Communications Research Centre

AN AUDIO-GRAPHICS SYSTEM FOR TELECONFERENCING

by

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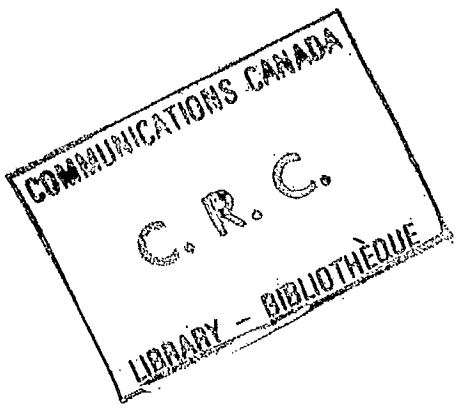
(Informatique Directorate)



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SUMMARY

This report describes an experimental audio teleconferencing system installed between Communications Research Centre, Shirley Bay, Ottawa, and the Department of Communications Headquarters, 100 Metcalfe St., Ottawa (a separation of 12 miles). This audio teleconferencing system is augmented by a variety of visual indicator signals for talker identification and "wish-to-talk", and a number of graphics transmission facilities. It is being used as a research facility to determine characteristics of teleconferencing meetings and desirable technical characteristics for teleconferencing systems.

1. INTRODUCTION

There is a developing need for improved group communications services in decentrallized organizations. Presently available systems have been found to be unsatisfactory, for a number of behavioural and economic reasons. For example, existing conference telephone services have a number of behavioural deficiencies which have prevented them from becoming a major substitute for face-to-face meetings. In spite of this, the conferencing telephone permits convenient access to participants at relatively low cost. By way of contrast, the video telephones and point-to-point video systems developed and commissioned in a number of countries over the past few years have very limited

penetration compared with the switched telephone network, but they overcome some of the behavioural limitations of the conferencing telephone. However, they have been found to require new and in some cases unsatisfactory behavioural adjustments and attitudes[1,4]

This report describes an experimental narrow bandwidth teleconferencing system which has been developed to determine some of the most important characteristics of a satisfactory and economically feasible teleconferencing system. Behavioural and technical research carried out on this system has been used to contribute to the objectives of the DOC Teleconferencing Program outlined below.

2. THE DOC PROGRAM

2.1 OBJECTIVES

In November 1971, CRC proposed the formation of a teleconferencing project, to study this field. Subsequently, the Social Policy and Planning Branch (SPPB) of DOC undertook a planning study called Teleconference Canada[2] which set objectives for the DOC teleconference program, as follows:

> "In general, to develop the capacity and knowledge necessary to determine the value of teleconference systems as a means of satisfying the needs of non-commercial users within and external to government, with particular emphasis on specific Canadian application.

And in particular:

2.1.1 to determine the utility and feasibility of various teleconferencing systems as an administrative and management instrument for use by Federal departments and agencies;

2.1.2 to determine and evaluate the role of teleconference systems as an instrument which could promote national, political and social objectives by improving communications between governments, representative associations and institutions across the country;

2.1.3 to determine the utility and feasibility of teleconferencing systems for specialized uses such as tele-medicine;

2.1.4 to contribute to research and to the development of appropriate evaluation methodologies, concerning behavioural aspects, into mediated communications interaction in teleconference systems;

2.1.5 to identify the shortcomings of current and proposed systems for teleconferencing and related applications, in order to suggest areas for technological research and development."

Priority in research into the effectiveness of teleconference systems was given to two interrelated aspects of the problem,

i) to contribute to the design of teleconference systems in order to enable users to conduct their business effectively and efficiently.

ii) to develop insights into the importance of psychological and sociological variables in the teleconference process.

It is clear that certain socio-psychological variables, such as role relationships, can effect materially the acceptance of teleconferencing as a desirable communications option: i.e., conference chairman may find their authority dispersed in a teleconference environment. Nevertheless, it is also clear that many socio-psychological variables, while they can be observed and measured in an experimental setting, cannot be controlled in an operational environment. Such observations will add to the body of knowledge of the human communication process, and can contribute to the design of operational teleconference systems, and their use. Priority in the research program was given to an examination of variables which can be controlled, either by system designers (i.e., teleconference equipment, the physical environment) or by users themselves (i.e., duration of conference, size of groups, conference format, etc.).

