U.S. NAVAL OBSERVATORY COLLECTION AND UTILIZATION OF TIME COMPARISON DATA

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ABSTRACT

Through the years, the amount of PTTI data collected by, disseminated through and utilized at the U. S. Naval Observatory has steadily grown. Approximately 10 years ago, the USNO began computerizing collection and reduction of these data. At that time this process was automated as much as possible, given the technical constraints involved. In the last few years, the advent of more sophisticated equipment and techniques has improved and further automated data handling. Not only has data collection been modernized, but new systems for disseminating data, bulletins, and other information have been introduced and are being developed. This paper is an overview of the development of automated PTTI data handling at the Naval Observatory, generally describes the current data handling practices, and briefly discusses near future trends in the management of data.

INTRODUCTION

The mission of the United States Naval Observatory (USNO), requires the determination and dissemination of uniform clock and astronomical time to "United States Naval vessels and aircraft as well as to all availing themselves therof" (SecNav Notice 5450). This mission statement, coupled with DoD Directive 5160.51 of 31 August 1971, which requires the Naval Observatory to supply traceability to the Master Clock for all DoD time, defines the primary function of the USNO Time Service Division. The Time Service must not only determine accurate time, but disseminate the information quickly and efficiently, and provide the Master clock time to those with timing requirements.

To carry out its mission, Time Service receives, disseminates, and utilizes PTTI and Earth Rotation data from sources located throughout the world. These sources include national and international laboratories, DoD field installations, and observatories which maintain time standards, make measurements of systems capable of being used for time synchronization, and/or make observations for Astronomical time and latitude data. The types of data handled are as varied as the sources. These data include OMEGA and LORAN-C measurements, earth rotation observations, navigation and communication satellite timing information, portable clock trip results, and much more. Over the last decade, the amount and frequency of data collected and disseminated has grown steadily, and, at times, even dramatically. To process the constant influx and growth of timing information, the Time Service has automated to a great extent, and continues to update, the data collection, dissemination, and analysis techniques. This process is aided by advancements in computer technology, by the addition of new modes of collecting information and by the use of statistical software to assist in the analysis of data.

Types of Data

As mentioned above, the types of data collected and analyzed by the Time Service Division in fulfillment of its mission are quite varied. Not only do the data from local sources, such as USNO clocks and telescopes have to be retrieved, but data of all kinds from remote sources must be collected and processed as well. Figure 1 lists the various types of data which are collected and maintained in databases whose integrity must be ensured.

The astronomical databases contain astronomical time and polar motion information from the optical Photographic Zenith Tubes (PZT) and the Connected Element Radio Interferometer which are run by the Naval Observatory. However, these data only comprise a part of the Earth Orientation data utilized by the Naval Observatory. Polar Motion data from the Doppler Navigation Satellites and from satellite laser ranging programs run by the University of Texas are collected regularly. Very Long Baseline Interferometry earth orientation data from both the Polaris project of the National Geodetic Survey and the TEMPO project of the Jet Propulsion Laboratory contribute to the earth orientation database. All of these are analyzed and utilized for earth orientation production and research. Both the preliminary (Rapid Service) and the final (Circular D) international earth orientation parameters, as determined by the Bureau International de l'Heure (BIH), are included in the data collected into the databases.

Data which are used for determining remote time scales, timing LORAN-C chains, and/or satellite time transfer information are all maintained in machine readable form. LORAN-C, OMEGA, TRANSIT and GPS data are monitored by the USNO, and by international laboratories and DoD field sites. Figure 2 is a list of some of the LORAN-C chains and where they are monitored. Time transfers from Defense Satellite Communications System (DSCS) are available, and used to calibrate other systems as well as maintain DSCS synchronization with the USNO master clock. It is with these systems that traceability back to the Master Clock can be realized.

Local timescale data are kept on a separate database. The hourly readings of the clocks are used to maintain the local timescales, and to steer the master clock. Portable clock data are also collected and stored with local timescale data. Since the portable clocks are very important for ensuring that remote time scales are remaining on time, this aspect of the database is also very important. An historical file of measurements obtained during portable clock trips is maintained. The local clock measurements are not only used to formulate USNO time scales, but are also transmitted to the BIH for use in the formation of International Atomic Time (TAI). Presently USNO is a major contributor to TAI.

