A NEW INSTRUMENT FOR UNATTENDED CATV MEASUREMENTS FOR YEARLY PROOF OF PERFORMANCE AND ROUTINE MAINTENANCE

Albert Helfrick
Kay Elemetrics Corp. Pine Brook N. J.

George Fenwick
Telecommunications Inc. Dover N. J.

ABSTRACT

This paper presents a new instrument, the Kay 9021, and discusses the methods and equipment required for automatic, unattended CATV measurements. The authors discuss the types of parameters that may be measured, and the data-logging equipment that is required. Methods of reducing interference to the subscriber are analyzed. Included is a description of a new high-level sweep system receiver and its application to unattended measurements. Also discussed is a useful piece of auxiliary equipment not commercially available but which may be constructed by the system operator. Results of actual system tests are presented and analyzed.

Time history measurements are required by the Federal Communications Commission for yearly proof of performance. Time study measurements are often helpful in locating and predicting system failures as well as a method of status monitoring. Such measurements, when manually performed, can be rather expensive, prone to errors and can tie up valuable manpower and equipment for days at a time.

This paper describes methods of unattended system measurements using the Kay 9021 "Digital Recording Receiver." Also described is a "home-brew" item which even a small system operator could construct that makes possible automatic time annotation.

TYPES OF UNATTENDED MEASUREMENTS

Almost any system parameter may be studied over periods of time. These parameters may be studied at the head end, at the trunk amplifiers, at the subscriber terminals, etc., depending on which part of the CATV system is to be isolated for fault analysis.

Some of the more important parameters to be analyzed are: (1) System frequency response, (2) Carrier levels by wide-band spectrum analysis, (3) Spurious signals, such as co-channel by narrow-band spectrum analysis, and (4) Any other parameter that may be suspect such as a specific voltage, frequency, etc.

This paper deals with the first two categories of unattended measurement. The need for measurement of specific voltages and currents is usually indicative of a special problem and is not required by the FCC nor is it useful in the isolation of routine problems.

EQUIPMENT REQUIREMENTS FOR UNATTENDED MEASUREMENTS

Since it would be desirable to do the measurements without continuous services of a technician or engineer, some means must be provided for automatic data logging. Automatic data logging takes several forms. Analog data recorders are relatively inexpensive and useful. There are several strip-chart recorders or modifications of the basic strip chart recorder such as an X-Y recorder, drum recorder, or circular chart recorder. Or, some applications would require a digital logging device such as a strip printer or teletype machine. Generally, digital printers are useful only when the data analyzed is in a digital format such as frequency. But, converting analog data to digital numbers is often self defeating since it is much easier to see general trends from a histogram than scanning columns of figures.

The authors have found the strip chart recorder the most useful and cost effective. There are two modes of operating the strip chart recorder. One is to use a chart driven by a clock motor. But, this allows the measurement of only one parameter on a continuous basis. The second mode is to drive the chart at a rapid rate, such as a few centimeters per second but allowing the unit to run for only a few seconds during the accurately known time period, when the actual measurements take place. The beginning and ending of the chart motion is thus synchronized with the independent variable of another instrument such as a spectrum analyzer. There will be a series of plots inter-connected on a continuous strip of paper each one separated from the other by a fixed period of time. This intermittent operation allows a huge number of data points to be generated and studied on one piece of paper.

The 9021 Digital Recording Receiver has such a strip chart recorder. Recorders with timers and specialized instruments using recorders as an integral part of the system are also sometimes available to the CATV system operator.

SPECIAL CONSIDERATIONS FOR TEST EQUIPMENT USED IN UNATTENDED OPERATION

Reliability is one of the most important characteristics of any test equipment used for recorded measurements. The measuring equipment is often required to operate for long periods of time without adjustment or maintenance. The reliability must be established for the environment in which the tests will take place. Extremes of temperature and humidity are the usual stresses which cause problems.

All electronic instruments have some measure of temperature instability. It is necessary to have some idea of the magnitude of this temperature dependence especially if the instrument is used in the uncontrolled environment of field equipment. Sometimes the error introduced by temperature is of little consequence to the actual measured amount. However, if the error is great, then the temperature compensation factor must be known if the equipment is to be successfully used in the CATV environment.

If the equipment is located in a place that has no electrical power, battery operation must be used. Sometimes an automobile battery is the most cost-effective battery to use. But, be sure that the battery has sufficient ampere hour capacity to operate the equipment for the desired time. Also note that the ampere hour capacity of most batteries decreases with lowered temperature. Check the specifications of the energy storage system you intend to use.