Technical and some behavioural research work for this project has been conducted by CRC and the planning and other behavioural work by the SPPB. This report is concerned with the CRC component of the project relating to the implementation of an audio-graphics system.

2.2 THE CRC TELECONFERENCE PROJECT

The CRC project* consists of three concurrent activities.

a) Field trials to study the use of teleconferencing under operational conditions.

b) Behavioural research carried out in a laboratory to study the effects of variables including configuration of the system, environment and tasks, and the comparison of effectiveness of various teleconferencing media under controlled conditions.

c) Other studies such as preliminary economic and systems analysis, survey work and literature studies designed to complement the first two activities.

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* Resources made available to the CRC project were inadequate to construct the facilities needed for both field and laboratory work concurrently. Therefore an experimental system for field studies was constructed first. The laboratories were constructed at a training school of the Canadian government at Carleton Place, Ontario, and preliminary studies commenced in April 1974.

2.3 FIELD TRIALS

Three prototype operational teleconference systems exist in Canada today. Bell Canada has an Ottawa-Toronto-Montreal-Quebec city two-way video system in use on a market test. The University of Quebec has developed a twelve station system joining the main centres of their Quebec-wide campuses. This system uses audio augmented in some places by telewriter and graphics capability. The characteristics and user reaction to both these systems has been studied by CSG researchers under contract to DOC[3,4]. Department of Indian and Northern Affairs has an audio teleconferencing system operating between Ottawa and Yellowknife and Whitehorse. This system and the Bell Canada system have been studied by researchers under contract to DOC[5]. In addition, it was decided to construct an in-house system to provide first hand experience on all aspects of teleconferencing. A decision was made to build an audio system, augmented with various forms of graphic devices such as facsimile and telewriters, after considering the following factors:

1. An examination of the existing teleconference work being carried out by other agencies revealed a strong emphasis on either television or straight audio systems. Very few, groups were working on the effectiveness of augmented audio systems[6], in spite of the fact that the advantages of such systems might make them very acceptable.

2. Workers at CRC believed that it should be possible to build and use a audio-graphic system which would be capable of achieving the effectiveness of a TV system for most meeting tasks, yet would utilize telephone communication channels.

3. At the time of initiating this project, cost and technical difficulty of linking the CRC location (12 miles from Ottawa) and DOC/HQ with two-way TV channels was very much greater than for an audio-graphic system, which can utilize readily available standard telephone channels. Microwave transmission systems would have required licencing and would have been much more expensive. A cable television system would have taken a considerable time to engineer and install, and the common carriers indicated that they would require a fairly long contract to make it worthwhile from their point of view.

4. Preliminary economic studies already showed convincing evidence that intercity video systems were likely to cost 10 to 100 times that of audio systems for the next decade. Most of this cost is due to video transmission costs. (The Bell Canada system uses the TV broadcast network standby facilities which are normally idle and thus do not incurr the transmission expenses.) Since intercity teleconferencing is considered to be of higher priority than intracity teleconferencing, economics dictates serious consideration of narrow bandwidth systems.

2.4 THE USER GROUP

Before a final decision was made to build the CRC audio graphic system it was necessary to ensure that a legitimate need existed for teleconferencing between groups located at CRC and DOC/HQ. In the summer of 1972, CRC summer students conducted a survey of the meetings between CRC and HQ staffs. This survey was designed by a consultant in collaboration with the project staff and examined the frequency, type, duration and population of meetings.

Of the 236 people questioned 85 indicated some reasonable level of meeting activity involving HQ staff. (Subsequently, it has been found that the term "meeting" used in the survey was probably interpreted by many respondents to include seminars, briefings, and the like, a form of contact which we had not intended to include in the definition).

On the basis of the analysis of this survey and the other factors, the decision was made in favour of a CRC to DOC/HQ audio graphic teleconference system.

3. DESCRIPTION OF SYSTEM

3.1 CONSIDERATIONS

The system was required to be flexible, and to be augmented with a number of facilities. The utility of these facilities was then studied as part of the research program.