Collection of Data

Prior to the 1970s, the data collected by the Observatory were all logged manually. These included PZT measures, OMEGA and VLF readings, and local clock comparisons. Initially, only locally monitored time pulses from LORAN-C, and OMEGA, were available to the USNO. However, it was soon evident that remote LORAN-C chains should also be monitored in order that time at wherever there were chains available could be traced back to the Master Clock. This was accomplished by establishing Precise Time Reference Stations (PTRS), laboratories and Observatories which maintain one or more clocks coordinated with the USNO master clock. Many of these could monitor LORAN chains locally and send the information to Time Service via TWX, mail or telephone messages. To further assist in the timing of remote LORAN chains, time transfers received from DSCS terminals also began to be to be utilized for this purpose.[1]

The arrival of an IBM 1800 Data Acquisition and Control System (DACS) (pictured in figure 3) in the early seventies enabled local clock data to be collected more accurately and more frequently. The IBM 1800 began collecting clock comparisons hourly and regularly monitored the local time scales. The frequency of collection had a beneficial effect on the accuracy of the time scales. The DACS was soon also being utilized to control the PZT and collect the timing ticks for each observation. The IBM 1800 would trigger the shutter of the PZT at a given computed time with far more precision than a human observer. It could also "observe" on cloudy nights, which meant that, if the clouds broke in the early morning, it was possible to retrieve data from the nights observation. As with the clocks, the increased amounts of data added weight to USNO time and polar motion determinations.

The amounts of external data being collected by the Observatory grew as remote chains and PTRSs were added. The data were entered into the computer on punched cards which, at the start, were punched manually from the TWX messages, telephone messages, and data received via US mail. It very quickly became impractical to process and manipulate these data by hand.

Approximately ten years ago, the decision was made to automate, as much as possible, the data handling for the timing of LORAN chains, and any other applicable PTTI function.[2] Utilizing equipment and technology available in Time Service at that time, (a TWX that punched paper tape, and the IBM 1800 DACS), a system was set up whereby data sent from the field via TWX would no longer have to be manually entered. A standard format for TWX PTTI input was devised which allowed the 1800 to sort through the messages on the tape and to locate the necessary data. These data were then punched onto cards in the correct format for the database on the mainframe computer. This system was originally used for DSCS data, but was soon expanded to include other types of data, such as LORAN-C readings, TRANSIT satellite timing data, and photographic zenith tube (PZT) results from the Time Service substation near Miami, Florida.

By the late seventies, it was evident that the Data Acquisition needs of the Time Service were beginning to outrun the currently available DACS. The daily paper tape from the TWX was getting longer as more data were sent, and the IBM 1800 was taking longer to read it. Cards were starting to jam in the 1800 with increasing regularity, and the number of service calls was growing. The types of data being sent were becoming more diversified. New technology was, of course, available, and by 1981, the IBM 1800 had been replaced by newer, faster, more complex, machines.

The functions of the IBM 1800 were taken over by an IBM SERIES/1 (figure 4) and an HP1000 (figure 5). The far more sophisticated capabilities of these two machines opened new methods of data collection and data handling.

The SERIES/1 is the primary DACS for local clock comparison collection and time scale monitoring. It is backed up in this function by the HP1000. The SERIES/1 also collects the raw timing data from the Global Positioning System (GPS) navigation satellites which the Observatory receives directly, and continues the role of the IBM 1800 in the control of the PZT.

The HP1000 is used to back up the SERIES/1 for local clock collection. However, it also has a data collection role of its own. It collects the data from the automatic receivers for the locally monitored LORAN-C chains. It also receives daily the clock comparison and LORAN-C data from the new automatic data collection systems that the USNO is installing in remote field sites. More information on these systems may be found in reference 3.

The basic philosophy of data collection via TWX has not changed with the replacements in data acquisition systems. The data are still processed through the DACS. However, the mode of collection has changed dramatically from the paper tape/ punched card method.

Since the SERIES/1 has no paper tape reader and no card punch, the basic automatic data handling process had to change somewhat. A line was run from the Telex machine so that all incoming messages could be read directly on to a circular file on the SERIES/1. The PTTI data output from the TWX input was initially carried to the mainframe computer via magnetic tape, but it now can be sent directly from the SERIES/1 through a fiber optic line using remote job entry (RJE) software. The TWX file is also transferred daily to the HP1000.

In themselves, these improvements are significant. However, as stated before, the new machines have opened up other avenues of data manipulation. The TWX is no longer the sole source of remote machine readable data input.

As it is important that Time Service receive field measurements as quickly as possible in order to best utilize them, outside contributors are encouraged to send their data by the swiftest means at their disposal. For a significant number of these, the TWX is the best method (and, indeed, it is very efficient). Many contributors have only the mails or the telephone at their disposal. These are not as efficient as the mails take time, and all the data must be handled manually. This, in turn, can also lead to errors. The Observatory now uses another method of obtaining machine readable timing measurements - the General Electric MARK III international computer network

Use of the G.E. MARK III began for the Observatory with The MERIT (Measuring of Earth Rotation and Intercomparing Techniques) campaign. A subsection or 'catalog' of the General Electric MARK III international computer network was created to enable laboratories and observatories all over the world to transmit and utilize earth rotation data during the mini-campaign in 1980. This catalog was so successful that it was kept active after the campaign. In 1982, Time Service became administrator of this catalog, and began to expand the catalog to include different kinds of timing information. This catalog allows dissemination and utilization of data with laboratories that are willing to pay G.E. to be part of the service. Figure 6 is a list of the current users of the MARK III RC28 catalog. In terms of data collection, the Naval Observatory receives LORAN-C data from members of the catalog who previously sent the data via TWX or mail. GPS timing information from other laboratories is also received in this manner. By utilizing an automatic dialler and a modem, these data are transmitted directly into the IBM SERIES/1.