If equipment that operates only on 117V AC is employed it will be necessary to supply either power from the mains or to use an inverter. However, unless the equipment to be operated from an inverter is of unusually low power consumption, the battery size for a continuous 24 hour operation would be prohibitive. For example, if a spectrum analyzer requiring 100 watts is operated for 24 hours from an inverter of 50 percent efficiency, the required ampere hour rating for a 12-volt battery would be 400 ampere hours. This would require at least six automotive batteries and that is ordinarily impractical. However, to reduce the battery requirements it is possible to power the equipment only during the actual operating period, which is only a tiny fraction of the total time. A battery operated timer may be used to drive a large relay to apply power to the inverter for only ten minutes out of every hour. This allows sufficient time for the equipment to warm up and stabilize and still reduce the battery load by a factor of more than six. The factor is actually more than six since battery systems tend to last longer if a rest period is allowed between discharges. Therefore, the system may operate a full 24 hours from only one fully-charged automotive battery.

The 9021 employs such a design philosophy. Despite the capability of such a system to operate from batteries it is obviously preferable to use a location which has available AC power. However for the yearly proof of performance tests, the locations of the test points are set by law and usually do not have such power-equipped enclosures.

A weatherproof and theft proof enclosure must often be used. A variety of military surplus equipment cases are available for this purpose. The equipment, placed inside such boxes, is sealed against the weather, locked against vandals and may be chained to a utility pole. If power is available, the box may be insulated and heated with a small electrical heater. The degree of sophistication is limited only by the system operator.

ACTUAL TEST RESULTS

Several parameters were measured on the Telecommunications Inc. system in Dover, N.J. by using the Kay 9021 Digital Recording Receiver. This system has nearly 400 miles of cable and serves several towns.

Two basic parameters were measured: frequency response and carrier level.

The test systems were set up and debugged using the cable system office. The facility offered the convenience of a heated location where plenty of bench space and power were available to evaluate the test systems. Communication was available to the head end, which proved to be an absolute necessity during the early phases of the test system development.

The high level sweep system transmitter used was the Kay 9059B. The receiver used was the Kay model 9021. This receiver was specifically designed in 1975 for the CATV industry using state of the art techniques and the design philosophy presented in this paper.

The high level (15 dB above the carriers) sweeping signal covers the entire spectrum of interest in 2.56 milliseconds. Since this produces a slight but visible interference to a television receiver, the repetition rate is usually limited to one every six seconds or longer. The sweep can be detected anywhere along the system with a wide-band amplifier and detector. Because the sweep is short and the repetition time so long, some method of storing the sweep is required. This was done with a storage oscilloscope in the older Kay 9020 receiver.

Please refer to Fig. 1 which presents a block diagram of the 9021 to assist in following the details of the circuit. The RF input is applied to a 0 to 29 dB calibrated attenuator. This attenuator is marked with the carrier amplitudes in DBMV. Because the carriers are usually known or could be easily determined, this level is the most useful for reference. The RF is amplified by a wideband RF amplifier and then envelope detected. The detected amplitude is converted to 256 eight-bit binary words and then stored in a 2000 bit digital MOS memory. A 50 MHz narrowband amplifier/detector provides a signal for triggering the storage cycle. The entire storage is accomplished in 2.56 milliseconds allowing 10 microseconds for each eight-bit word. The data remains in the memory until updated by the next sweep. A print command is entered manually by the operator or automatically by the internal timer and either will cause a printout without loss of stored data.

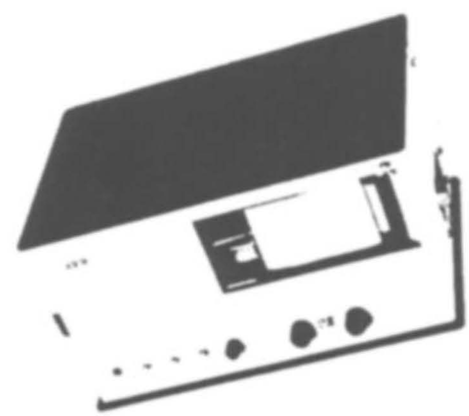


FIG. 1a KAY MODEL 9021 SWEEP RECEIVER

The print cycle operates at a much slower rate to match the relatively slow speed of the chart recorder. The 256 words are read out of the memory in about four seconds and applied to a D/A converter which converts the digital data to analog form. This analog data is amplified and printed on the chart recorder.

