METHODS & DESIGNS

Sociotechnical design factors in remote instrumentation with humans in natural environments[1]

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The use of telemetering and remote communication devices is becoming increasingly popular in clinical and social psychology. There are, however, a number of technical, economic, and social constraints that may limit severely the practical application of such instrumentation. A brief review of certain design factors including communication modality, social acceptability, complexity of the system, relative cost, data-reduction procedures, and FCC regulations is presented as a preliminary guide to system development.

It is a truism that most all treatment procedures today rely on a massive transfer of behavior from the clinic to the patient's usual living situation. Traditional psychotherapeutic methods are often handicapped by almost total reliance on verbal self-reports and clincially-confined patient behavior. Studies by Gray (1955) and by Carwright (1962) have indicated substantial differences between self-reported and observed behavior. Furthermore, as Barker (1965) and others have pointed out, it is often impossible to duplicate in the laboratory or clinic the frequency, duration, and complexity of particular stimuli and conditions that may be of concern. Therefore, an investigator or clinician wishing to study or to intervene in an individual's typical behavior patterns should consider the possibility of remote instrumentation. For a variety of quite valid reasons, such instrumentation may be rejected, but continuing improvements, such as component miniaturization, can be expected to provide increasingly realisitc options for researchers and practitioners.

Several references dealing with psychophysical instrumentation in general (Sidowski, 1966; Venables & Martin, 1967) and telemetered data in particular (Caceres, 1965; Mackay, 1968; Slater, 1963) are readily available; therefore, this paper will focus primarily on remote instrumentation systems that may be of special interest to clinical or social psychologists.

The earliest reports of remote communication with human Ss are found in the 1930's (e.g., Chaffee & Lights, 1934; Fender, 1937). This type of system represents the first example of instrumentation where the personalized unit is completely self-contained on the S without being connected to external wires. (Earlier units, by Einthoven [1877] for example, remotely monitored physiological functions by "wiring the patient into" existing telephone lines.) Personalized remote communication or *stimulation* units were developed prior to personalized remote *monitoring* units because a passive receiving system does not require amplification or a portable power source. Receivers could be constructed with a few components that were relatively small even in the 1930 period. In contrast, physiological monitoring and voluntary subject-activated communication units would have required, at that time, bulky vacuum tubes in order to provide the power and amplification necessary for signal-processing and transmitting components.

The development of transistors made remote monitoring units markedly more feasible. Numerous studies have reported the telemetering of physical location in animal ecology (e.g., Mackay, 1968) and of physiological data in humans (Battye & Joseph, 1966; Hoare & Ivison, 1961; Mackay & Jacobsen, 1957). Essentially all of the personalized units to date have had low transmitter power levels capable of transmitting in the order of several hundred feet, with the exception of some outdoor animal tracking units operating in flat areas. Physiological monitoring of schizophrenics in hospital wards (Tursky, 1962), asthmatic children at play (Schnauss & Rader, 1964), and normal children watching a movie (Lazarus, Spiesman, & Mordkoff, 1963) are representative of an increasing variety of S populations and transmitting environments.

Instrumentation with respect to voluntary S communication was significantly advanced by military applications such as the "walkie-talkie" and by more recent space exploration projects. However, relatively few psychologists have used either one-way or two-way signaling devices with humans in clinical or social settings. Two notable exceptions include an auditory prompting device consisting of a small behind-the-ear receiver through which the therapist may send a message to a trainee or a parent while interacting with a client in a specially-wired therapy room (Sanders, 1966; Welsh, 1966), and a small radio receiver with an earphone used to countercondition a hyperactive 10-year-old student in a classroom situation (Patterson et al, 1965). Two-way communication with adolescent delinquents using radio transcievers housed in leather belts has also been reported (Schwitzgebel, 1969).

DESIGN FACTORS

The following brief outline of design factors is intended to assist a clinician or researcher who is contemplating the use of remote instrumentation systems with humans in natural environments. The variables indicated here are by no means comprehensive, but represent some of the major factors to be considered.

Stimulus Modality

In principle, signals of informational value could be received by any of the five senses: visual, auditory (including subsonic), tactile, olfactory, and gustatory. The signal transducers providing the stimuli to Ss might function by electrical, mechanical, thermal, or chemical means. Auditory and visual signals produced electrically are the most common means of remote information exchange.