Two-way audio systems using loudspeakers at their terminals can be subject to a feedback problem due to the acoustic coupling between the loudspeakers and microphones. The usual technique to overcome this problem is through the automatic insertion of voice actuated circuits to the incoming channel when the outgoing channel is active. Unfortunately this can cause difficulties for the users when the system is used in a conversational mode since the loudest talker has the ability to capture the system, at the expense of cutting off others who wish to speak. It was therefore decided to implement an open-microphone audio system which, although subject to the feedback problem, could allow participants to interject comments when necessary. The feedback problem was overcome in this system by selecting uni-directional microphones and by careful attention to the acoustical properties of the rooms.

The graphics systems were selected to fulfill the basic needs in graphics exchange - the exchange of documents and the ability to sketch (as on a blackboard). Initially it was proposed to combine these two applications so that documents which had been exchanged, could be written upon at either end. However this development was not pursued because of the greater potential offered by slow scan TV, incorporating both applications into the same system. (Work in this area is proceeding under a related CRC project).

A unique talker identification system was designed to automatically indicate the name of the talker in the remote room. This system also permits

any talker to signify he would "wish-to-talk". This he can accomplish by pushing a button to illuminate his nameplate in a different colour on the remote room display panel. It was expected that this would be useful during meetings and seminars, as an electronic equivalent to raising ones hand. Because of the open microphone system, interruption by interjection is possible at all times, but it was felt that the more subtle signal method might be more acceptable in some cases. The CSG work on audio teleconferencing has led to their development of a so-called remote meeting table which also incorporates talker identification and wish-to-talk facilities[6].

Early in the CRC project, private telephone channels were installed to allow people at opposite ends to have private discussions. Three telephones were spaced around the table at each end, and connected through a second audio channel using a two digit dialling system. The system was used once or twice in early tests of the system, but was found to create disruptions. For example, the dial noise was picked up by the microphones, and heard in the other room. Furthermore, whispering was very audible in the opposite room. For these reasons, this subsystem was removed. However it is believed that the concept of a private "caucus" channel may have merit. For example, it might help to reduce the polarization of groups which seems to be a characteristic of teleconferencing. A direct telephone line outside the room is one solution although the use of this during the meeting itself would draw attention to the parties concerned.

3.2 LOCATION AND LAYOUT OF CONFERENCE ROOMS

The CRC and DOC/HQ teleconference rooms are similar but differ in detail due to the geometry of the rooms (Figures 1,2). Each room has carpeted floors and draped walls to reduce acoustic feedback problems.

Seven seats, each equipped with their own microphone are provided at U shaped (DOC/HQ) and V shaped (CRC) tables. The loudspeakers and the talker identification panel are located at the centre of the front wall. A projection screen is mounted above the loudspeaker. Images from a telewriter receiver located outside the room are projected onto this screen. This location of the receiver was necessary because of the heat and fan noise from this unit.

The telewriter transmitter was originally placed on the table top and could be moved to any location. However, the unit was found to be hard to write on in this position so it was subsequently flush-mounted in the table.

Facsimile machines were considered to be too complicated to be operated by untrained personnel, and were originally located in a nearby office with the intention that they be operated by support staff. They were never used in this location so they were then placed in the rooms to make them more visible. This did not lead to any substantial useage and they have since been removed. (Facsimile service is still available through the mail rooms of the two centres).

Without the facsimile machines, the rooms can be operated without the need for technical assistance. The whole system is turned on with one switch, and no skill or knowledge apart from a simple introduction is necessary.

