Current Status of EEG Telephone Telemetry

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Introduction

Telephone, radio and television communication systems will play an increasingly important role in the future for improving health care delivery. In 1968 a series of investigations was instituted to evaluate the technical and financial feasibility of transmitting electroencephalograms over telephone lines. In this paper the methodology and results of this on-going research program will be given. Applications of this telemetry system in clinical electroencephalography will also be discussed.

History of Telephone Telemetry of Physiologic Data

Although Einthoven successfully transmitted electrocardiographic signals over telephone lines in 1906[1], the era of medical telephone telemetry actually began after the second World War. The electronic and telecommunication system advances developed during the war and subsequently improved by the Space Program have made this mode of medical care and research a practical reality. Frequency modulation (FM), multiplex systems, sophisticated filters, transistors, constant bandwidth concept and computers are important outgrowths of this improved technology. The initial endeavors in transmitting medical data over telephone lines in the immediate postwar years were primarily devoted to electrocardiograms. The frequency modulation systems proved technically as well as financially feasible for transmission of this physiological signal by either acoustic or inductance coupling to the telephone line [2, 3, 4, 5]. The first successful telephone transmission of a single channel of electroencephalogram was reported by Rahm et al. in 1953[6]. In 1963 at the American Academy of Neurology meeting in Minneapolis, Minnesota, Irvine Levine demonstrated the real time FM transmission of a single channel of EEG from a patient in Braintree, Massachusetts[7]. At the same meeting photic and auditory evoked potentials were relayed via satellite and submarine cable from a subject at the Burden Neurological Institute in Bristol, England[8]. During the same year H. G. Niebeling also successfully transmitted EEG signals in Germany[9]. Although these initial endeavors were exciting, they had limited research and clinical applicability because only a single channel could be transmitted over a telephone line. Development of multichannel transmission at this time was hampered in the United States by the Federal Communications Commission policy which allowed the equipment of only Bell and other carriers to be attached to the telephone lines. However, the Bell Company was instrumental in developing and testing one and three channel Dataphones. A Dataphone is an integrated unit combining the FM-multiplex system electrically coupled to an ordinary telephone. The equipment is contained in a single housing. The initial sets, the 603A and 603B were capable of transmitting and receiving a single channel of medical or other analog data. In 1967 the Bell Company began field testing the 604A (transmitter) and 604B (receiver) sets. These units capable of transmitting and receiving three channels of analog

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Part of the Bell 604A-604B data set investigation was supported by a grant from the Intermountain Regional Medical Program, University of Utah.

Supported in part by NINDS Grant 2 T01 NS 05309 and by the Eleanor Roosevelt Cancer Foundation Research Institute.

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data over one telephone line were used until recently in this telephone EEG telemetry investigation.

EEG Telemetry Investigations

604A and 604B Bell Dataphone Studies

In November 1968 the first 6 channel EEG was transmitted over conventional telephone lines from the Magic Valley Memorial Hospital, Twin Falls, Idaho to the University of Utah Hospital, Salt Lake City, Utah, a distance of approximately 240 miles. In order to relay 6 channels, 2 Bell 604A (sender) and 2 Bell 604B (receiver) data sets plus 2 telephone lines were required. The instrumentation, transmission scheme, physical characteristics of the data sets, and cost analysis were previously reported.[9] As of June 30, 1972, 1045 EEGs have been transmitted. This system for both long and short distance real time analog transmission has proved technically successful for the following reasons:

1. There is no loss of fidelity in the transmitted record.
2. Minimal extraneous artifacts, usually caused by switching transients in the telephone central office, are occasionally present, but readily identified.
3. The Dataphones have been very reliable. The original sets were used for 500 hours of transmission without failure. In August 1971 the 604A's malfunctioned and were replaced within 24 hours by the Bell Telephone Company.

The disadvantages of this system are:

1. Two data phone combinations and two telephone lines are needed to transmit six channels. The number of channels may be increased by the use of additional units. However, the increased rental and line costs make this financially impracticable.
2. The cost of the tracing is increased somewhat. Since the initial publication about the system[9], the Bell Telephone Company has reduced the monthly rental of the two 604A and B data sets from $390 to $270 per month ($85 for two 604A's and $185 for two 604B's). A breakdown of patient cost based on the transmission of twenty-five records per month from October 1, 1970 to June 30, 1972 is as follows:

TABLE 1

PATIENT COST BASED ON TRANSMISSION OF 25 RECORDS PER MONTH

Data set rental	$10.80
Business phone rental	2.64
Cost of transmission—weekday, daytime, DDD for 35 minute record (2 lines)	17.50
Paper and miscellaneous expenses	5.00
Technicians' salaries	
Twin Falls—half time—80 hrs/mo	7.33
Salt Lake City—20 hrs/mo	1.82
Professional fee	10.00
	$55.09

Since the initial part of this study was supported by a Federal grant, patients were not billed for their examinations until after May 1, 1970.

Other Multi-Channel Data Sets

Although the Bell Telephone Company continues research on multi-channel data sets, particularly a six channel model, a 1968 ruling by the United States Federal Communications Commission in the matter of "Use of the Carterfone in Message Toll Telephone Service"[10] has stimulated independent investigation. Direct access to the telephone network with other equipment was one of the positive outgrowths of this decision. FM-multiplex units and other converters can now be directly coupled to the telephone lines through a Data Access Phone.

Phase-Lock-Loop Data Sets

In 1969-1970, 3 and 6 channel bread board transmitting and receiving data sets were constructed by the University of Utah Department of Bioengineering using the integrated circuit "phase-lock-loop" technique[11, 12]. It was hoped that with this technique eight channel sets could be developed without having to use the expensive filters required for multichannel constant band FM transmission. If successful this would have reduced the data set costs by one-fifth. The preliminary tests with the six channel set were disappointing. Although the frequency response in each channel was DC-60 hertz, the best signal to noise ratio was only 60/1. The poor performance when only phase lock loop circuitry was used was a result of a) sensitivity to variations of incoming signal levels, with variability on each phone line; b) interchannel

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coupling as a result of ability of the phase lock loop to "lock" onto harmonies of low frequency channels.

A sample from an original and transmitted EEG from Twin Falls, Idaho to the University of Utah Medical Center is shown in Figure 1. It became apparent that in order to develop eight channel units with this technique additional filters would have to be used in order to obtain high fidelity transmission thereby increasing the cost. Therefore there were no financial advantages over the available sets and the project was discontinued.

Constant Bandwidth FM-Multiplex 8 Channel Data Sets

Currently there are two companies in the United States — Parallel Data, San Francisco, California and Electro-Mechanical Research, Sarasota, Florida — that have developed data sets capable of transmitting 8 channels of EEG over a single conventional telephone line. At the 1971 American EEG Society meeting in Minneapolis, Minnesota Dr. Harley E. Schear et al. reported that the Parallel Data sets had been used in real time FM transmission of approximately 300 EEGs