Most of the databases are stored and manipulated on the USNO's mainframe computer. At the start of automatic data handling of Time data, this computer was an IBM 360/40 (figure 7). It ran in a batch mode, using punched cards or magnetic tape for input. About the same period that the IBM 1800 DACS was becoming obsolete, the computing needs of the Observatory as a whole began to outrun the capabilities of the computer. In 1980, the IBM 360 was replaced by an IBM 4341, shown in figure 8, which not only offers batch capabilities with OS/MVT, but also offers an interactive operating system.

Dissemination of Data

Up until very recently, almost the sole method of general data dissemination was via the U.S. mail. A few military users were authorized to get PTTI data via TWX daily, and, because of requirements for determining earth orientation on a quick turn around basis, the BIH received USNO data via TWX weekly. With the advent of the HP1000 and the MARK III, the mails are no longer the sole source of data dissemination. The weekly bulletins are available electronically, and transmission to the BIH no longer requires a TWX.

The HP1000 has also been set up as an Automatic Data Service (ADS). This service, described more fully in reference 4, is a telephone service which allows the outside user to connect to the HP1000 and extract data and information. A 'mailbox' service also allows the input of messages, data, or anything else a user would care to share with the Naval Observatory. The addition of this service has allowed a new method of disseminating information. Anyone with a modem and terminal is now able to retrieve SERIES 4, SERIES 7, SERIES 17, GPS data, OMEGA data, LORAN information, status reports of various systems, and much more. Figure 9 shows the Table of Codes which guide the user to files which are of interest. The explanations contain other codes for files which may be accessed.

The G.E. MARK III is also an efficient method of data dissemination. When it was created in 1980, the RC28 catalog's main purpose was to allow data dissemination to the BIH. After the mini-MERIT campaign, Time Service continued to send earth rotation data to the BIH in this manner. The expansion of the catalog, both in terms of users and of data types, has meant that international laboratories and observatories are now able to receive Bulletins 4,7,and 17 from Time Service much more quickly. Now, not only do the earth rotation data go via this method to the BIH, but local clock data, essential for determining TAI are also sent via the MARK III. GPS data and USNO observing schedules are available as well.

Internal Transmissions

The HP1000, IBM SERIES/1, IBM 4341 and the G. E. Mark III do not operate in a vacuum. As may be deduced from above, there must be interaction between the machines in order that the various types of data collected and disseminated can be most efficiently utilized. There is, of course, a "traditional method" of moving data between machines: via magnetic tape. However, in the case of the four machines utilized for time service purposes, magnetic tape is only a backup method of transferring data. There are direct communications links between the three on site machines and the MARK III is accessed directly through the SERIES/1 via automatic dialer. This configuration is illustrated in figure 10.

The SERIES/1 is linked to both the HP1000 and the IBM 4341. This means that data from the SERIES/1, or the 4341, such as GPS, local clock intercomparisons, or Earth rotation data, may be sent to the HP1000, or data from the HP1000 may be sent to the SERIES/1 and/or the 4341. In this way, calculations made, or bulletins created on any of the machines may be made available on the HP1000 for the public.

The G. E. MARK III is accessed through a modem and automatic dialer on the SERIES/1. This configuration allows transmission to and reception from the MARK III of data files, which can then be sent wherever appropriate in the Time Service network.

Much of the data transmission is completly automated throughout the network. For example, the SERIES/1 telephones the MARK III once a day and checks to see whether there are any LORAN-C data. If there are, these data are appended to the TWX file and are processed with the other data. The raw GPS data from the receivers is collected by the SERIES/1 and sent twice a day to the HP1000, where it is processed and put into final form. Final GPS data is then automatically sent back up to the SERIES/1 where it is stored until it is placed on the MARK III. Data from the automatic systems are transmitted to the SERIES/1 once a day, after being automatically collected by the HP1000. These totally automated transmissions mean that fewer person hours have to be spent in transmitting data from place to place, freeing the staff for the analysis of the data collected.

Although much of the transmission has been automated, it has not all been done by any means. There is automatic transmission from the MARK III, for example, but none to it. There are no automatic transmissions to and from the 4341, nor are all transmissions between the SERIES/1 and the HP1000 automated. However, even the 'manual' processes between the machines are expedited because of the efficiency and speed of various links.