The tactile mode of reception has received some sustained attention by researchers (e.g., Bliss, 1966, Geldard, 1957; Hawkes, 1960), but attempts to use this mode in remote signalization are rare (e.g., Applied Psychological Services, 1966). Tactile stimulation for communication purposes might be produced by activating a coiled spring with an attached pin to "tap" the S's skin (Bice, 1961; Bird, 1969) or by releasing a short burst of air from a modifed aerosol can arrangement (Donaldson, 1967; Lucas, Bell, & Kreul, 1965). Thermal buttons (heat-producing disks with high electrical resistance) are less satisfactory due to long latencies and the possibility of burns. Again, assuming that the tactile signals need to convey only one bit of information (a two-choice situation), the *locus* of stimulation may be used as the

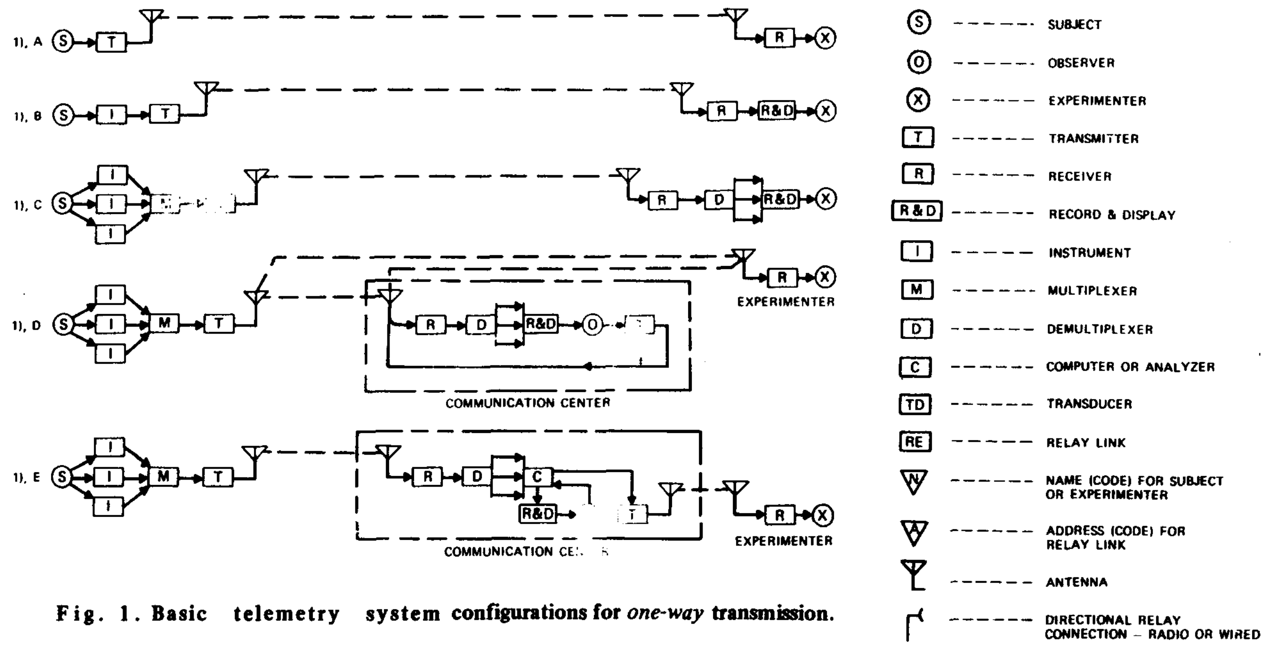

Fig. 1. Basic telemetry system configurations for *one-way* transmission.

relevant cue. All that is required is a pair of stimulators well separated on the body surface. For example, circumferential pressure bands might be placed along each arm at several points and differentially activated by remote control on the basis of a predetermined code.

Although gustatory stimulation is one of the most commonly used positive consequences in laboratory conditioning experiments, no examples of remote gustatory stimulation for Ss with freedom of movement in natural settings could be found in the literature. This stimulation could, however, be instrumented by attaching a food container to the person, with contents released on remote command. For example, M & Ms might be locked into a dispenser worn by a youngster in the classroom and opened either automatically or manually upon performance of a desired behavior. Similarly, olfactory sensation, subjectively pleasant or unpleasant, could be produced remotely by the activation of an atomizer or aerosol container. It should be noted that both gustatory and olfactory stimulation techniques suggested here are very speculative in nature inasmuch as some associate conditioning must be assumed (e.g., Ss might pocket, rather than eat, the candy) or some novel dispensers would have to be developed for direct stimulation of these senses. Various types of transducer options are indicated in Table 1. References in the table were arbitrarily selected as representative and are by no means exhaustive for any single category.