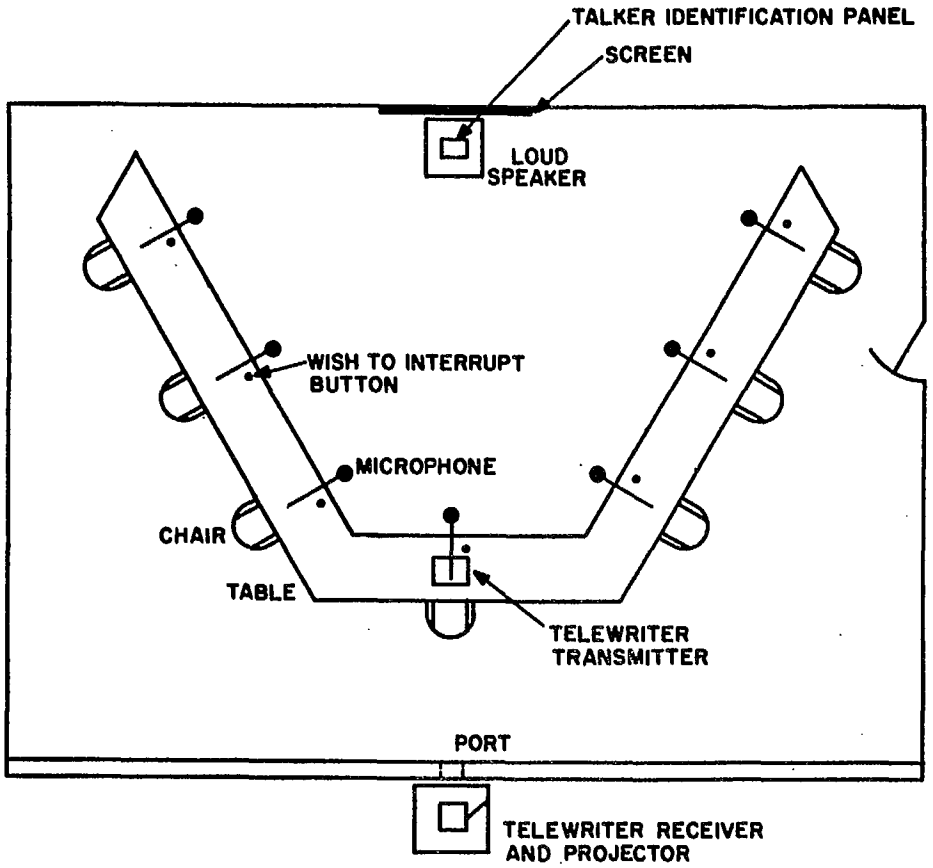

Figure 1. The Teleconferencing Room Arrangement at CRC

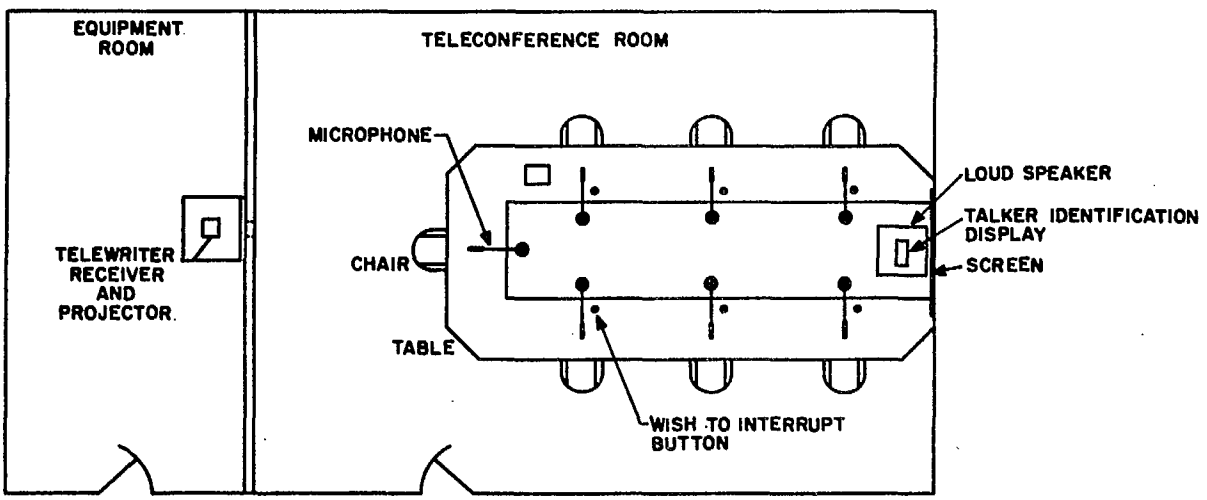

Figure 2. The Teleconferencing Room Arrangement at DOC/HQ

3.3 THE AUDIO SYSTEM

The audio system (Figure 3), utilized 8 KHz bandwidth channels available from Bell Canada. These are simplex circuits requiring one in each direction to make a 4 wire duplex system. (The frequency response of the audio channel has been measured and was found to be 15 - 40,000 Hz ± 1 dB. This is presumably due to the circuits being carried at base band on dedicated cable for this particular short haul system.)