Analysis and Utilization

The local and remote data collected by the Time Service are processed and analyzed for both production and research purposes. It is not the function of this paper to describe in great detail the reduction techniques or statistical analyses that form the work of Time Service. However, a brief mention of some of the purposes of the data handling techniques is pertinent.

The earth orientation data are used to determine as accurately as possible, UT1-UTC and polar motion, and to predict the position of the Earth in space with as small a standard deviation as possible. To do this, observations from many different techniques must be used. Analysis of these data is performed to determine the accuracy and precision of the observations, and how they may best be used for prediction purposes.

For timing remote LORAN-C chains, data from many different sources are essential. With only occasional calibrations via portable clock measurements or DSCS transfers available for these chains, intercomparison between systems is necessary to determine individual clock rates to keep the chains steered as closely as possible with U.S. Naval Observatory master clock. Data not only from the chains themselves, but from laboratories, field sites, or observatories which can monitor these chains are analyzed for this purpose.

These, and other projects of the Time Service Division call for large amounts of data. Statistical analyses done with either software packets such as BMDP, or by programs written at the Observatory, require as large a sample as can be utilized in order to get an accurate picture of the data as possible. Much of the production work, as well, such as earth orientation predictions, or LORAN chain timing and prediction, also require a large baseline of data. The numerous databases are required by Time Service for both the production and analysis.

The Near Future

The network that has been developed between the IBM SERIES/1, HP1000, IBM 4341, and the G. E. MARK III has added much to the efficiency of processing and of dissemination of PTTI and earth rotation data. However, improvements are continuing to be made. The amounts of data are still increasing as automatic systems are installed, new LORAN chains are established, additional DSCS modems are fielded, and more GPS satellites are launched. This increasing data load means that still greater automation is required to ensure that the available manpower can fully utilize the vast amounts of data available.

As intimated above, there are plans and ideas to continue to develop the automatic processing of data which pass through Time Service. Although some of these plans are just extremely tentative, others are very real concepts. Projects which are being implemented include improvements and enhancements in all aspects of data management in Time Service.

Redesigning the database on the mainframe computer is one of the realistic near future goals of the Time Service. Currently the database exists on a batch mode operating system. Although this system is good, the 4341 has acquired an operating system which is interactive in nature. By changing the database so that it runs on this new system, the door is open to better utilize the capabilities of the 4341.

New remote automatic collection systems are being added at many PTRS sites. This fact, coupled with increased usage of the automatic data service, means that the HP1000's responsibilities will eventually move beyond its capabilities. It has been definitely decided that the current HP1000 will be replaced by a more powerful machine that will be able to handle more efficiently the increased data load. The plans for this have already begun, and the present configuration will be replaced within two years.

Further enhancements are also planned for the SERIES/1. The SERIES/1 already consists of two processors, which doubles its efficiency, but more disk space is needed. Upgrading the operating system is also on the agenda.

Increased use and further automation of the data flow of the MARK III are both being planned. The number of laboratories and Observatories on the system is steadily growing, and it is hoped that this growth will continue. It is also anticipated that the types of data available on the MARK III shall also grow as the needs and desires of the timing community for easily accessible, machine readable data grow. Further automating the current data flow is also planned. Many of the transmissions are routine, and automating them would free additional personnel for other projects.

The newer types of data will be more fully utilized in the near future. There is a great deal of potential still to be tapped in the GPS data, the DSCS data, and the automatic systems. Currently studies are being made on how best to utilize these data,as fully and as effectively as possible. The necessary computer programming is being done for these studies.

As more technology and new types of data are made available, ideas of improvments in the existing data handling structure will naturally occur. Perhaps many of the concepts that exist today will also be eventually incorporated into the structure of data handling at the Naval Observatory.

CONCLUSION

In carrying out its mission requirements, the Time Service Division of the U. S. Naval Observatory quickly and efficiently collects, utilizes and disseminates time data of all sorts. Not only the methods of utilizing the collected data, but also the means of data collection and utilization are essential for the successful Time Service operation. Automating the flow of data through the Naval Observatory to the greatest extent possible has been one means of improving the service provided for the Timing user community. By automating, or at least streamlining, the routine data flow, skilled personnel are released to work on the data analysis which is necessary to ensure precise, accurate and timely information. Using machines, rather than people, for data entry also minimizes the risk of error in data exchange. Thus far, the Observatory has been highly successful in utilizing available technology for rapid dissemination to the many users of PTTI and Earth rotation data.

REFERENCES

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3. Wheeler, P.J., "Automation of Precise Time Reference Stations (PTRS)" in Proceedings of the Fifteenth Annual Precise Time and Time Interval Meeting: (in press).