Electromechanical Considerations

Several basic transmitting configurations are possible. The simplest arrangement involves *one-way* communication from a single S in a fixed location to an E in a fixed location. For example, the E might ask a parolee to send periodic coded signals from work as a means of verifying the parolee's location and activity. Diagram "A" in Fig. 1 illustrates this arrangement. (A useful glossary of terms frequently used in telemetry may be found in NASA's Technology Utilization Report [1965]). Information is voluntarily sent by the S, usually by voice or keyed transmissions. The E receives and simultaneously interprets the data.

At the next sublevel, (Fig. 1B), an instrument is interfaced between S and E whereby the information is sent continuously, or on some time interval, and does not necessarily require the voluntary participation of the S. In this case, an E may wish to monitor GSR or heart rate of a particular student while in a remedial reading class for the purpose of estimating autonomic arousal to academic material and teacher attention. Typically, this situation requires that the E record and display the received information so that a subsequent interpretation can be made. Figure 1C is identical to 1B with the exception that now multiple sensors are used and multiple measurements are made. Due to the relative lack of noise-free radio

Table 1
Transducers to Provide Intelligibility Signals to Ss in Natural Settings

Modality	Transducer	Signal Type	Approximately Bandwidth	References
Visual	Light Flash	Coded On-Off	A few Hz to KHz	
	TV Handset	Continuous	mHz	Chater, 1967
Auditory	Handset	Coded On-Off	500 Hz	Cochran, 1967; Kerwien & Steiff, 1963
		Continuous	3000 Hz	
	Earphone	Coded On-Off	500 Hz	Black, 1957; Lyons & Valiquette, 1966
		Continuous	3000 Hz	
Tactile	Vibrator	Coded On-Off	2000 Hz	Bice, 1961; Myasnikon, 1964
	Air Jet	Coded On-Off	1000 Hz	Donaldson, 1967; Lucas et al, 1965
	Electric Shock	Coded On-Off	500 Hz	Gibson, 1963; Hawkes, 1961
	Thermal Button	Coded On-Off	1/10 Hz	Geldard, 1965; Hensel & Witt, 1959
	Pressure Cuff	On-Off/Continuous	A few Hz to 100s Hz	(None located)
Olfactory	Atomizer	On-Off	A few Hz to 100s Hz	(None located)
Gustatory	Food Dispenser	On-Off	A few Hz to 100s Hz	(None located)

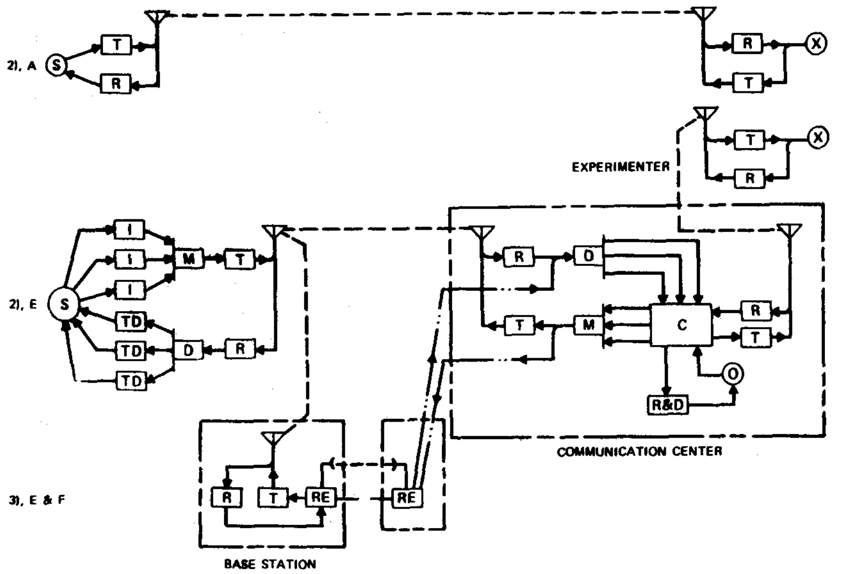

Fig. 2. Basic telemetry system configurations for *two-way* transmission.

channels, it may be advisable to separate (i.e., "multiplex") two or more signals such as GSR and heart rate within a single radio channel by transmitting such signals at different times, frequencies, or phases. On the receiving end, it is then necessary to decode or demultiplex the received signal in order to obtain the original measurements.