The audio system does not utilize any form of voice-actuated loss insertion so care had to be taken with the design to reduce acoustic feedback problems. The following precautions were taken:

1. Cardiod microphones (25 dB rejection on rear axis) were used. The microphones were installed so that the rear axis was directed approximately towards the centre of the loudspeakers.

2. Microphone preamplifier compressors were designed and built at CRC to control loudness peaks which tend to trigger feedback oscillation.

3. The rooms were acoustically-damped with carpets and drapes. The CRC room walls were acoustically tiled. (This was not done at DOC/HQ due to the unsuitable nature of the partitioning used in that building and the fact that it is rented). The CRC room window was equipped with a soft shutter.

4. The microphones were mounted on floor stands, without contact with the table.

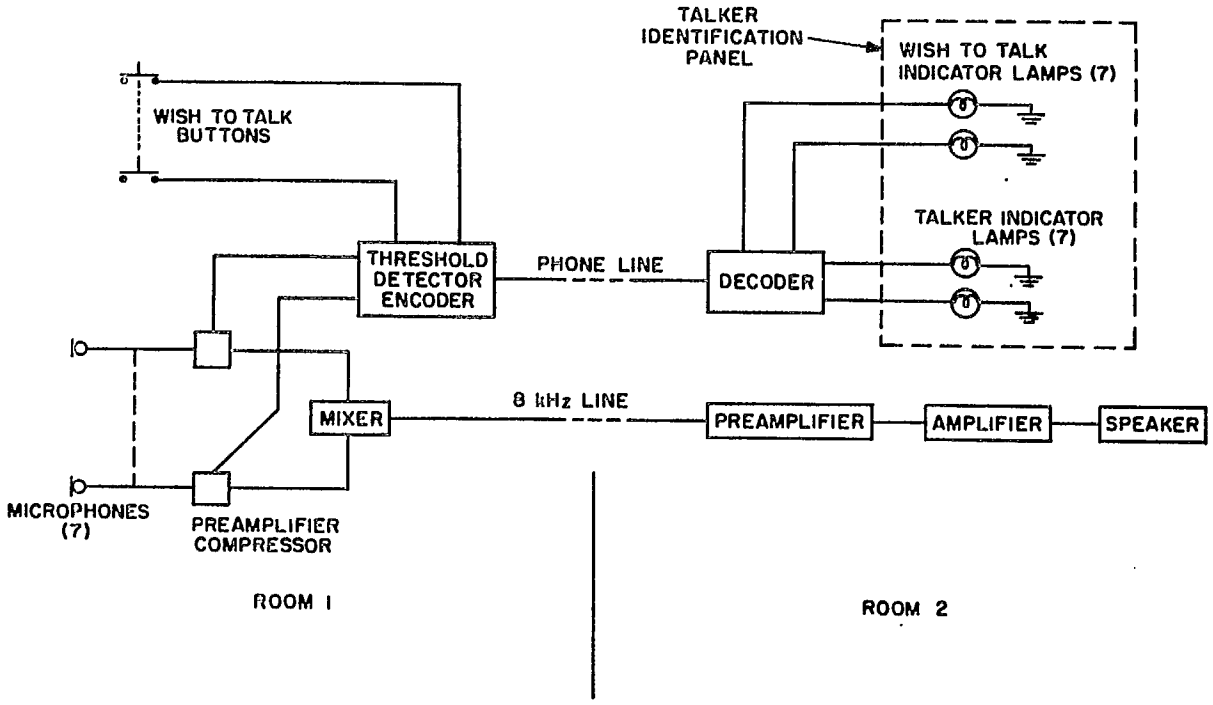

Figure 3. The Talker Identification and Wish-to-Talk Systems of the Augmented Audio Teleconferencing System

3.4 TALKER IDENTIFICATION FACILITY

The talker identification system was studied to determine whether a visual indicator could assist users to overcome the problem of associating voices with the names of talker (Figure 3).

A sample of the acoustic energy arriving at each microphone was derived from the preamplifier compressors and passed to a threshold detector to determine when a microphone was receiving acoustic signals above a preset level. The decision was then four-bit digitally-encoded, and transmitted over a dedicated phone line using a four frequency code. At the distant end the signal is decoded and used to light a lamp which illuminated the talker's name on a display panel. At the start of each meeting the names of each participant can be written on the talker identification display panel in the appropriate space, corresponding to the seating arrangement (Figure 1).