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DATA TYPES

INTERCOMPARISON OF CESIUM CLOCKS
OMEGA MEASUREMENTS
LORAN-C MEASUREMENTS
REMOTE TIME SCALES FOR MONITORING SITES
PORTABLE CLOCK REDUCTIONS
NAVOBSY TIME SCALES
SATELLITE TIMING INFORMATION
(DSCS, TRANSIT)
UTC(BIH) - UTC(I)
EARTH ORIENTATION PARAMETERS
(UT1, POLAR CORDINATES)
GPS TIME TRANSFER MEASUREMENTS
ASTRONOMICAL OBSERVATIONS

FIGURE 1

REPRESENTATIVE SAMPLE of MONITORING STATIONS

7970 NORWEGIAN SEA

OP FRANCE
HP SWITZERLAND
ON SWITZERLAND
NPL ENGLAND
RGO ENGLAND
NAVSECGRU SCOTLAND

7980 SOUTHEAST USA

NAVOBSY
NOTSS RICHMOND, FL
AGMC NEWARK AFS, OH
WHITE SANDS MISSILE RANGE, NM

7990 MEDITERRANEAN SEA

OP FRANCE
HP SWITZERLAND
ON SWITZERLAND
IEN ITALY
RGO ENGLAND
NAVSECGRU ITALY

8970 GREAT LAKES

NAVOBSY

9960 NORTHEAST USA

NAVOBSY
NOTSS RICHMOND, FL
AGMC NEWARK AFS, OH
NBS BOULDER, CO

9990 NORTH PACIFIC

PMEL ELMENDORF