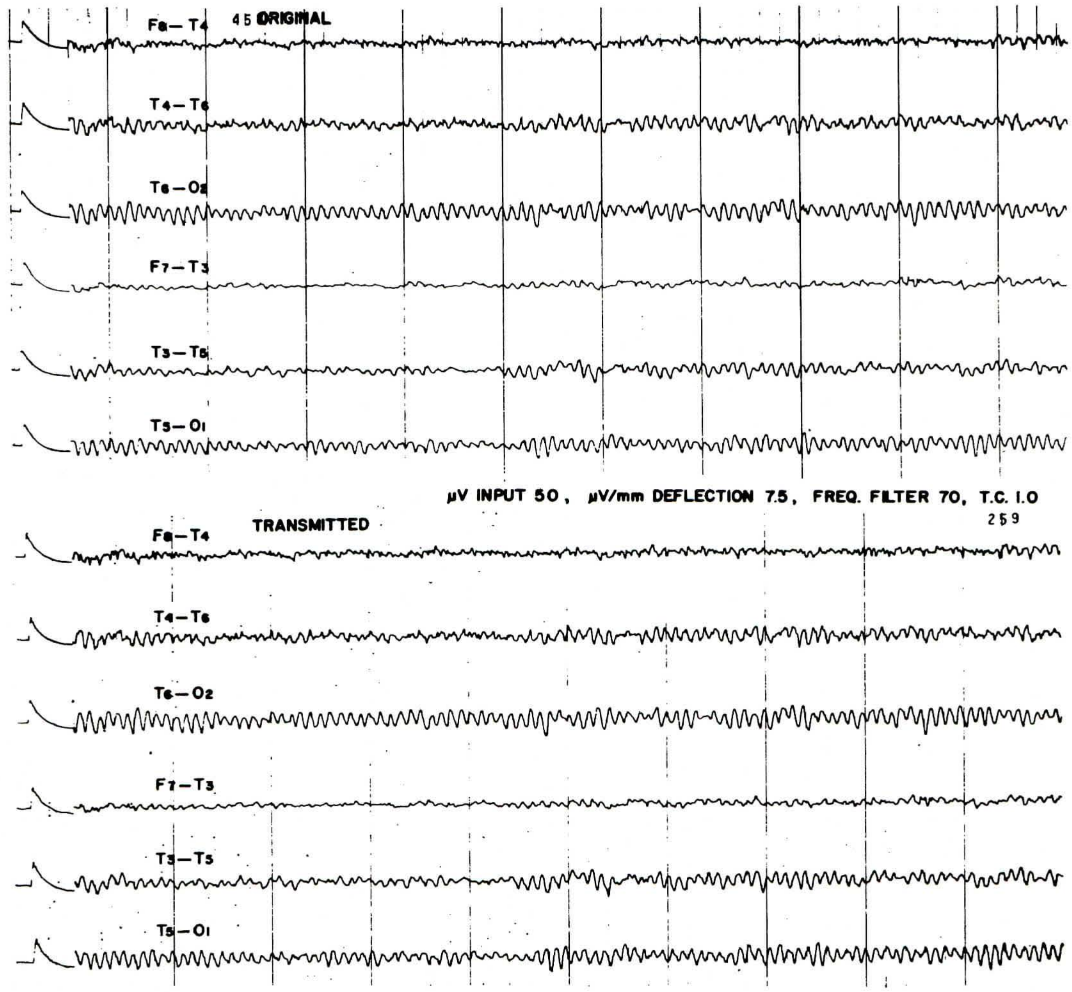

Figure 1 Comparison of sample from 6 channel original and transmitted EEG. Twin Falls—Salt Lake City, one DDD line, phase lock loop circuitry.

from the Enloe Hospital in Chico, California to the San Francisco Neurodiagnostic EEG Center.[13] The technical specifications as advertised appear to be satisfactory for transmission of quality electroencephalograms; however, to the best of our knowledge the sets have not been thoroughly evaluated by independent investigators.

EMR

In February 1972 tests were initiated to evaluate the eight channel telephone FM data set developed by the Electro-Mechanical Research (EMR) Corporation, Sarasota, Florida. These were conducted over local and long distance lines. After several modifications a set is now available which closely approximates the important specifications recommended for electroencephalographs by the International Federation of Societies for Clinical EEG and Neurophysiology.[14]

1) Linearity: This is limited by noise. In the worst case it is less than 3%.
2) Frequency response:
   DC-40 hertz - 10% ↓ in ampl.
   DC-60 hertz - 20% ↓ in ampl.
   DC-65 hertz - 30% ↓ in ampl.
3) Phase shifts: Phase distortion is minimal as determined by comparison of transmitted and received square waves.
4) Noise level: Signal to noise ratio (peak to peak/peak to peak) — Local transmission: 200/1 best — 100/1 worst — Long distance: 70/ best — 40/ worst. Baseline noise is worse at times of peak telephone loads. Transient telephone switching spikes are easily identified (Figure 2a and 2b).
5) Interchannel coupling: 2½% in the worst case as measured on an oscilloscope.
6) Similarity between channels: All channels identical as shown by transmitting calibration signals and the same EEG signal to all channels.
7) Channel delay differences: As measured on an oscilloscope - the difference between any two channels is less than one millisecond.

The output required to drive the lines is approximately 6 dbm.

These data sets (Figure 3) have been routinely used since July 1972 in the real time transmission of 150 EEGs from Twin Falls to the University of Utah Medical Center. No malfunctions have occurred.

In Figures 4 to 8 original and transmitted records are compared to illustrate differences in baseline noise as well as attenuation of faster frequencies. However, these limitations appear to be minor. The fidelity is very good and should not interfere with interpretations. In many respects the attenuation of the higher frequencies would be similar to a record obtained with the high frequency filter setting at 35 on the Grass Model 6 (Figure 9). Because of the potential problem of reproduction of fast transients, a wave form generator was used to simulate spikes. This showed that the high frequency roll off limited amplitude for pulses less than 10 milliseconds duration (Figure 10).

With 8 channel transmission, particularly by direct distance dialing (DDD), an increase in baseline noise can occur and is comparable to the occasional poor long distance voice connection (Figure 11). However, this should not interfere with interpretation of the transmitted record with the possible exception of cerebral death determinations. If this is a problem then the number can be redialed until a satisfactory connectionn is made.

It is anticipate that the patient charge for this service will be approximately $40.00.

TABLE 2

PATIENT COST BASED ON 25 RECORDS/MONTH

Cost recovery charge for EMR data sets	$ 5.00
2 data access phones (rental $40.30/month)	1.60
Cost of transmission—1 line, weekday, daytime, DDD for 35 minute record	8.75
Paper and miscellaneous expenses	5.00
Technicians' salaries	
Twin Falls—half time—80 hours/month	7.33
Salt Lake City—20 hours/month	1.82
Professional fee for interpretation	10.00
	$39.50

This is approximately $10.00 below the cost of the Bell 604A and B transmission system and gives two additional channels. A major expense is the price of the data sets which sell for $6,000.