The switching characteristics of the system were selected after a consideration of what seemed to be natural. When a person begins to talk in a previously quiet room the system responds in the order of half a second. When he pauses, and nobody from the same end takes up the conversation, the talker indicator lamp stays on for about 1½ seconds, before going off. In this way, the pauses in natural speech are spanned. On the other hand, when he is interrupted by a person at his own end, the indicator is switched rapidly to the new speaker. The system does not allow more than one talker identifier light on at the same time because of the potential confusion. (Other research shows that simultaneous speech is a very unusual occurrence. Laughter is perhaps the only simultaneous conversation from a group of people and the system responds to this by flickering around the names).

It has been observed that the system response characteristics are dependent on the number of people in the room in several ways. First, the acoustical characteristics of the room are changed significantly, and secondly, the background noise (breathing, paper and cloth rustling, etc.) are increased. In addition, if no one is speaking, the increased background noise sometimes triggers the talker identification system. The effects on room noise have been reduced by placing long goosenecks to the microphones to raise the level differential between speech and background noise. Also, quiet low-velocity air conditioners have been installed in each room.

3.5 WISH-TO-TALK FACILITY

The timing of an interjection in face-to-face conversation is based on both the verbal and the nonverbal gestures of the talker. Since the narrow-band system does not provide the visual nonverbal components to talkers at different locations, some difficulties can be expected to arise in attempts to carry out group discussions with this system. To reduce these difficulties, a "wish-to-talk" feature was added to the system. A button is located at each microphone position which, when pressed, causes the occupants name (on the talker identification display at the far end) to be illuminated in a distinctive colour. Therefore, "wish-to-talk" is not confused with "talker identification". Once the floor is yielded to the interruptor, his "wish-to-talk" colour is automatically changed to the "talker-identification" colour. In practice, most interruptions take place without the use of the "wish-to-

talk" feature. This is because it is easy to interrupt with the open microphone system used in the CRC-DOC installation. In a voice-actuated loss-insertion system it may be more useful and indeed necessary to provide "wish-to-talk" facilities, because the current speaker cuts off the inactive channel[6].

3.6 THE TELEWRITER SYSTEM

Conference participants at each end of the teleconference link have a need to communicate by writing as well as by voice. This requirement was met by using a commercial telewriter arranged in the configuration shown in Figure 4. Each room has one seat equipped with a telewriter transmitter. Outside of each room is a telewriter receiver with the overhead projection modified to project the received imagery into the conference room through a port onto a screen above the loudspeaker.

The system was found to be unsatisfactory in several respects. First, it was somewhat clumsy to use, because the person writing was required to move a pantograph mechanism connected to the pen, in order to generate the outgoing positional signals. Secondly, the writing surface of only 3 x 4½ inches is smaller than is customarily used. Thirdly, the projection format is not entirely satisfactory. Two formats for projection are available - single and double frame. The double frame system is preferrable because, after the paper is advanced to provide a new frame, the preceding frame