NASA FAIRBANKS
SHEMYA AFB, AK
*DSCS ELMENDORF

*INDIRECT MEASURE

FIGURE 2

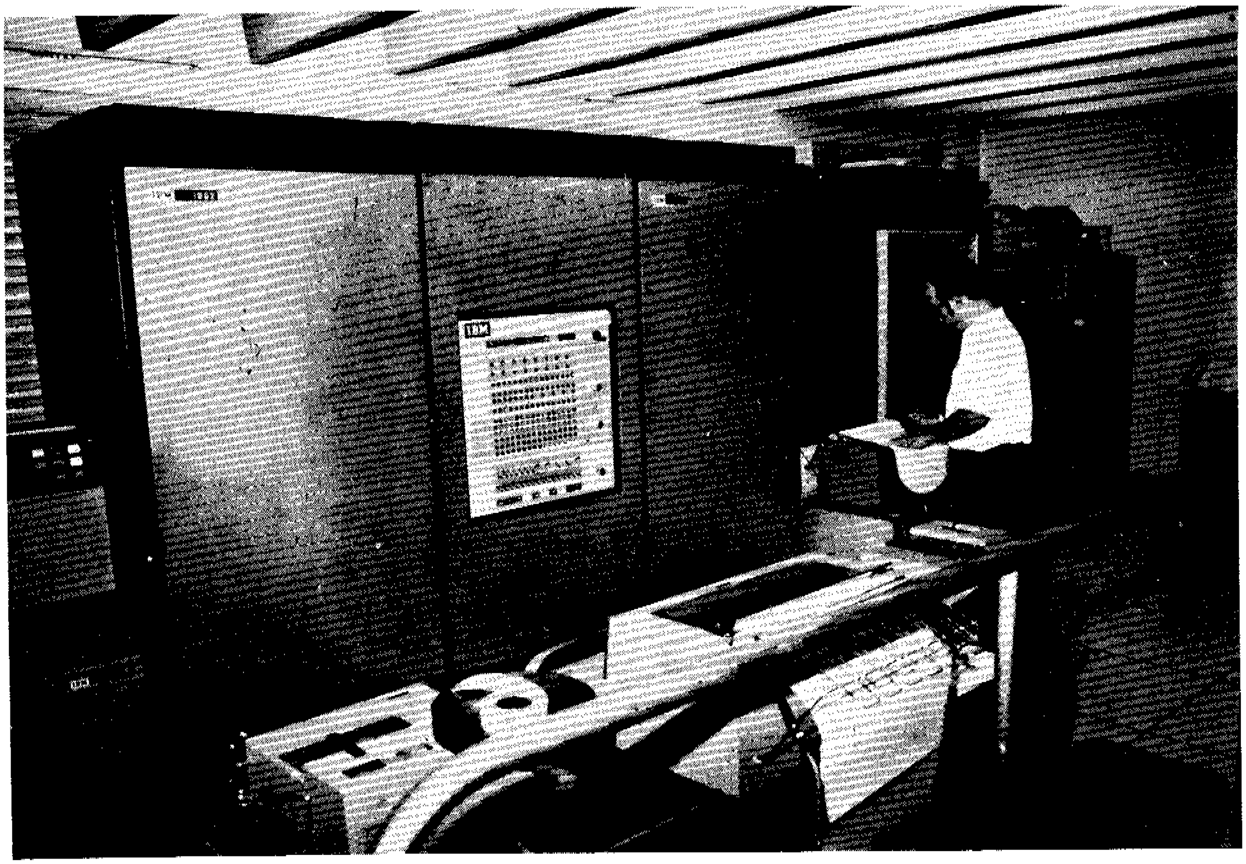

FIGURE 3

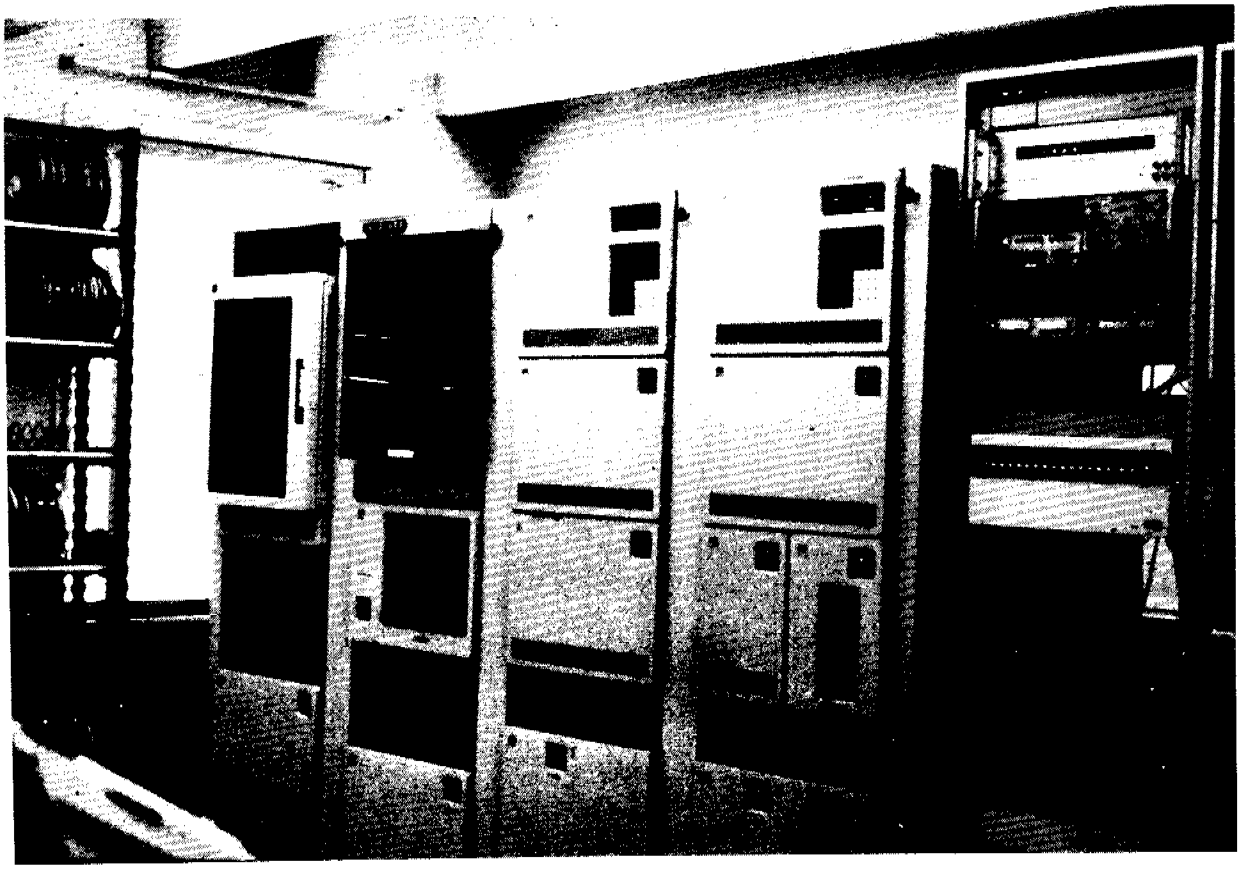

FIGURE 4

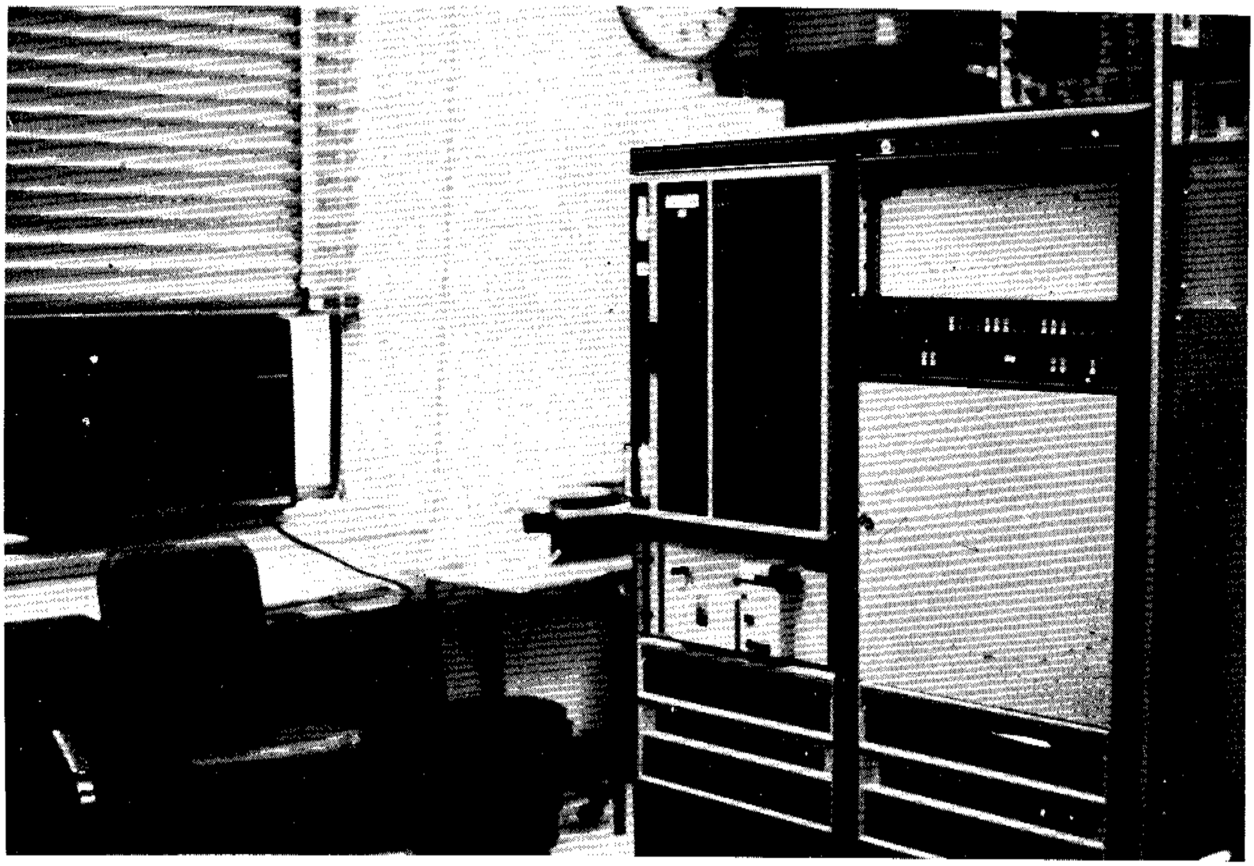

FIGURE 5

USER #	ACTIVITY/USER	QUIK-COMM	ACRONYM
RC28000	CATALOG ADMINISTRATOR (USNO)	USNO	-
RC28210	ASTRONOMY DEPT. UNIV. OF TEXAS, USA	AUTA	UTEXA
RC28210	CENTER FOR SPACE RESEARCH, U OF TEXAS	AUTA	CSR
RC28235	JET PROPULSION LABORATORY, PASADENA	JPLP	JPL
RC28240	NATIONAL GEODETIC SURVEY, ROCKVILLE	NGSV	NGS
RC28260	TIME SERVICE, US NAVAL OBSERVATORY	TIME	USNO
RC28265	INSTITUT FUER ANGEWANDTE GEODAESIE	IFAG	IFAG
RC28270	SMITHSONIAN ASTROPHYSICAL OBSERVATORY	SAOB	SAO
RC28280	EARTH PHYSICS BRANCH, OTTAWA	EPBR	EPBR
RC28300	CERGA, GRASSE, FRANCE	CERG	CERGA
RC28310	BIH, PARIS, FRANCE	BIHF	BIH
RC28311	INSTITUTO ELETTROTECNICO NAZIONALE	IENT	IEN
RC28314	INSTITUTO Y OBSERVATORIO DE MARINA	--	OMSF
