board for channel T. Thus one switch will be on while the other is off and vice versa under control of the master split screen control signal.

If OVERLAY is depressed, the input 2 of the "or" gate (3) function is a one; therefore, the output at x is the one state. Also input 1 of the "and" (4) is a zero, and so its output is a zero that is inverted to cause a one to appear at output 21. Since both outputs are a one, both FET switches in the special effects board will be on, thereby adding the two video signals selected.

Four independent controls are necessary, one for each channel. The three others constitute the remainder of the circuitry in Fig. 12.

ROOM CAMERA CONTRAST REVERSAL

We had initially intended to perform contrast reversal within the room camera and to select the appropriate signal remotely by means of a reed relay. This proved very difficult, because of the camera's internal circuitry. We thus designed a circuit specifically for this purpose to be located on the input board.

Figure 13 shows the details of the room camera contrast reversal circuit. The main advantage of this circuit is that it permits independent adjustment of the "set-up" or dc level of both positive and negative contrast signals. Positive contrast set-up is established by the 5K variable resistor, and negative contrast by the 10K variable resistor.

The composite blank signal is inverted to clamp the negative contrast signal during the normal blanking time and is essential to avoid a white border on the picture and/or visible retrace lines on the monitors. The relay shown to select either positive or negative contrast is activated by the contrast reversal switch on the room camera control unit.

The output driver is shown with a variable output to permit equalization of signal level with the other cameras in the system. Its output is connected via back panel wiring to the four special effect channel boards described in App. G.

VIDEO SIGNAL EQUALIZATION

To allow for video signal equalization among all the cameras and to properly terminate each coaxial cable with its 75-ohm characteristic impedance, the circuits shown in the lower part of Fig. 14 were used. A single 75-ohm potentiometer would have served better, but we were not able to locate one when we needed it, and as it was our arrangement proved satisfactory. As with the room camera, the outputs are all connected to the special effect channel boards. All outputs, including that of the room camera, are brought out to test points to permit easy equalization by the potentiometers located adjacent to them on the front panel of the input board.