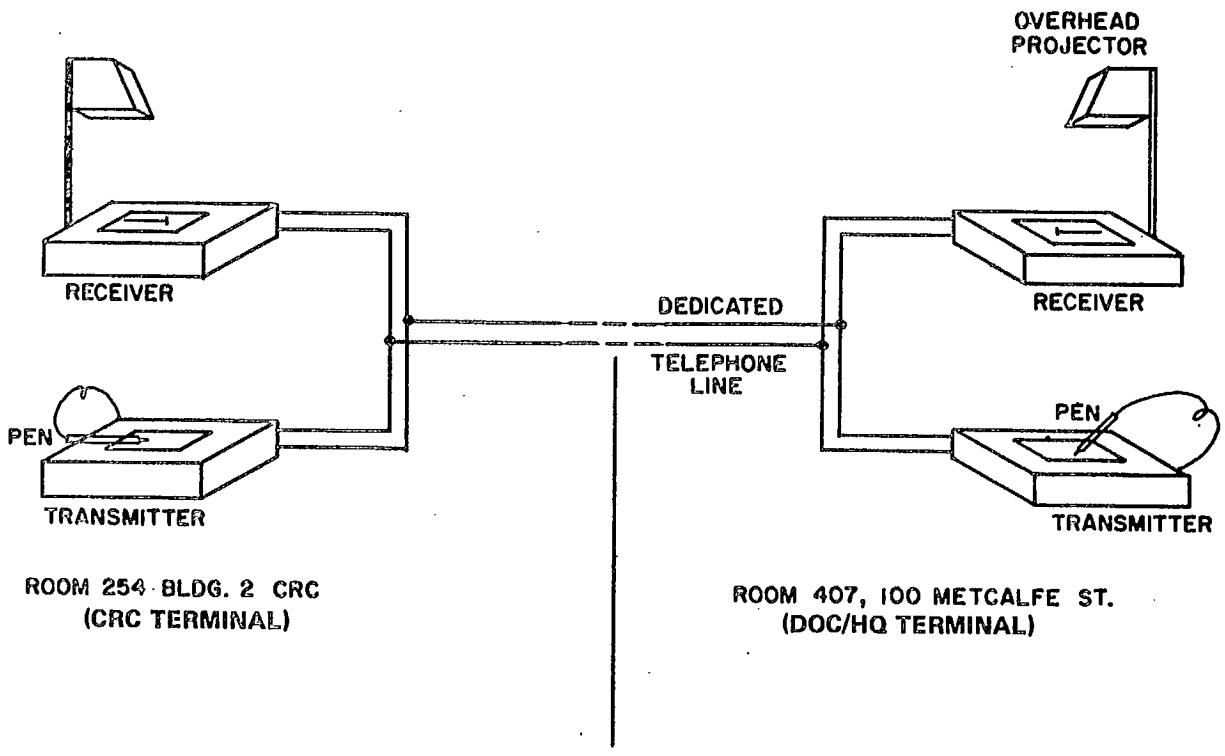

Figure 4. The Telewriter System

remains in view. Unfortunately a rather tall projection format results, which is difficult to accommodate on the screen. Finally, if the system is not regularly used, the receiver unit pen dries up and will not write without some skilled attention.

Useage of the system has been low except for certain technical briefings. The majority of meetings between managers normally do not require the system.

3.7 THE FACSIMILE SYSTEM

A facsimile capability seemed an obvious requirement of any audio-graphic teleconference system. An examination of the available technologies revealed that most were similar in design consisting of a revolving drum carrying the original copy which is scanned by a photo cell. One of the features considered to be critical was speed of transmission. For presently-available units, this is between 2 - 6 minutes over the DDD network for an 8½ x 11 inch document, providing a transmission rate of about 20 pages per hour. Since the machines available are by no means foolproof or easy to operate, there was some concern about where they should be located and who should operate them. For example, if conferees were to operate them during the conference they would not be able to participate properly. Thus, initially the machines were located in an adjacent room, where they were operated either by the project staff or the conferees. After several months, it was found that the machines were not being used. Then they were relocated in the conference rooms, to remind users of the availability. But this resulted in so little added use that they were finally removed altogether. At the time of writing, facsimile service is now only available through the mail rooms at CRC and DOC/HQ.

A conclusion to be drawn from this is that facsimile may be considered more as a fast mail service for document transmission before meetings, rather than a part of a realtime interactive teleconference system. This concept may change with the advent of faster machines, which promise to provide transmission speeds of one standard page (8½ x 11 inches) in the order of 20 seconds.

3.8 THE PHONE PATCH

A phone patch has been designed and installed to allow a third party to be patched into the system from any telephone, or with the conference call from any group of telephones. This system can be useful for calling people into the meeting for one part of the agenda only as it would allow them to work at their desks until actually needed.

4. STUDIES WITH THE SYSTEM

A number of user groups within the DOC have carried out a variety of meeting tasks with the system, commencing in June 1973. The reactions of these users to the system and a comparison of their reactions to the

reactions of users of the Bell Canada and University of Quebec systems is now underway. Preliminary results from these studies is available in other reports[7]. It is enough to state here that the augmentation of the audio system with "talker identification" and "wish-to-talk" indications assists in making meetings more effective.

5. ACKNOWLEDGEMENT

The authors wish to acknowledge the major contribution of Dr. J.G. Chambers to this project. Dr. Chambers lead this project before moving to a new assignment. Also J.R. Storey and V.A. Goodman who have provided a number of major improvements to the system.

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