RC28316	PHYSIKALISCH - TECHNISCHE BUNDESANSTALDT	--	PTB
RC28317	NATIONAL PHYSICS LAB., TEDDINGTON, U.K.	NPLT	NPL
RC28321	TOKYO ASTRONOMICAL OBSERVATORY	TAOB	TAO
RC28324	VAN SWINDEN LABORATORIUM, NEDERLAND	VSLA	VSL
RC28339	TECHNISCHE UNIVERSITAT, GRAZ, AUSTRIA	TECH	TUG
RC28350	SUB ADMINISTRATOR, 310 - 399 (BIH)	--	-
RC28355	OBSERVATOIRE ROYAL DE BELGIQUE	ORBB	ORB
RC28360	INSTITUT GEOGRAPHIQUE NATIONAL	IGNF	IGNF
RC28365	GROUPE DE RECHERCHES DE GEODASIE SPATIALE	--	GRGS
RC28390	EUROPEAN SPACE AGENCY OPERATING CENTER	--	ESA
RC28400	INTERNATIONAL LATITUDE OBSERVATORY	ILOM	IPMS
RC28405	RADIO RESEARCH LABORATORIES, JAPAN	__	RRL
RC28410	KANOZAN GEODETIC OBSERVATORY, JAPAN	--	KGO
RC28420	NAVAL RESEARCH LABORATORIES, WASHINGTON	__	NRL
RC28430	DIVISION OF NATIONAL MAPPING, AUSTRALIA	__	NATMAP
RC28440	OHIO STATE UNIVERSITY, DEPT. OF GEODETIC SCIENCE AND SURVEYING	DGSS	DGSS