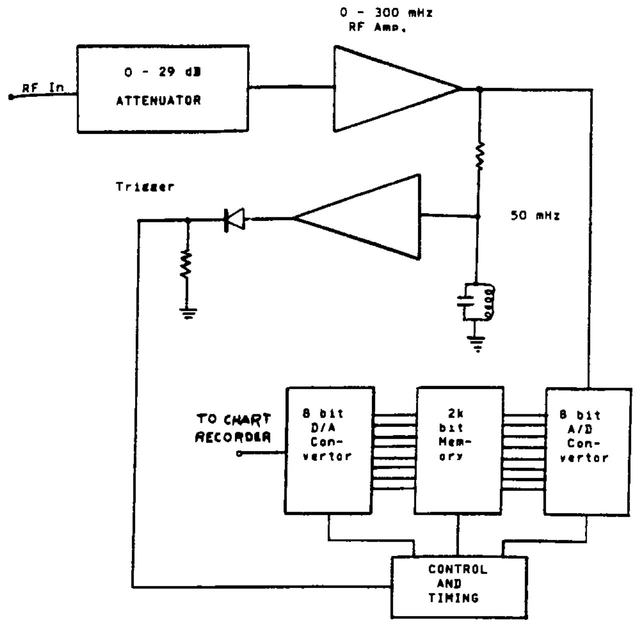


FIG. 1b SWEEP RECEIVER BLOCK DIAGRAM

To reduce the interference to the subscriber to an absolute minimum it was decided to sweep the system only once during each measurement time period. At either once or twice an hour it was obviously necessary to synchronize the sweeper and the receiver so that the receiver would be "on" and "listening" when the sweeper was triggered. This was accomplished with a battery operated crystal controlled clock. Two CMOS chips, a crystal, and a handful of resistors and capacitors were used to construct an accurate battery operated timer. The schematic of the timer may be found in Fig. 3. Battery operation is essential to avoid errors due to power outages. The timer will run for months on four standard D cells.

When synchronizing the clocks, a very handy reference is the time of day service provided by one of the system channels. Should the transmitter and receiver clocks become unsynchronized, it is a simple matter to reset the system. The sweeper at the head end is timed to sweep 10 seconds after the exact hour and exact half hour. The timer may be overriden at any time for routine maintenance chores without upsetting the timed measurements.

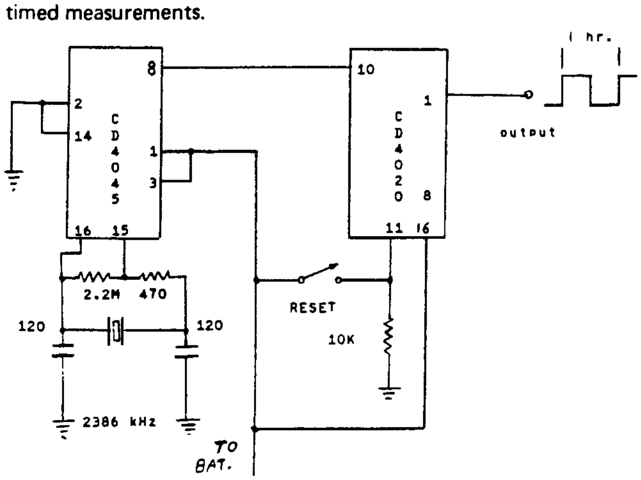


FIG. 3 BATTERY OPERATED TIMER SCHEMATIC

Tests on the Dover system were run on two different trunks: one 12 amplifiers deep and the other 27 amplifiers deep. The tests were run for 24 and 60 hours respectively. Fortunately both locations were heated structures since outside temperatures were near zero several nights.

Fig. 4 shows six successive frequency response traces taken at a test point after a 12 amplifier cascade. The frequency response is measured from 50 MHz at the low end to 300 MHz at the upper end. Since the frequency response of this system had been set up in the past using only the carriers normally handled on this system and a field strength meter, there were two areas with dips in the response. The sharp peak at the 270 MHz end of spectrum is due to the cumulative effect of mistuning the high end peaking coils to improve the high end performance when channel R was added to the existing system.