In Figs 1D and 1E a further level of complexity is indicated (i.e., a communication center). The communication center allows both the S and the E to be mobile if desired. In D the communication center has an O associated with it who can, in turn, communicate with the E–a useful procedure for checking reliability and validity of subject-transmitted data. In configuration 1E, a memory and/or analyzer function is added to the communication center. This apparatus, such as a computer, would be capable of automatically analyzing data and sending results, when appropriate, to the E.

The second major level of complexity provides for *two-way* communication, and thus allows for a certain degree of interaction and mutual control. Here, the sublevels, as previously represented in Fig. 1A-E, can be repeated providing for both a transmitting and receiving capability. This type of capability is illustrated in Fig. 2 where subsystems A and E are shown. Figure 2A represents a familiar walkie-talkie channel. Just as instruments can be added in the output or transmitting path from the S, transducers can be provided in the input or receiving path to the S for interaction or control purposes. In Fig. 2E, with the availability of a computer function, it would be possible for the computer to analyze the data and then, as a result, either initiate a return communication signal directly or else automatically notify the E who might then initiate communication.

An increasing level of complexity occurs when, as in Fig. 1E & F, the communication area for the S is extended beyond a fixed remote setting to more flexible environmental settings. The technique used to accomplish this is the addition of a remote base station relay link. This base station might be placed in the home, for instance, where the S would have freedom of movement, including possibly some area near home such as playgrounds, hang-outs, movie houses, etc. The S-E communication might be accomplished by a directional-radio relay link or by a transmission line furnished by the telephone company.

A communication from the S is accomplished as follows: (1) A signal is sent from the S's transmitter and antenna unit to the base station antenna and receiver. This signal is made available to the relay link in multiplexed format. (2) The relay link prepares the signal for transmission either via radio or telephone line. (3) The communication-center relay station receives and demodulates the signal, if required, making it available for demultiplexing. (4) The signal is sent to computer or analyzer for analysis, recording, display, notation, and transmission to the E.

In a similar manner, a signal *to* the S from the communication center is accomplished as follows: (1) The signal from the communication center is multiplexed, if required, and sent to the relay link. It is there prepared for transmission via radio or telephone line. (2) The base-station relay link receives and demodulates the signal if required and makes it available to the base-station transmitter. (3) The remote base station transmits the signal to the S in his natural environment. (4) The S's personalized unit antenna receives the signal and sends it to the unit's receiver where it is demultiplexed, if necessary, making the communication signal available to an attached transducer.

Note that the communication-center transceiver, receiver, and antenna shown in Fig. 2E are not required in the E & F configuration. This function is replaced by a relay link consisting of a commercially-leased telephone line.

As long as a signal from the S can be received at the remote base station, the use of a rented telephone line allows the communication center or laboratory to be any distance away. In addition to this advantage, one may be able to use a somewhat smaller antenna at the base station. Unfortunately, a number of equipment and telephone representatives apparently believe that special equipment regulating the pulse, frequency, or amplitude of the signal (i.e., modulator/demodulator or "modem" is required at both the sending and receiving end of the telephone line. This *may* be true if the usual home or office telephone line is used, but not necessarily so if a separate "data-link" line is rented. (A "data-link" is essentially nothing more than a pair of wires running from one location to another, which may be designated by the E, through the telephone company switchboard. The rental rate is determined by type of line and distance, and may range between $5.00 and $20.00 a month for a community-based project.) There are a number of technical issues here relative to signal frequency, bandwidth of data-link, etc. In some applications, a relatively inexpensive acoustical coupler may be attached to the regular telephone line. This type of arrangement has the obvious advantages of less costly line rental and of greater flexibility in choosing remote locations. Researchers should check into these matters carefully before purchasing or leasing modems, line equalizers, etc. As a matter of general practice, investigators who are not technically sophisticated should budget consulting time for an objective engineering evaluation of a proposed system in order to avoid "over-engineering" by equipment suppliers or commercial systems companies.