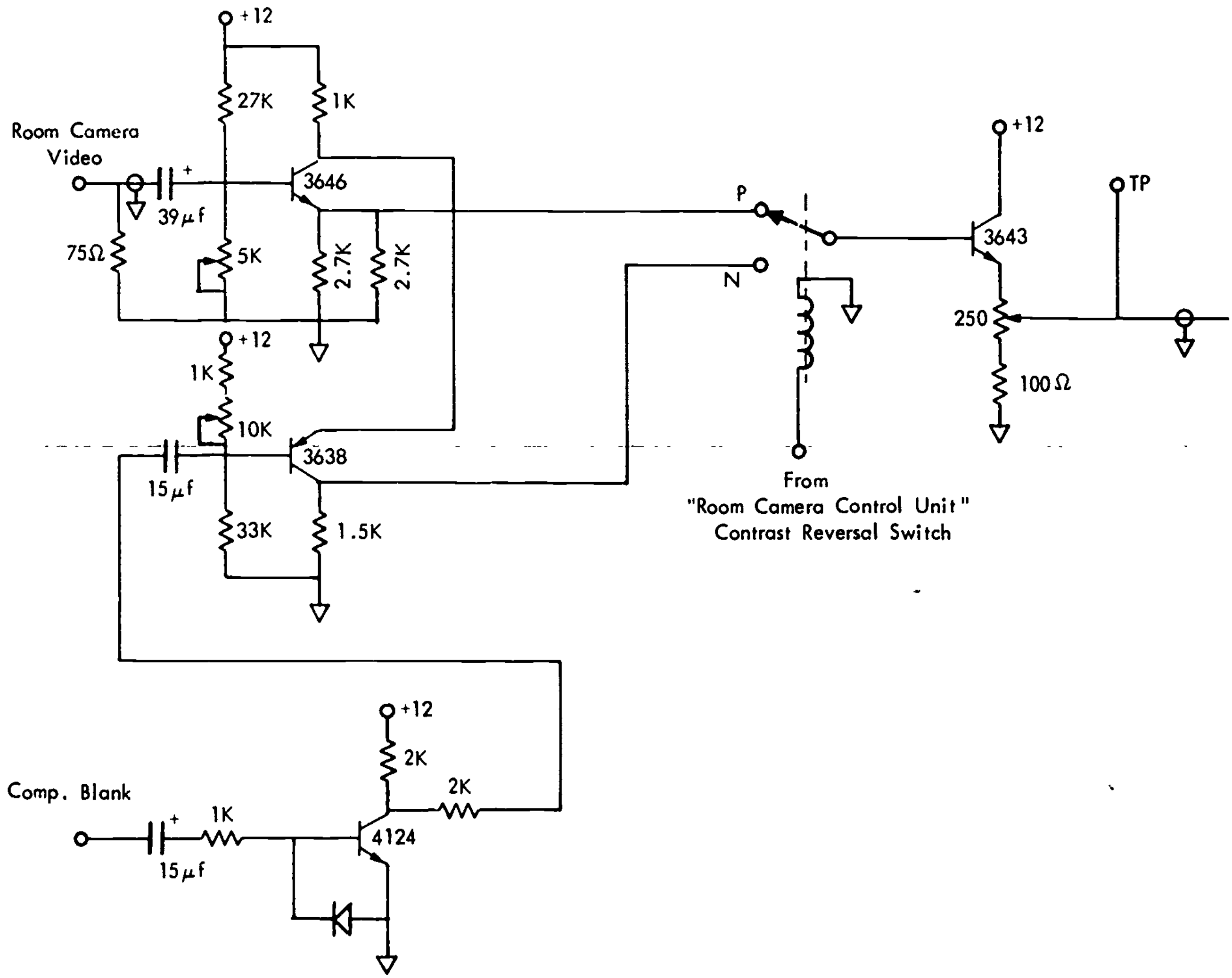

Fig. 13—Room camera contrast reversal section of input board

CONTROL PULSES

Also shown in Fig. 14 are the circuits used to provide horizontal and vertical drive pulses appropriate for use with the logic described earlier.

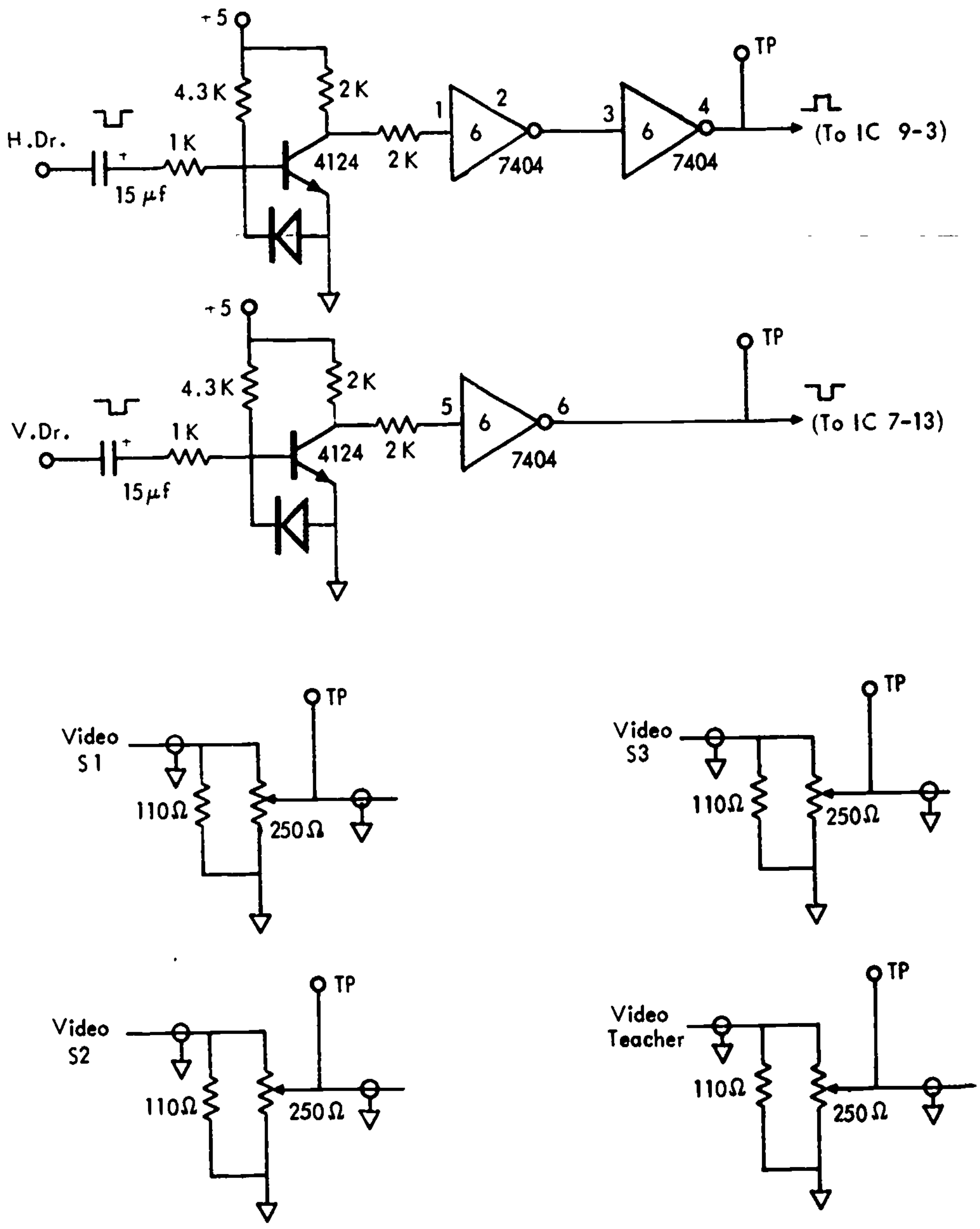

Fig. 14—Video input equalization and pulse amplifier section of input board