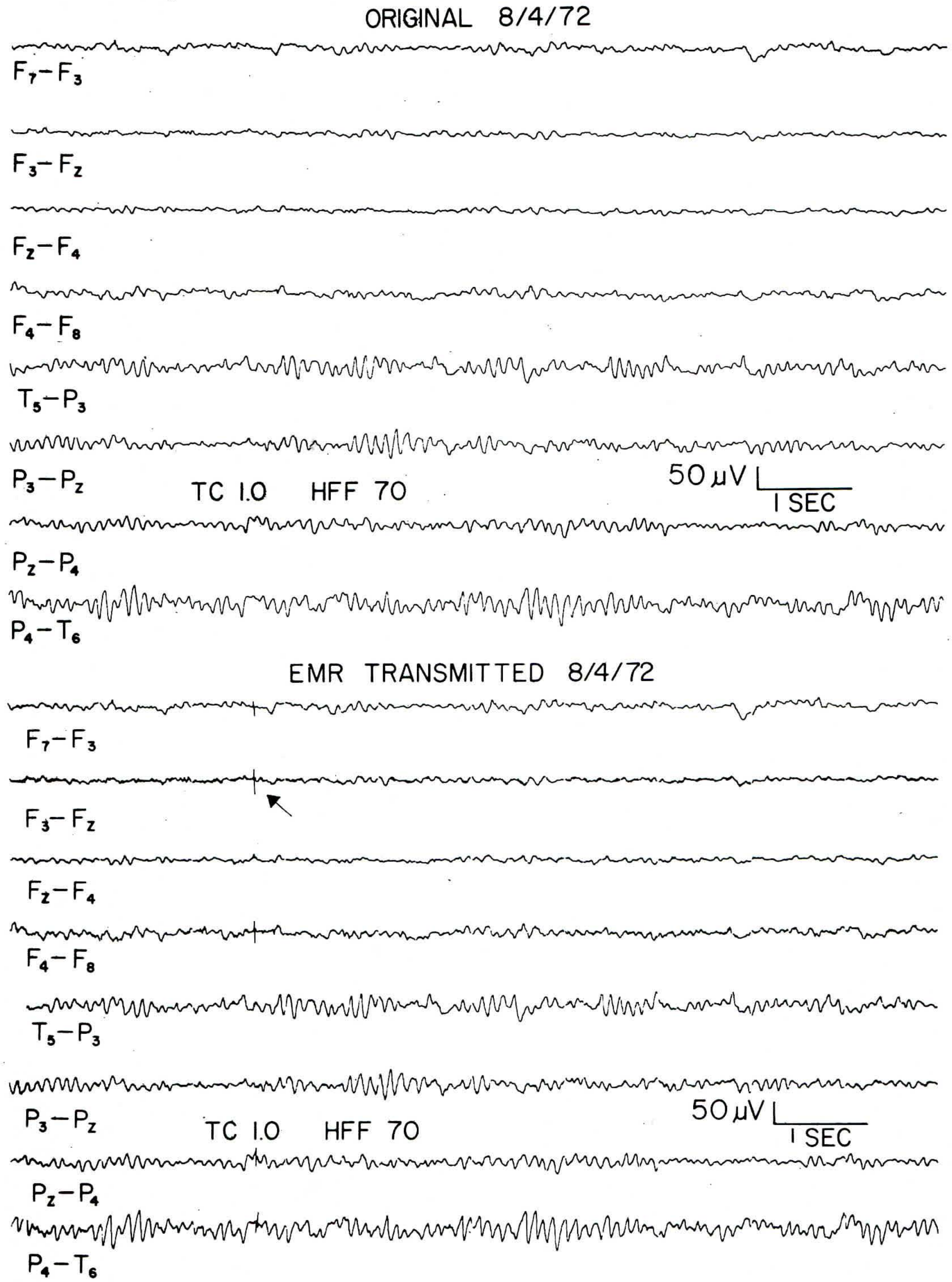

Figure 2a & b Example of noise artifact in the transmitted 8 channel EEG caused by switching transient in one of the telephone central units. EMR data sets—Twin Falls—Salt Lake City, one telephone line (DDD).

Other Methods

Digital Transmission

Low et al. have recently reported on a system for the long distance digital transmission of EEG signals.[15] Because the high bit rate needed to transmit eight channels simultaneously requires several conventional telephone lines, the data are converted to binary pulse code modulation and stored on analog tape. The tape is then replayed at one quarter the recording speed and the data reformated to serial form before being transmitted over one telephone line. The main technical advantage of this system is that extraneous noise is markedly reduced once the data are captured. The disadvantages are that it requires approximately two hours to transmit a thirty minute record and, excluding the electroencephalographs and/or pen recorders at the sending and receiving sites, the cost of the equipment is approximately twelve to thirteen thousand dollars. However, since it is possible that common carriers in the future may only offer digital transmission services, this system requires further investigation.

Facsimile Transmission

Facsimile transportation of EEGs has been used in the Chicago area for over two years.[16] Developed by Erich and Trudy Gibbs, this non-real time scheme uses continuous FM facsimile recorders, standard telephone equipment and operates over conventional telephone lines. Over 1,000 samples of EEGs have been transmitted from five satellite laboratories to the central station. However, the transmission speed is extremely slow, varying between 4 and 6½ minutes (depending on the type of recorder) for a single ten second EEG page. Consequently, in order to be economically feasible, only a few sample pages from the original EEG can be transmitted. In the end the original EEG is mailed to the central laboratory for a final interpretation.

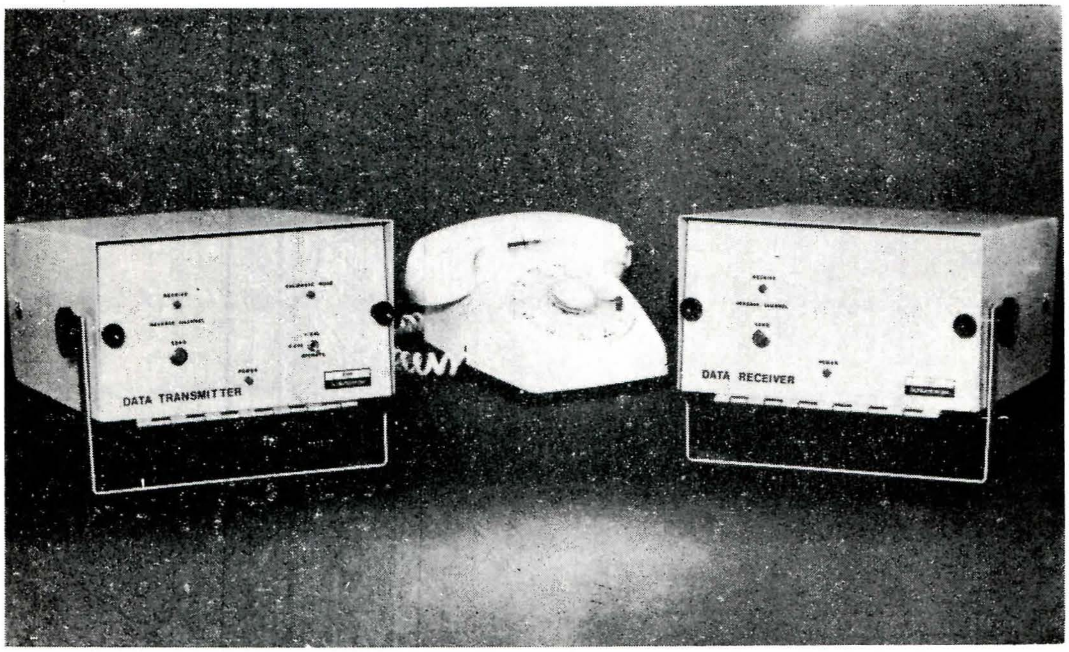

Figure 3 EMR transmitter and receiver data sets with Bell data access phone.