It is possible, and eventually necessary, for a systems designer to specifiy in more detail each of the electro-mechanical modules of the system configurations summarized here. For example, a S's personalized unit must perform certain signal-conditioning functions as well as meet social constraints, such as size and weight. Ideally, personalized transceivers used in social research should exhibit the following characteristics: (1) be capable of being worn for extended periods of time without deterioration of signal quality (e.g., through electrode polarization), (2) transmit signals having temporal attributes of the same order of magnitude as the overt behavior of interest, and (3) use transducers minimally confounded by artifacts such as S movement or background radiation from common sources such as television and FM radio stations.

Although it is desirable to design the sensors and transducers as an integral unit for ease of attachment, particular care must be taken in placing amplifiers near sensors when low-level signals are involved due to the possibility that current leakage will distort the signals. In most telemetry systems this requirement is conveniently met by placing the amplifying circuits and power supply in a separate package and making an external hardwire connection to, say, GSR or EEG electrodes some distance away.

Antenna configurations may take several basic forms. These configurations will significantly effect the system's performance, and therefore, important technical and social decisions must be made early in the design phase. For example, a vertical antenna may consist of a wire running from the S's foot to his waist; a horizontal antenna across the back of his shoulders may be sewn into a jacket or shirt; a loop or coiled dipole antenna may be built into a belt around the waist. The transmitting characteristics and efficiency of an antenna are contingent upon many factors, such as configuration, length, internal resistance, proximity to the ground, proximity to the S's body, and so forth (Bird, 1969). These factors become particularly critical when the personalized units are to be used for both transmitting and receiving, since, as previously indicated, the amount of transmitting power is constrained by the unit's portability. The use of integrated circuits in the personalized equipment–which decreases the size of the electronics package, thereby allowing a larger power package–can sometimes permit a more socially acceptable configuration. The essential problem in almost all remote applications involves a compromise between the increased power required by small sophisticated circuitry and traditional limitations of weight and size.

Social Considerations

An important factor in psychological research conducted in the community, rather than in a clinic or laboratory, is the acceptability of the apparatus to the S's peers. For example, it is difficult to imagine under what conditions one might persuade an individual to go about his normal activities with an antenna projecting above his head. Generally, speaking, our technology is more flexible than our social mores. The researcher, therefore, is advised to be cautious in relinquishing an instrument design which he believes is necessary for the personalized units to be used without undue embarrassment. If the system proves to be "technically recalcitrant," the investigator's usual options are a more modest research objective, purchase of more sophisticated components or technical help, paying S fees, or simply postponing the project.

In some applications, with psychiatric patients or parolees perhaps, it may be necessary that the personalized unit be permanently attached to the S and be relatively inaccessible. In other applications it may be necessary to remove the personalized units one or more times a day. These factors are obviously important in considering the nature of the packaging and method of attachment. The unit may be designed as a part of an undergarment or a piece of jewelry. An investigator will quickly discover, however, that this type of arrangement is often an unrealizable goal. The problem of finding a satisfactorily sensitive and relatively noise-free body area for attachment of a transducer is compounded by the fact that power packs are seldom able to be located at the same site, and therefore some wire connection between the transducer and power/transceiver pack is required. For example, a ring or wristlet might be desirable transducer sites for electrocutaneous measurement, but a wire connection to a circuit package in the S's shirt pocket or on his belt would be required. A more feasible design might use a metallic cloth plantar electrode with the transducer attached to the ankle. Table 2 summarizes a number of possible attachment methods and some representative literature references.

Of the various modalities that may be used in two-way communication systems, the auditory-verbal mode is undoubtedly the most common. While this requires little, if any, training to use, in comparison to modes requiring the use of coded signals, the privacy of the communications is not assured. Furthermore, in situations such as a classroom, this type of communication tends to disrupt ongoing social interactions. Coded tactile and/or light signalization is a possible alternative.

Still another consideration involves some realistic estimate of physical abuse by potential Ss as well as the time and place of typical but important transmissions. Will Ss want to remove the apparatus or will it fail to function when you most want information? For example, mobile but hospitalized medical or surgical patients tend to go into lavatories when ill, where, even if a signal is received, rescue is difficult. Behavior-disordered youngsters may accidently or intentionally damage attached units.