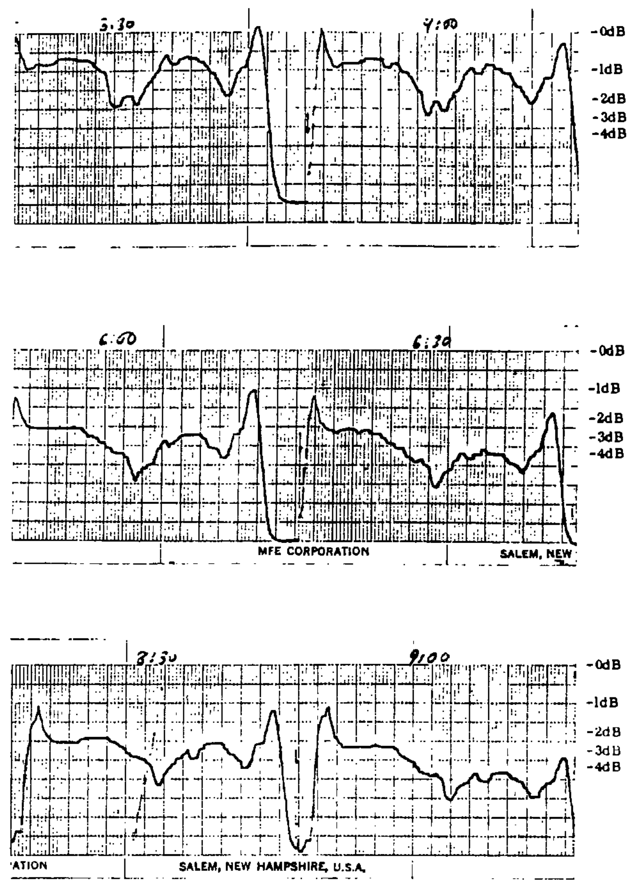


FIG. 4 FREQUENCY RESPONSE TRACES AFTER TWELFTH AMPLIFIER

Notice that for the five and one half hour period from 3:30 pm to 9:00 pm the high end dropped by 3 dB and the low end by 1 dB. The temperature dropped by about 12° Farenheit. For a cascade of only 12 amplifiers this was considered a faulty system. Subsequent investigation did show an incorrect pilot carrier level at the head end. This unit was repaired and the system rebalanced. Fig. 5 shows the sweep response of the repaired system. The system now had a more correct tilt and the dips were not quite as bad. Notice the traces during the five and one half hour from 2:50 pm to 8:20 pm. The high end had gone down by 1.5 dB and the low end had remained relatively unchanged.

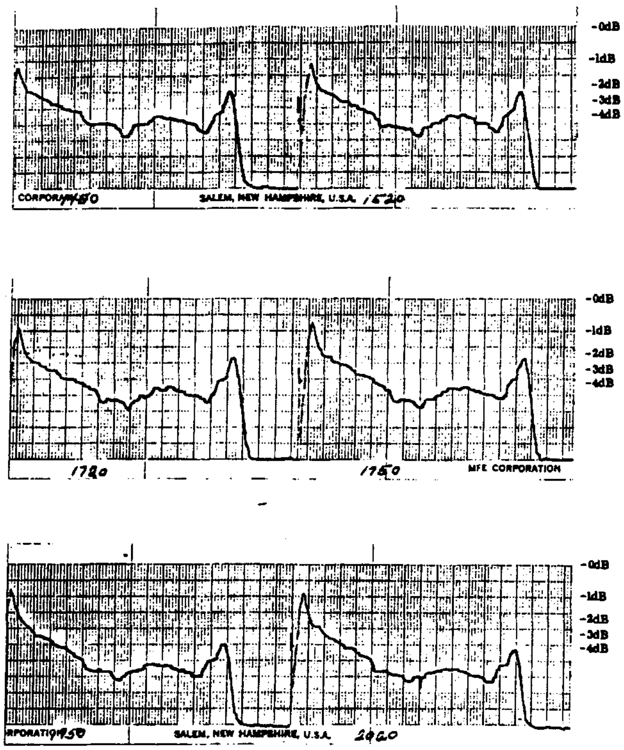


FIG. 5 FREQUENCY RESPONSE TRACES OF REPAIRED SYSTEM

During the time that these measurements were made there were no customer complaints and none of the routine measurements made by the installers and technicians indicated any trouble despite the existence of a bona fide malfunction.

Typical test results of the wideband spectrum analysis are shown in Fig. 7. No serious problems were encountered in these traces. These strip chart recordings are documented by an online time code generator. This time code generator indicates the time of day by injecting three RF signals into the CATV system. The time is then coded as a binary number, the amplitude of the three signals indicating zeros or ones. Fig. 6 shows an expanded spectrum analyzer trace of the time code signal showing the binary number 101. Since only three RF signals are used, the unit will repeat after eight hours. Therefore, additional information will be required for completely unambiguous annotation. The addition of this device to the system allows the technician to place the equipment in the field without requiring an exact knowledge of the precise time the equipment was started (see Table 1). Furthermore, the annotation allows the data to be reconstructed should the strip become damaged or if any of the measurements are missing due to equipment malfunction or loss of power.