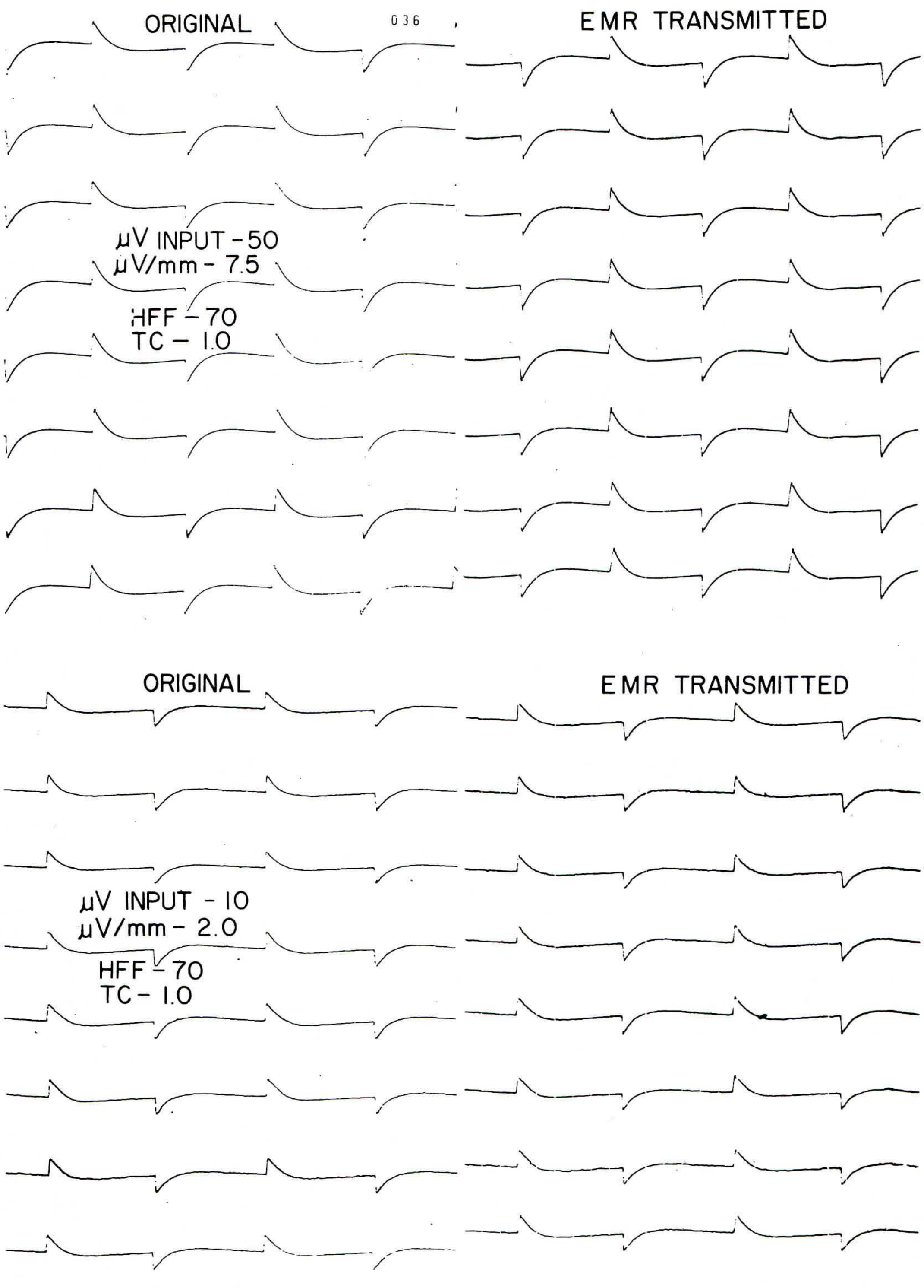

Figure 4a & b Comparison of 2 calibration signals and baselines. From original and transmitted tracings. EMR data sets, Twin Fallls—Salt Lake City, one telephone line (DDD).

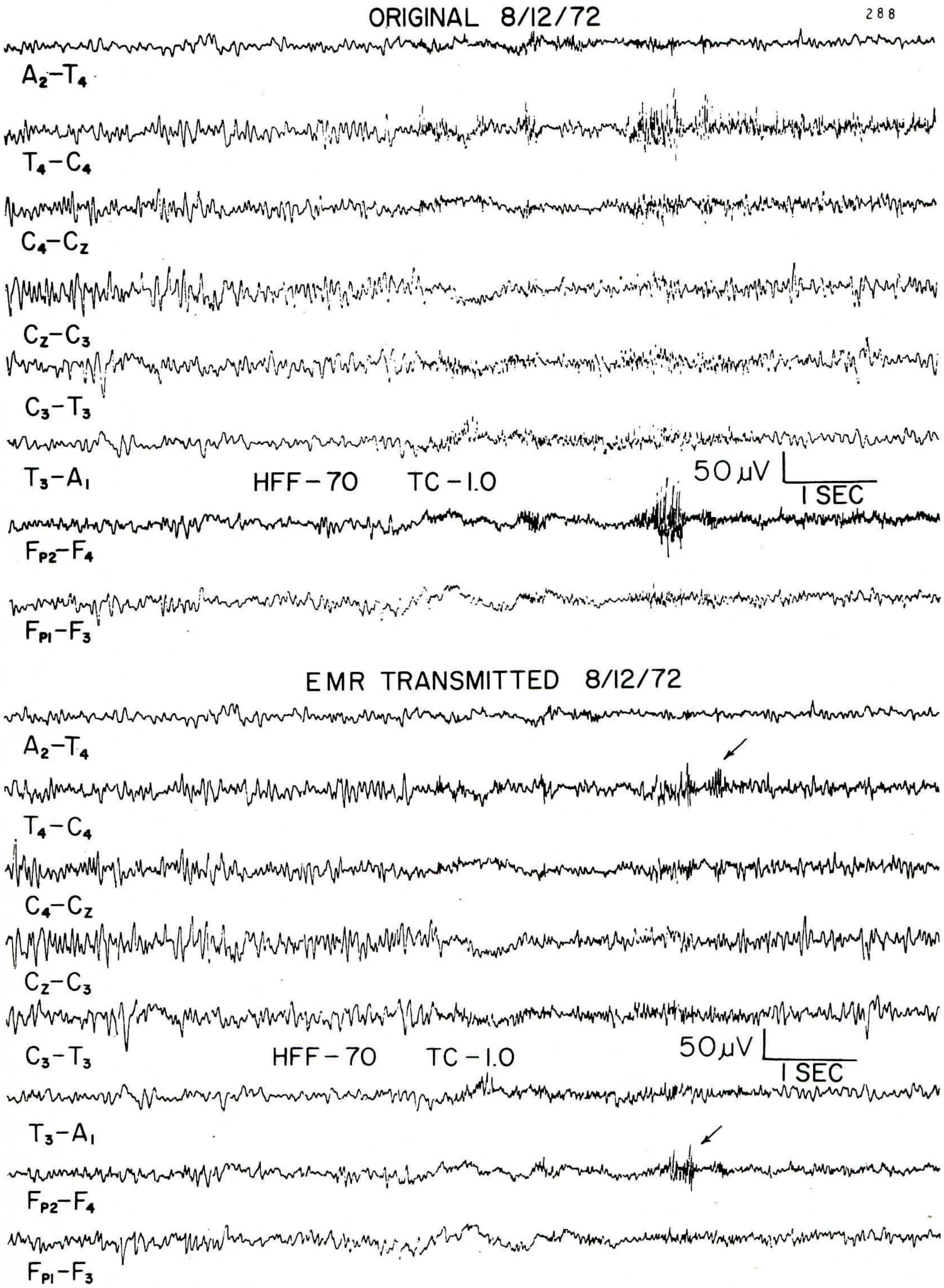

Figure 5a & b Sample from 8 channel original and transmitted EEG. Illustrates attenuation of high frequency forms, in this case muscle spikes. EMR data sets, Twin Falls—Salt Lake City, one telephone line (DDD).