Cost

The cost of establishing a remote instrumentation system may be double that of a similar hard-wire laboratory system. Consider, as an illustration, more-or-less routine monitoring of physical signals such as GSR, EEG, EKG, and respiration. A moderately priced four-channel high-impedance dc amplifier and oscillograph will cost $4,000-$6,000. An additional $1,500 may be spent for couplers, electrode assemblies, electrical shielding, supplies, etc. Thus far, remote and laboratory systems are similar. However, at this point, the remote system requires at least one multichannel telemetry unit and associated attachments costing approximately $800. In addition, a minimum of two stationary transceivers and antenna, one within range of the S and

Table 2
Attachment Methods of Telemetry Units

Body Part	Location	References
Head	Hat	Botsch, 1966; Curtis, 1964
	Head Band	Fischler & Frei, 1963; Simons & Prather, 1964
	Skull	Fischler & Frei, 1963; Skutt, 1967
	Ear	Lyons & Valiquette, 1966
Shoulder and Torso	Harness, Front	Hoare & Ivison, 1961; Bergey et al, 1966
	Harness, Back	Webb et al, 1958; Botsch, 1966
	Jacket	Simons & Prather, 1964; Bergey et al. 1966
Torso	Chest Strap	Norland & Semler, 1964; Fascenelli, 1966
	Waist Belt	Battye, 1966; Boreen et al, 1961
Limbs	Arm Band	Allred & Johnson, 1966; Ko et al, 1963
Unattached	Pocket	Rader & Meehan, 1966; Roy, 1966
Implanted	Alimentary Canal	Gleason & Latimer, 1962; Mackay, 1964

the other at the communication center or laboratory, must be purchased at approximately $1,200. Engineering service, fabrication of novel transducers or attachment methods, batteries, telephone line installation and rental, staff time involved in FCC licensing if necessary, and other special arrangements could be conservatively budgeted at $2,000. Remote communication systems *not* involving telemetry of physiological responses may cost, *proportionately*, even more when compared to most clinical research projects that routinely use little or no equipment beyond an audio or video tape recorder.

The lease or purchase of a computer is another possible expense. The nature and quantity of the data rather than the means of its acquisition determine the advisability of computer assistance. The lower signal-to-noise ratio of telemetered data is likely to make data analysis more complex and therefore more likely to necessitate the use of a computer. In some cases, particularly where fine-grain and continuous analysis is desired, as in monitoring for medical purposes, the degradation of the signal may be so severe as to make telemetry absolutely impractical. Due to the great variability of radio signal interference in different locations, an on-the-spot demonstration is essential, and potential purchasers should remember that EKG, which is often used in such demonstrations, is one of the strongest physiological signals.

Determination of initial costs are usually more obvious and straightforward than the determination of long-term costs. Long-term costs include the expense of system operation, maintenance and upkeep, and the cost of a failure of the system during a functioning period. This last item is necessarily somewhat subjective and is often overlooked in the design phase, but in many cases (again, particuarly in medical applications) it may be one of the most important long-term cost factors.

Data Reduction

Due to the complexity of establishing a remote information link with a S, most studies involving this type of instrumentation are longitudinal. However, observations of the same S at different points in time are often spuriously significant due to a day-to-day dependence, particularly on self-reported measures. Lathrop (1965) and others have discussed statistical issues relative to continuous measurement of single Ss. Campbell (1969) has summarized a number of other threats to data validity that have particular likelihood of occurring in nonlaboratory situations: e.g., maturation, effects of repeated testing, instrument calibration changes, S selection bias, and reactive effects of experimental arrangements.

Because large amounts of data may be accumulated very rapidly, some process of data reduction should be decided upon at the outset. One relatively straightforward procedure is to record data on magnetic or punched paper tape for computer processing. This is expensive in terms of initial investment, as previously mentioned, and does not necessarily provide for real-time monitoring and for therapeutic or experimental intervention.

Most social scientists and clinicians need a less expensive procedure. The first and most helpful step is converting data in analogue form to digital form. A voltage-to-frequency converter (digital voltmeter) may be used in conjunction with a digital printer to provide reliably coded, continuous information (Krausman, 1968). An on-line and even less expensive alternative that digitalizes data by operating a series of photocells and microswitches from the pens of an oscillograph has been suggested by Fitzgerald, Vardaris, and Teyler (1968). These procedures are, of course, equally applicable to hard-wire and telemetered data.