TIME	TIME CODE
0000	000
0100	001
0200	010
0300	011
....	...
0700	111
0800	000
....	...
1500	111
1600	000
....	...
2300	111

TABLE 1

The time code generator is not at present a commercially available device and was constructed for these tests. The unit consists of three oscillators operating at 110, 115 and 120 MHz. The level of these oscillators is controlled by a crystal controlled clock; the higher level indicates a binary "one" and the ten dB lower level indicates a binary "zero."

Fig. 7 shows three spectrum analyzer traces taken at one hour intervals. The time code of the trace at the bottom of the display is the binary number 101 which in this case, corresponds to 1:00 pm. The middle trace is 2:00 pm and the top is 3:00 pm. The vertical scale is five dB per major division.

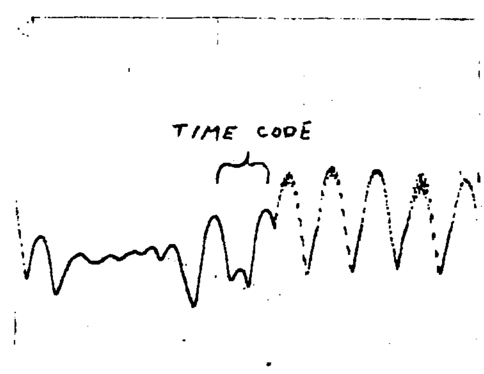


FIG. 6 EXPANDED SPECTRUM ANALYZER TRACE SHOWING TIME CODE GENERATOR

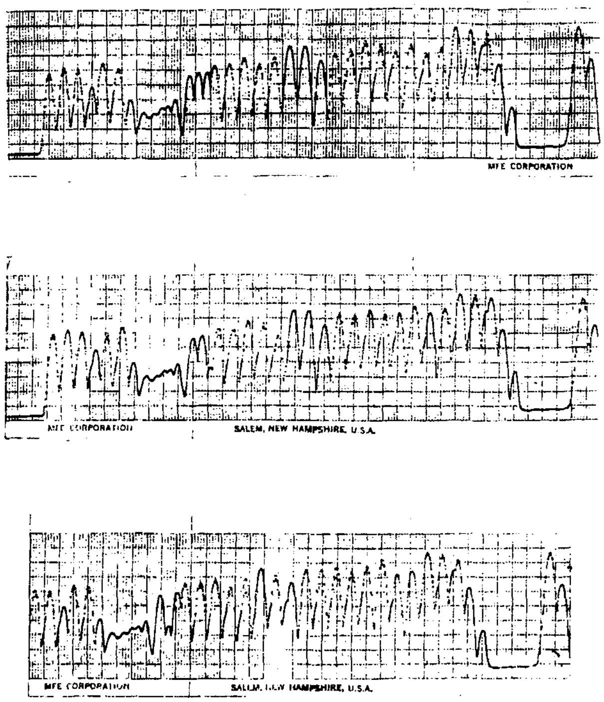


FIG. 7 TYPICAL TEST RESULTS OF WIDEBAND SPECTRUM ANALYSIS

Several differences between the results of sweep testing and the results found with wideband spectrum analysis are apparent. The five dB per division scale of the spectrum analyzer trace makes it difficult to resolve one dB variations. The trace could be expanded to two dB per division but the speed required tends to tax the speed capability of the chart recorder. Furthermore, the apparent signal amplitude depends on the nature of the modulation at the time of the measurement. Compare channel G amplitude at 1:00 pm and the amplitude at 2:00 pm. Note the change in apparent amplitude level although there is actually no change in carrier level.

For the two reasons mentioned first, the difficulty in measuring small differences in carrier level because of the compressed scale and the second, the errors introduced by the effects of modulation, it was determined that the sweep method was actually superior to the spectrum analyzer technique in locating small deviations in frequency response and temperature induced variations.