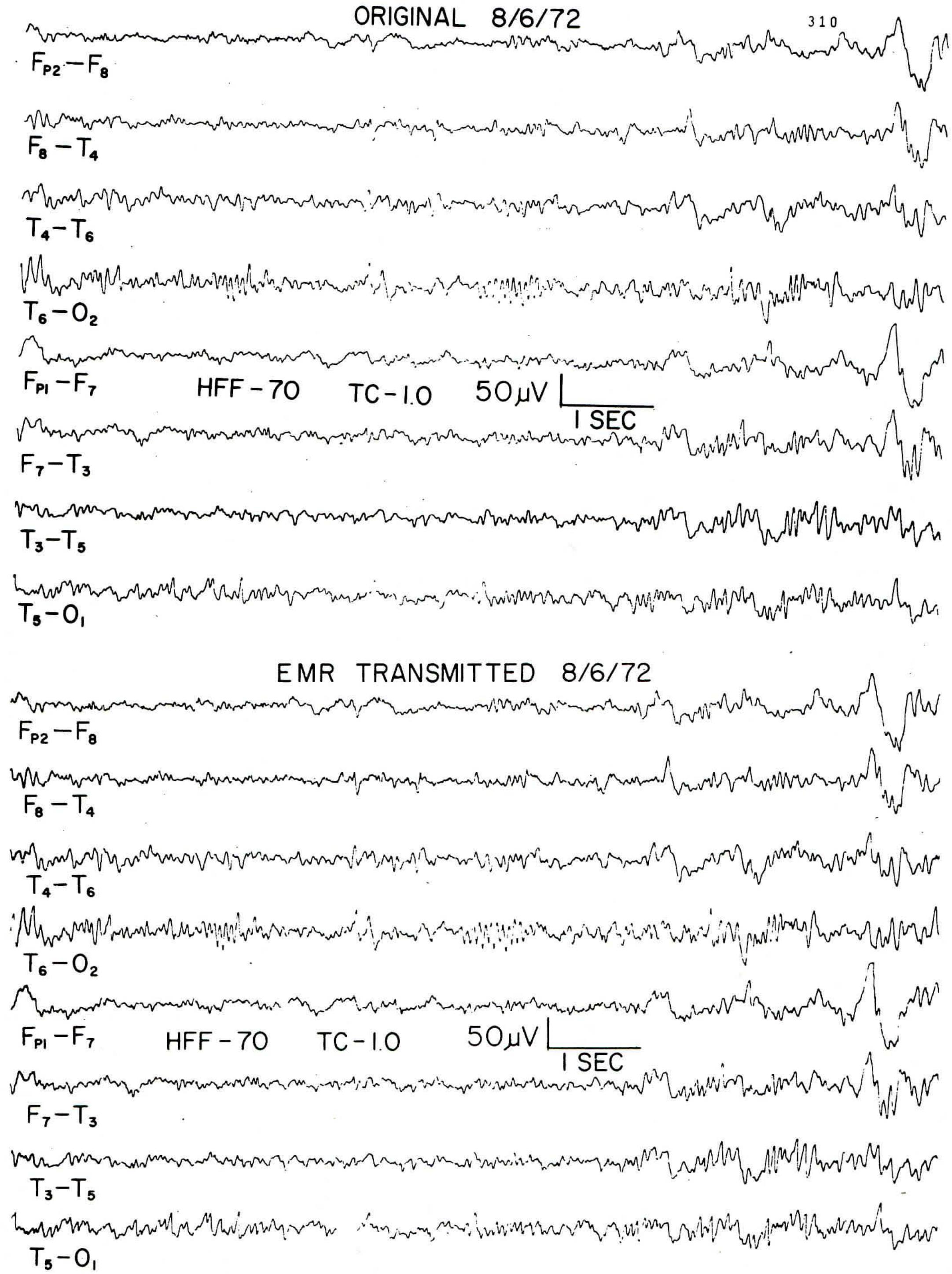

Figure 6a & b Sample from 8 channel original and transmitted EEG. Illustrates excellent comparison of low amplitude spikes in right temporal channels. EMR data sets, Twin Falls—Salt Lake City, one telephone line (DDD).

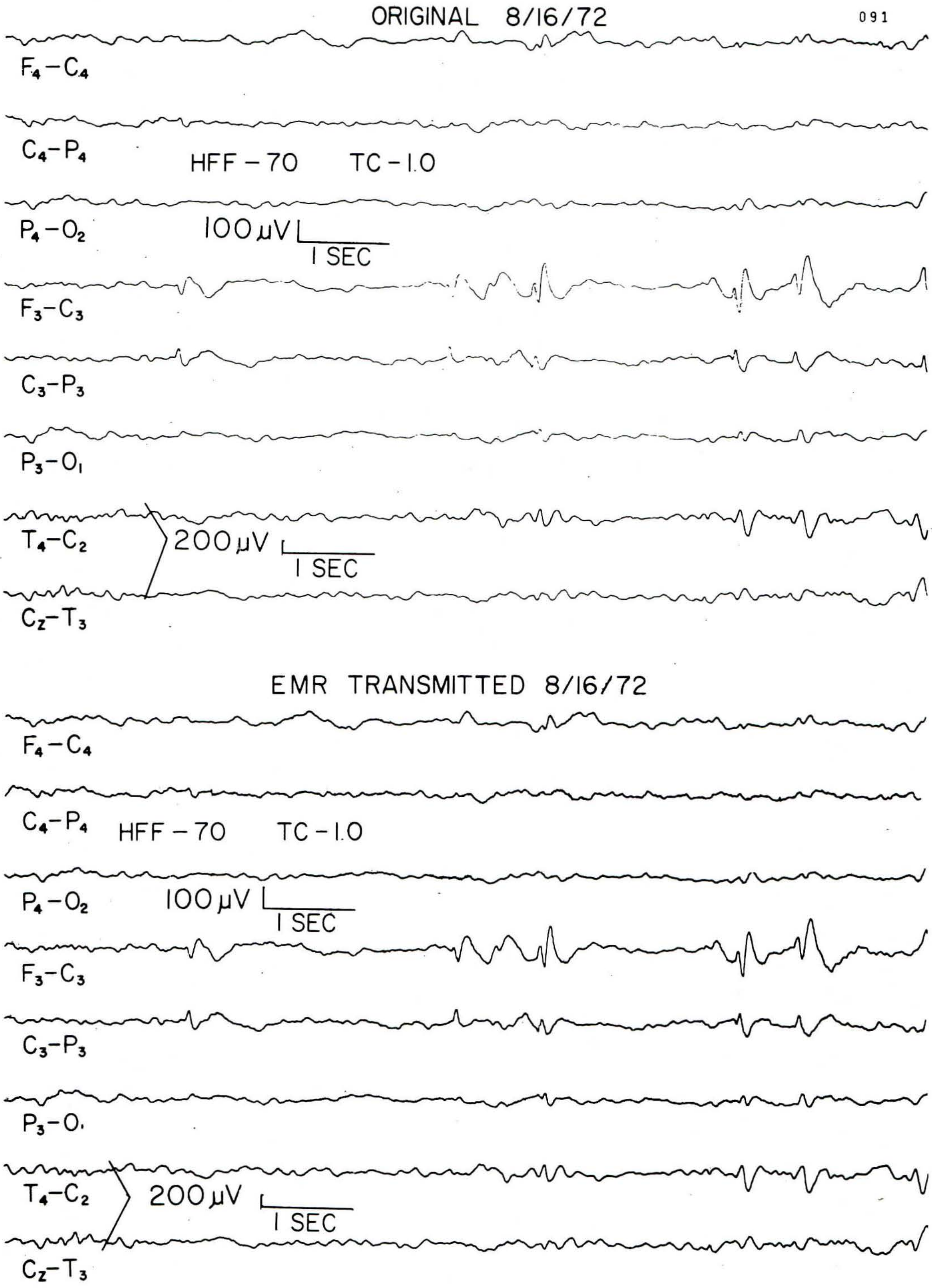

Figure 7a & b Comparison of sample from original and transmitted EEG showing excellent fidelity between the spike and wave discharges. EMR data sets, Twin Falls—Salt Lake City, one telephone line (DDD).