Legal Considerations

The Federal Communications Commission (FCC) has set forth rules and regulations governing all electromagnetic radiations in the frequency range of 10 kHz to 90 GHz. An investigator contemplating the use of a remote instrumentation system should consult Volume II, Part 2, of the FCC Regulations where various bands are specified for certain uses. No bands are specifically reserved for remote instrumentation systems for therapeutic purposes. Most all applications will therefore fall under one of the following five classifications: low-power trasmitting devices, citizen's radio service, business radio service, industrial radio location systems, and experimental research.

Low-power transmitting devices such as those that may be used exclusively inside a given building or hospital ward usually require no license. The 88- to 108-mHz band where this type of low-power telemetry operates is also the commercial FM band. This band has the advantage of readilly available commercial receivers but the disadvantage of crowding. The problem can be at least partly circumvented by tuning transmitters to frequencies of minimal use in the particular area of transmission. The effective transmitting distance for psychophysiological data is, at best, about 100 m. Two-way communication in this band is prohibited. (CF. Table 3 for summary of requirements and limitations of various low-power frequency ranges,)

The citizen's band is probably of little interest for many remote instrumentation

Table 3
FCC Regulations for Low-Power Communication Devices (as of January 1, 1969)

Frequency Range	Radiation Limit in Signal Strength	Alternative Radiation Limit in Power	Other Requirements
10 - 160 kHz and 190 - 490 kHz	$\frac{2400}{f_{kHz}}$ μv/m at 1000 ft	None	None
160 - 190 kHz	$\frac{2400}{f_{kHz}}$ μv/m at 1000 ft	1 W maximum input to final RF stage and 50-ft antenna	For power limit, all out-of-band signals must be 20 dB below unmodulated carrier
510 - 160 kHz	$\frac{24000}{f_{kHz}}$ μv/m at 1000 ft	100 mW maximum input to final RF stage and 10-ft antenna	For power limit, all out-of-band signals must be 20 dB below unmodulated carrier
26.97 - 27.27 mHz		100 mW maximum input to final RF stage and 5-ft antenna	For power limit, all out-of-band signals must be 20 dB below unmodulated carrier
88 - 108 mHz	50 μv/m at 50 ft 200 kHz maximum bandwidth	None	All signals out of 200 kHz bandwidth must be 40 μv/m at 10 ft. Telemetry and wireless microphone one-way transmission only.
70 - 130 mHz	50 μv/m at 100 ft	None	
130 - 174 mHz	50 - 150 μv/m at 100 ft Linear Interpolation	None	Pulsed transmission only. Maximum of 1 sec on, occurring no more than once every 30 sec.
174 - 260 mHz	150 μv/m at 100 ft	None	
260 - 470 mHz	150 - 500 μv/m at 100 ft Linear Interpolation	None	
Above 470 mHz	500 μv/m at 100 ft	None	

purposes due to nonprivacy and signal interference. Both low-power and business radio bands tend to suffer from similar problems of overpopulation of users. One frequency region of particular interest for remote systems is the 173-mHz band where mobile remote control and telemetry is permitted. The maximum power output from the tramsmitter is, however, limited to 1 W. It is advisable to monitor various possible frequencies in your particular locale prior to submitting construction and license applications if such are required by law.

The least restrictive of the five general alternatives previously mentioned is the experimental research service, which is licensed to qualified persons for the purpose of conducting scientific or technical radio research or for communications in connection with federally-funded research projects. Stations so authorized may use any government or nongovernmental band as long as the investigator can justify his request by demonstrating that none of the other services is adequate for his experimental application. The final allocation of a frequency may not be completed for 6 months from data of original application, and the investigator cannot be assured that the band finally assigned will be compatible with his equipment. Although changes may amount to little more than retuning cyrstals, the conservative procedure is to purchase radio components only after the allocation has been made.[2]

CONCLUSIONS

The issues of remote instrumentation discussed in this paper are by no means comprehensive, nor perhaps the most sociologically relevant. A certain fascination and fear associated with observing and possibly controlling behavior at a distance still exists among a substantial number of psychologists as well as the general public. If such techniques of instrumentation are to become more than experimental curiosities or science-fiction nightmares, we are obliged to seek ways of building into our apparatus more precision, flexibility, and aesthetic appeal. These are more speculative matters of system development that may be considered at a later time.

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NOTES

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2. A useful brief introduction to "FCC License Applications for Biotelemetry" can be obtained without charge from the Bioinstrumentation Advisory Council, 3900 Wisconsin Ave., Washington, D. C. 20016.