Although the conclusion here is that the high level sweep check is superior to the measurement of carrier levels for the determination of system response, it is still debatable whether the high level sweep measurements may be used in lieu of carrier level measurements. The FCC regulations do specify that the visual signal level cannot vary more than 12 dB during a 24 hour period. If one measures the relative gain of the system as a function of frequency then it is necessary to know the level of the visual signals at the head end for that time period to certify the signal level at the test point. This can be accomplished by using a recording spectrum analyzer but this may be unnecessary. Usually the signal levels at the head end are very stable and reliable and thus able to provide the desired reference. Perhaps a one-time measurement should be made at the head end with a recording spectrum analyzer. And, this will document the fact that the signal variation due to the head end is negligible.

Consider the money saving aspects of unattended measurements for yearly proof or performance measurements.

Usually to monitor three test points over a 24 hour period would require the services of four technicians; three for a full eight hour shift. This would involve climbing three poles and installing drop cables. (These cables may be tied up about 8 feet for each access.) One technician is required to make the rounds using a field strength meter to record manually the carrier levels. This would be required to continue for the full 24 hours. During the last round of measurements the drops must also be removed again requiring two technicians.

Using a figure of $14.00 per hour this amounts to a cost of $272.00 for the entire job. The $14.00 per hour reflects the cost of salaries, fringe benefits and overhead (such as gasoline, oil, equipment expense, etc.).

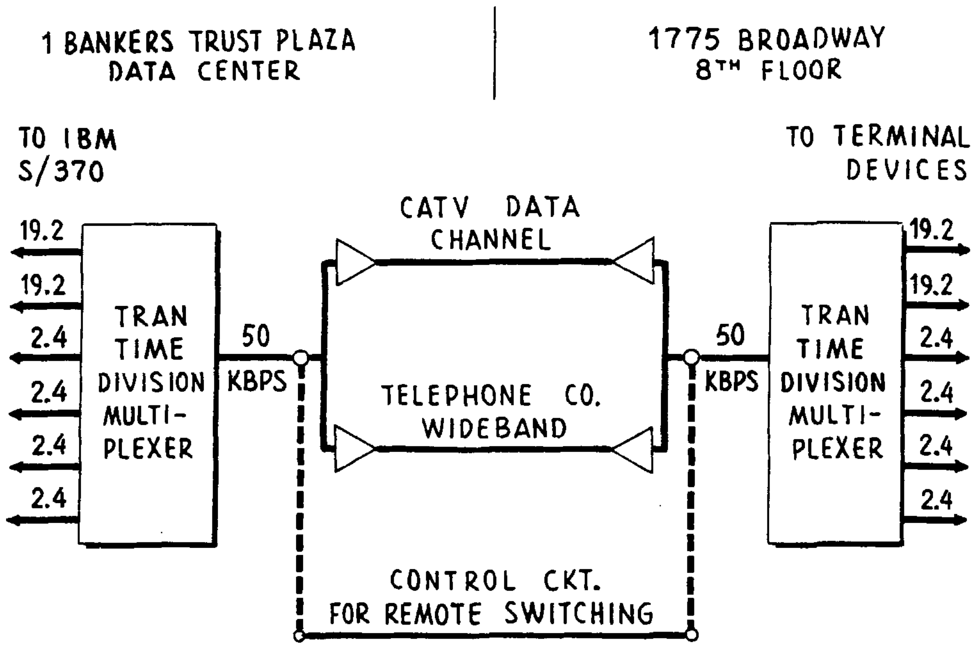
But, using automatic battery operated equipment only two technicians are required to set up the measurements and to remove the equipment 24 hours later. Assuming this requires four manhours each, this cost is $112.00, a saving of $160.00 per each 24 hour measurement. Particularly in large systems, where it may be necessary to repeat the operation in several towns, the total cost saved will be substantial and well worth the cost of the equipment required. This equipment is also valuable for attended operation usage where the written records of system faults and corrections and the easy portability from the small size and self contained battery operation make it easy to troubleshoot any system problems.

To summarize the conclusions of this paper, two basic types of unattended RF measurements applicable to CATV systems have been discussed. The equipment required for such measurements has been outlined and the description of the units has been presented. An actual system malfunction was discovered, repaired, and verified using the high level sweep system and the Kay 9021 Digital Recording Receiver.

The use of unattended measurements should be helpful in diagnosing system faults and as a money and time saving device for the yearly and proof of performance measurements.

" Our thanks to Bob Geissler of Vitek Electronics for the use of their Spectrum Recorder Timer , model SRT-1, in the preparation of this paper "

BANKERS TRUST COMPANY
EXISTING TELECOMMUNICATIONS CONFIGURATION



THE CABLE TELEVISION DATA NETWORK