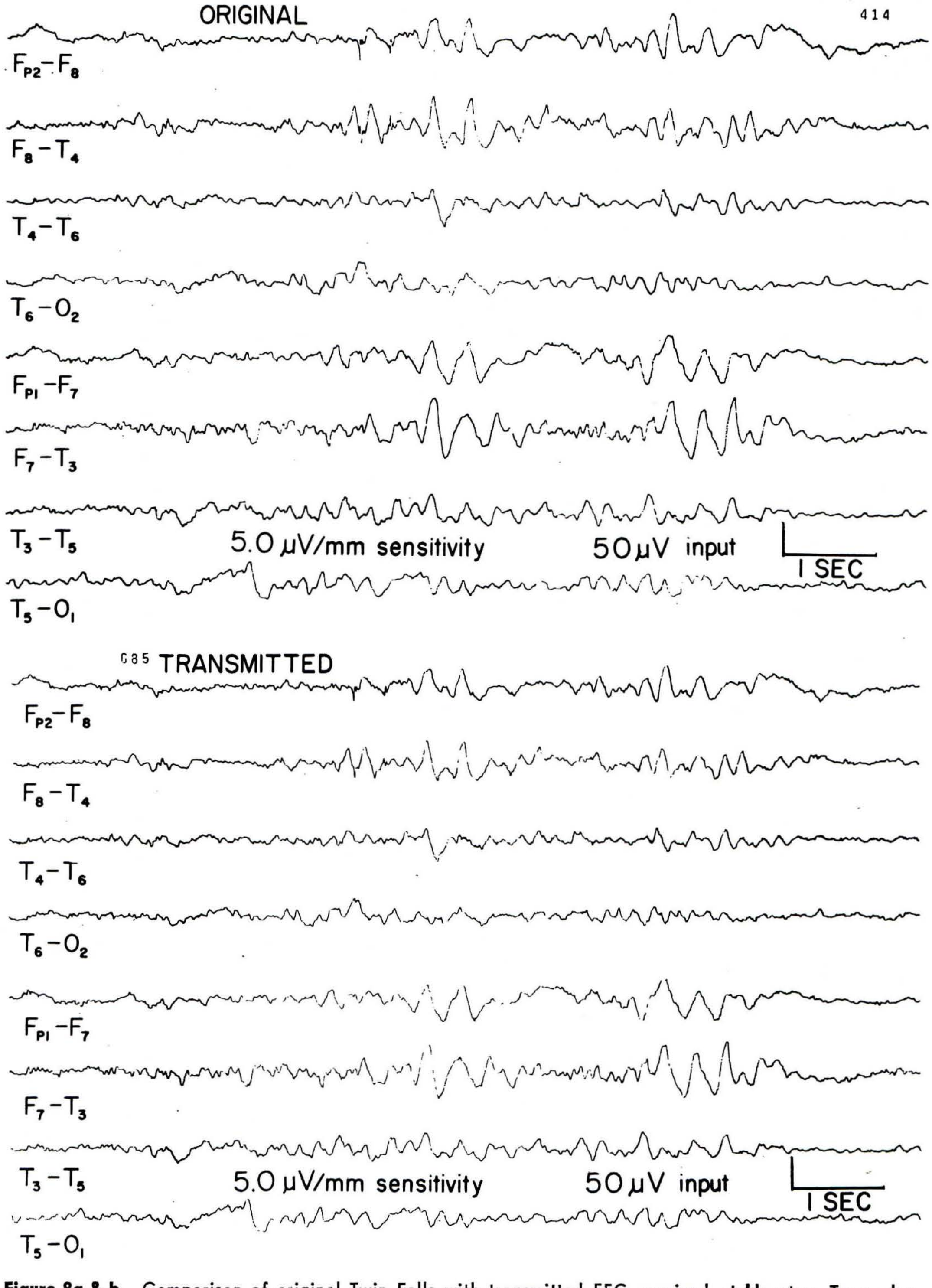

Figure 8a & b Comparison of original Twin Falls with transmitted EEG received at Houston, Texas during the American EEG Society Meeting, October 1972. EMR data sets, one telephone line (DDD).

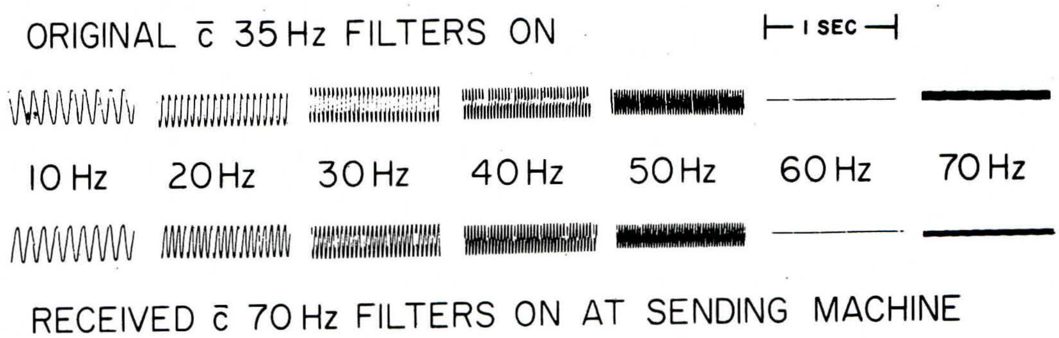

Figure 9 An amplitude comparison of sine waves between an original tracing recorded with the high frequency filter setting at 35 and a transmitted record in which the original tracing was recorded with the high frequency filter at 70 is shown. Note the approximately 30% reduction in amplitude at 50 Hz in the transmitted tracing. This illustrates that a transmitted recording is similar to a tracing obtained with the high frequency filter on the Grass Model 6 at 35. EMR—Twin Falls—Salt Lake City, one telephone line (DDD).

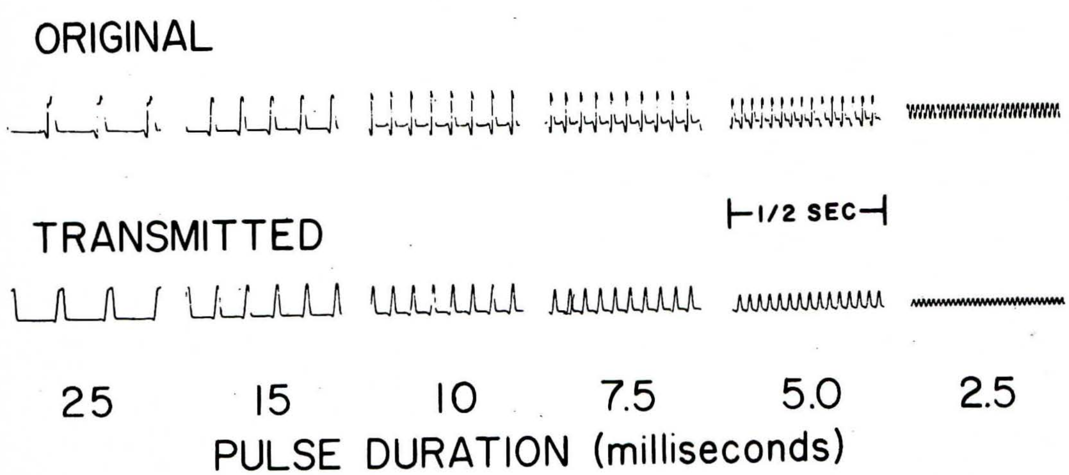

Figure 10 Simulated spikes of various durations showing an amplitude reduction beginning with pulses less than 10 milliseconds. EMR data sets, local telephone line.

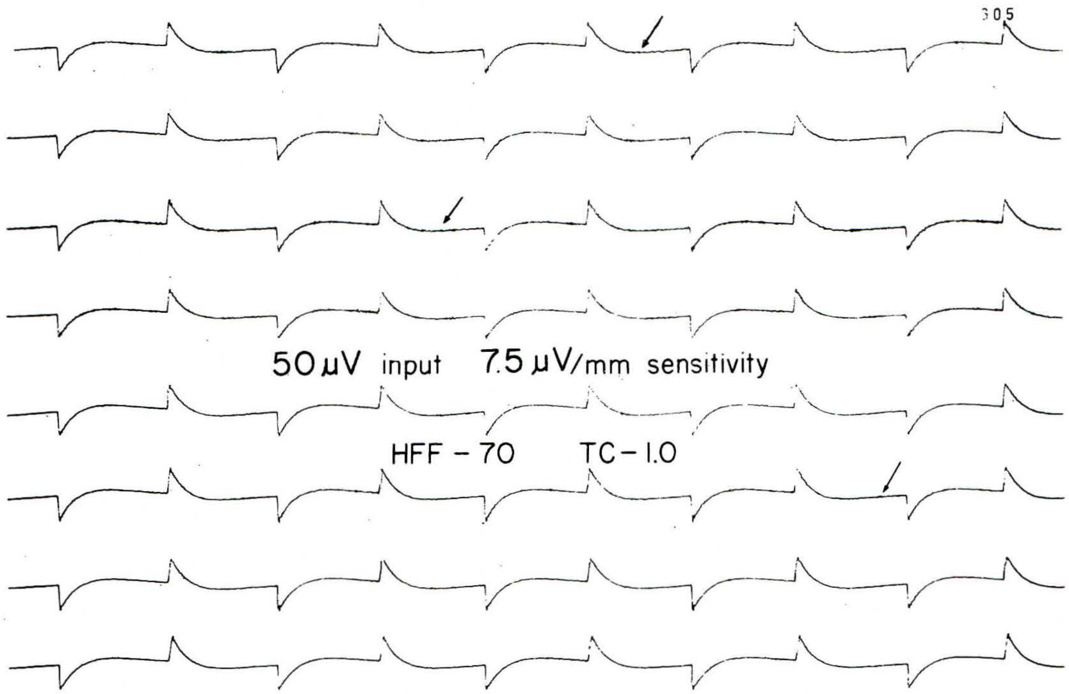

Figure 11 In this sample of calibration transmitted from Twin Falls to Houston, Texas there is an increase in baseline noise caused by a bad connection. EMR data sets, one telephone line (DDD).

Discussion

Major problems confronting clinical electroencephalography are the non-availability of this test to all segments of the population and the existence of many substandard technicians and interpreters. Although progress has been made, primarily through educational programs, there still remains a need for further improvement. The results of four years' investigation of EEG telephone telemetry demonstrate that the system can be helpful. Technically it appears feasible because of the existing United States telephone network and the recent development of eight channel telephone FM data sets. The ultimate utility will be determined by economic considerations. With increased utilization of this technique, EEG societies and federations should establish standards for data sets in order to assure quality transmission.

In selecting communication media for transmission of analog and digital medical signals, the physical characteristics, availability, dependability and cost of the system have to be considered. Today the telephone network best meets these requirements.

Physical Characteristics

Telephone lines are designed to transmit frequencies between 300 - 3000 hertz, a medium fidelity range for voice signals. Since most analog medical data, including EEG have frequency components near D.C., a modulation system is required. In addition, if simultaneous multichannel transmission is needed, the signals must be multiplexed. The number of channels that can be transmitted over the telephone network is limited by data bandwidth, cross talk and signal to noise ratio. Within the telephone voice frequencies, frequency modulation (FM) multiplex units are capable of transmitting and receiving several channels of EEG with essentially no loss in signal quality. By further increasing the number of channels, data bandwidth is lowered and the signal to noise ratio decreased.

However, despite this, the results from tests on the EMR data sets indicate that quality eight channel EEG can be transmitted over a single voice telephone line. In fact the specifications for this equipment in almost all instances satisfy the criteria for encephalographs recommended by the International Federation of Societies for Electroencephalography and Clinical Neurophysiology.[14] However, it appears improbable that more than eight channels of EEG can be transmitted over a voice line with adequate fidelity. This could readily be accomplished with wider bandwidth channels, as provided by cable and microwave; however, availability and cost prohibit this type of clinical EEG telemetry.

Availability and Dependability

Approximately half of the almost two hundred million telephones in the world are located in North America[17]. There are very few areas in the United States without this service. Today the most accessible, reliable and least expensive system for transmission of medical data, regardless of origin, i.e. hospital, home, etc. to the interpreter or computer is the telephone line. Cable and microwave transmission have effectively handled the increasing volume of local and particularly long distance calls. With the exception of special holidays such as Christmas, immediate connections through direct distance dialing (DDD) can be made.

Since the FCC ruling in 1968 other data sets can now be connected through a Bell data access phone to the telephone lines. This unit consists of a small portable business phone and data set coupler and can be connected to any telephone jack. In Salt Lake City this system rents for $20.30 per month ($18.30 for business phone and $2.00 for coupler).

Various types of line services for local and long distance calls are offered by the common carriers. The selection of private, WATS, Telpac and local foreign exchange lines over the DDD system will depend on volume and distance.[18]

Financial

The Twin Falls - Salt Lake City real time EEG transmission linkage has proved to be financially feasible. However it is impossible to give an exact cost analysis that would cover all aspects of the telephone telemetry of brain waves. There are many tangible as well as intangible items. The purpose, existing facilities and equipment, personnel, cost of data sets, "on line" versus "off line" transmission, line expenses, volume, distance and anticipated duration of service have to be considered. What may be feasible in one area of the country may not be in another. If the system is used as a laboratory service, the willingness of insurance companies to pay a possible increased rate also has to be taken into account.

Equipment, personnel and line service modifications can be made that would reduce costs. For example, if a modified oscillograph is used at the terminal, a standard encephalograph is not required. However, this decision has to be based on anticipated volume as well as the inservice needs at the receiving hospital. It has also been suggested that the recording unit at the satellite laboratory could be eliminated, thereby bypassing the direct write out. With this adaptation qualified personnel would not be essential at the sending laboratory, since the patient and EEG would not require monitoring. However this "short-cut" will inevitably result in poor quality transmission and serve no useful purpose.

Transmission during the evenings and weekends would reduce line charges; however, this is inconvenient for the physician, technician, and patient. If medical data telemetry becomes more widely accepted as a means of improving health care delivery, the common carriers may have to reduce their tariffs in order to make this more economically feasible. Reduction in purchase price of data sets will depend on future market volume.

Applications

Transmission of electroencephalograms over conventional telephone lines can be used in the following ways:

Service: This system can be advantageously used in rural and urban communities, providing hospitals with routine and emergency service which otherwise would not be available. In addition, since it is well recognized that there are physicians reading EEGs who are inadequately trained, quality of interpretations can be improved by affiliation with a reputable laboratory.

Rural — Because the population necessary to support a neurologist and/or neurosurgeon is approximately 100,000,[19] the majority of the estimated 2,500 to 3,000 hospital and clinic EEG laboratories in the United States[20] are located in large communities. Consequently, patients living in smaller cities, particularly in rural areas, are often required to travel long distances for an EEG. The problem of distance, increased expenses of travel and delays in obtaining reports may influence the physician to avoid ordering EEGs. Non-afbulatory and emergency patients are deprived of this service. The non-availability of EEG facilities is nationwide although most prevalent in sparsely populated states, particularly those in the Intermountain West. For example in Montana, the fourth largest state in area with a population of approximately 700,000, only four cities and one state hospital have laboratories.[21] The counties in which these cities are located contain approximately 261,000 people. Consequently EEG facilities are not readily available to 63% of the state's population. A telephone EEG service from one or several remote areas to a central facility can be provided as demonstrated by the Twin Falls — Salt Lake City link.

Urban — This service may also help electroencephalographers who interpret tracings at several hospitals. Inter-hospital travel time can be reduced and emergency records quickly evaluated.

Training: Only a little over 200 of the 3,000 to 5,000 EEG technicians in the United States have been certified by the American Society of EEG Technology.[20] The majority of these are employed by University Medical Centers and large clinics. In offices, smaller hospitals and clinics the technicians have for the most part been inadequately trained and are not properly supervised. The benefits to the technician from this transmission scheme are several. In large metropolitan areas they not infrequently divide their time between several hospitals, either obtaining EEGs on a hospital owned machine, or transporting the encephalograph to the installation. This is not only time consuming but proper supervision is often lacking. In addition, particularly in outlying laboratories that mail tracings to a center for interpretation, the technician is alone and only rarely has the opportunity to converse with other technicians or electroencephalographers. With this system the transmitted record is monitored by an experienced technician at the receiving site. By pushing the reverse channel signal button, the tracing is interrupted and he can talk to the technician over the same line, thus being able to make suggestions about identification and correction of artifacts, localization runs, etc. This upgrades the quality of the test and serves as a method for ongoing training.

Research: The application of the computer in clinical electroencephalography is still in its infancy stage. However, it is anticipated that within the next several decades, programs for computer analysis, classification, storage and retrieval of electroencephalograms will exist similar to what is now available for electrocardiograms. If this becomes a practical reality and is accepted by the practicing electroencephalographers, then the EEGs, whether in analog or digital form, will probably be transmitted over conventional telephone lines from regional hospitals to the computer center.

Telephone telemetry of EEG can be used to monitor patients in intensive and newborn care units, during surgery and from their homes. In Vancouver General Hospital the on-line continuous monitoring of comatose patients is under investigation.[14] Transmitting EEG signals from epileptic patients or subjects with other intermittent syndromes from their homes is also being evaluated.[22, 23]

Summary

The methodology and results of four years' investigation of telephone telemetry of EEG have been reported. Real time, analog, simultaneous, quality transmission of eight channels of brain waves over conventional voice lines is now possible. Financial considerations as well as present and future applications of this system are discussed.

ACKNOWLEDGMENTS

The authors wish to acknowledge the valuable contributions made by the following:

1) Mr. Lee V. D'Alessandro, Chief Technician, University of Utah Medical Center.

2) Mrs. Irene Oliver, Head Administrator; Dr. Birdsall N. Carle, Head, Department of Pathology; Dr. Bernard L. Kreilkamp; Mrs. Leslie Price, EEG technician and the medical staff of the Magic Valley Memorial Hospital, Twin Falls, Idaho.

3) Mr. Richard Vorce and Mr. Ross B. Tilton, EMR Telemetry, Sarasota, Florida.

REFERENCES

1. EINTHOVEN, W., Le telecardiogramme, Arch. Int. Physiol., 4:132, 1906.
2. KANATSOULIS, A., Le tele-electrocardiographe, Presse Med., 59:458-459, 1951.
3. DIAMOND, E. G. and BERRY, F. M., Transmission of electrocardiographic signals over telephone circuits, Am. Heart J., 46:906-910, 1953.
4. RAHM, W. E., JR., BARMORE, J. L., ELLESTAD, I. M. and DUNN, F. L., Local and long distance transmission and storage of electrocardiograms and other low frequency signals, Circ. Res., 1:518-522, 1953.
5. MELVIN, J. P., Telephone telemetry, J. Mississippi Med. Assn., 5:84-86, 1964.
6. LEVINE, I. M., JOSSMANN, P. B., TURSKY, B., MEISTER, M. and DE ANGELIS, V., Telephone telemetry of bioelectric information, JAMA, 188:794-798, 1964.
7. RAY, C. D., BICKFORD, R. G., WALTER, W. G. and REDMOND, A., Experiences with telemetry of biomedical data by telephone, cable and satellite: domestic and international, Med. biol. Engng, 3:169-177, 1965.
8. NIEBELING, H. G. and VAN GOGH, H., Das Telefon-EEG (I. Mitteilung), Deutsch. Gesundh., 18:1365-1367, 1963.
9. BENNETT, D. R. and GARDNER, R. M., A model for the telephone transmission of six-channel electroencephalograms, Electroenceph. clin. Neurophysiol., 29:404-408, 1970.
10. United States Department of Commerce Federal Communications Commission, Federal Communications Commission Reports, Docket Nos. 16942 and 17073, Washington, D.C. Government Printing Office, 1968, pp. 420-429, 430-441, 571-575.
11. MOSCHYTZ, G. S., Miniaturized RC filters using phase-locked loop, Bell System Techn. J., 44:823-870, 1965.
12. GREBENE, A. B. and CAMENZIND, H. R., Frequency - selective integrated circuits using phase-lock techniques, IEEE J. Solid State Circuits, 4:216-225, 1969.
13. SCHEAR, H. E., PORI, J. and ROWE, W., Workshop on Telemetry, Janice Stevens, moderator, American EEG Society Meeting, Bloomington, Minnesota, September 16-18, 1971 unpublished).
14. KNOTT, J. R., SHIPTON, H. W., BUCHTHAL, F., HENRY, C., MARSHALL, C., STORM VAN LEEUWEN, W., and REMOND, A., Report of the Committee on Apparatus, Electroenceph. clin. Neurophysiol., 10:379-380, 1958.
15. LOW, M. D., BAKER, M., FERGUSON, R. and FROST, J. D., Acquisition of electroencephalographic data in a large regional hospital: Bringing the brain waves to the computer. In Art Lew (Ed.), Proceedings of the Fifth International Conference on Systems Sciences Computers in Biomedicine, Western Periodicals, 1972, pp. 9-11.
16. GIBBS, F. L. and GIBBS, T., The facsimile transmission of electroencephalograms, Clin. Electroencephalography, 1:171-175, 1970.
17. MARTIN, J., Telecommunications and the Computer, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1969, p. 317.
18. NORDLING, K. I., Analysis of common carrier tariff rates, Datamation, 17:28-35, 1971.
19. CARTER, S., Of priorities, promise and the path ahead, Neurology, 21:877-888, 1971.
20. HENRY, MARGARET, Secretary, American EEG Society, Personal Communication, June 1972.
21. CEREGHINO, J. J., Survey of existing services and facilities for the epileptic in the State of Montana, Regional Medical Programs Service, Arlington, Virginia, August 1969.
22. HANLEY, J., SWEIZIG, R. T., KADO, R. T., ADEY, W. R. and ROUNER, L. D., Combined telephone and radiotelemetry of the EEG, Electroenceph. clin. Neurophysiol., 26:323-324, 1969.
23. BICKFORD, R. G., MELBY, G., KARNES, W. and GROOVER, R., Teleprocessing of EEG from patient's residence, Electroenceph. clin. Neurophysiol., 26:117-118, 1969.