FIGURE 6

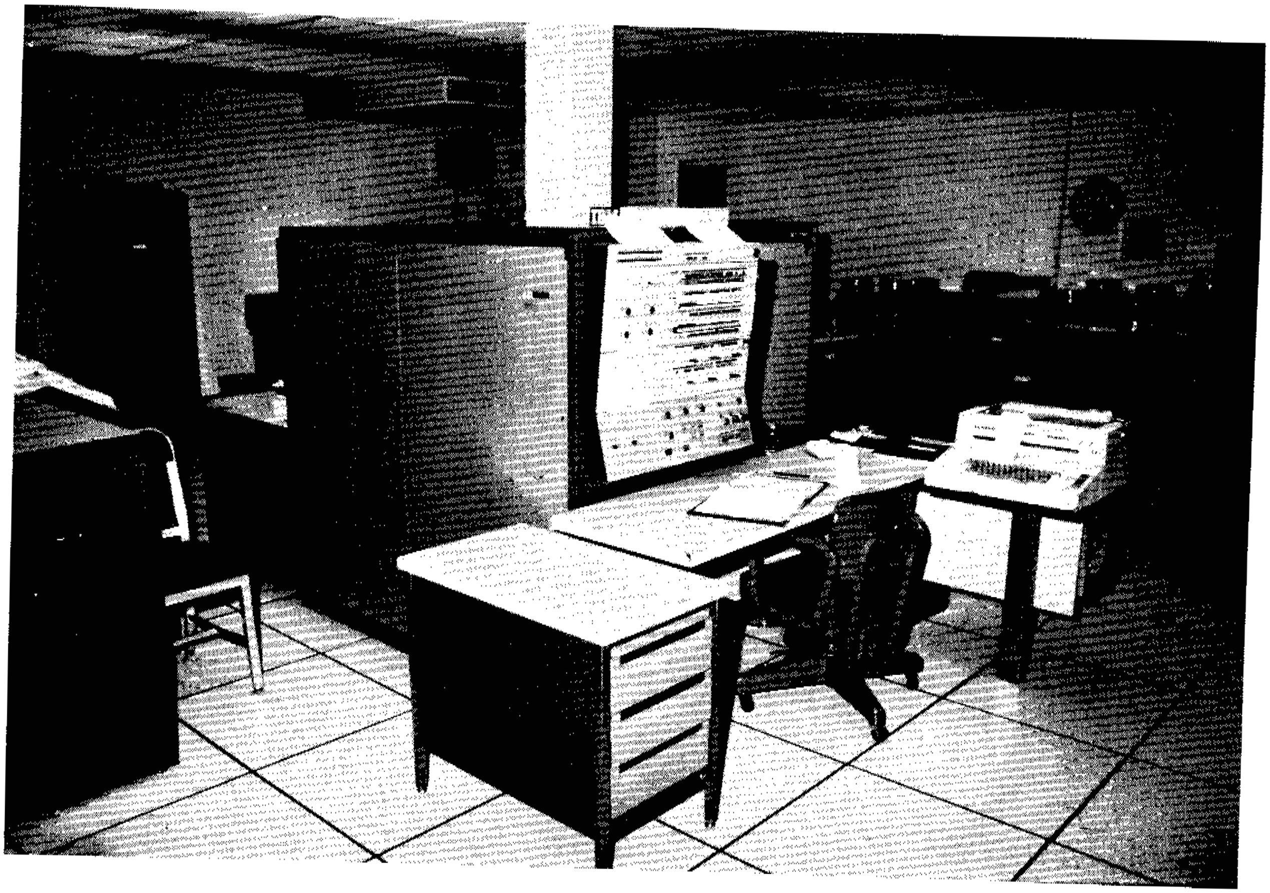

FIGURE 7

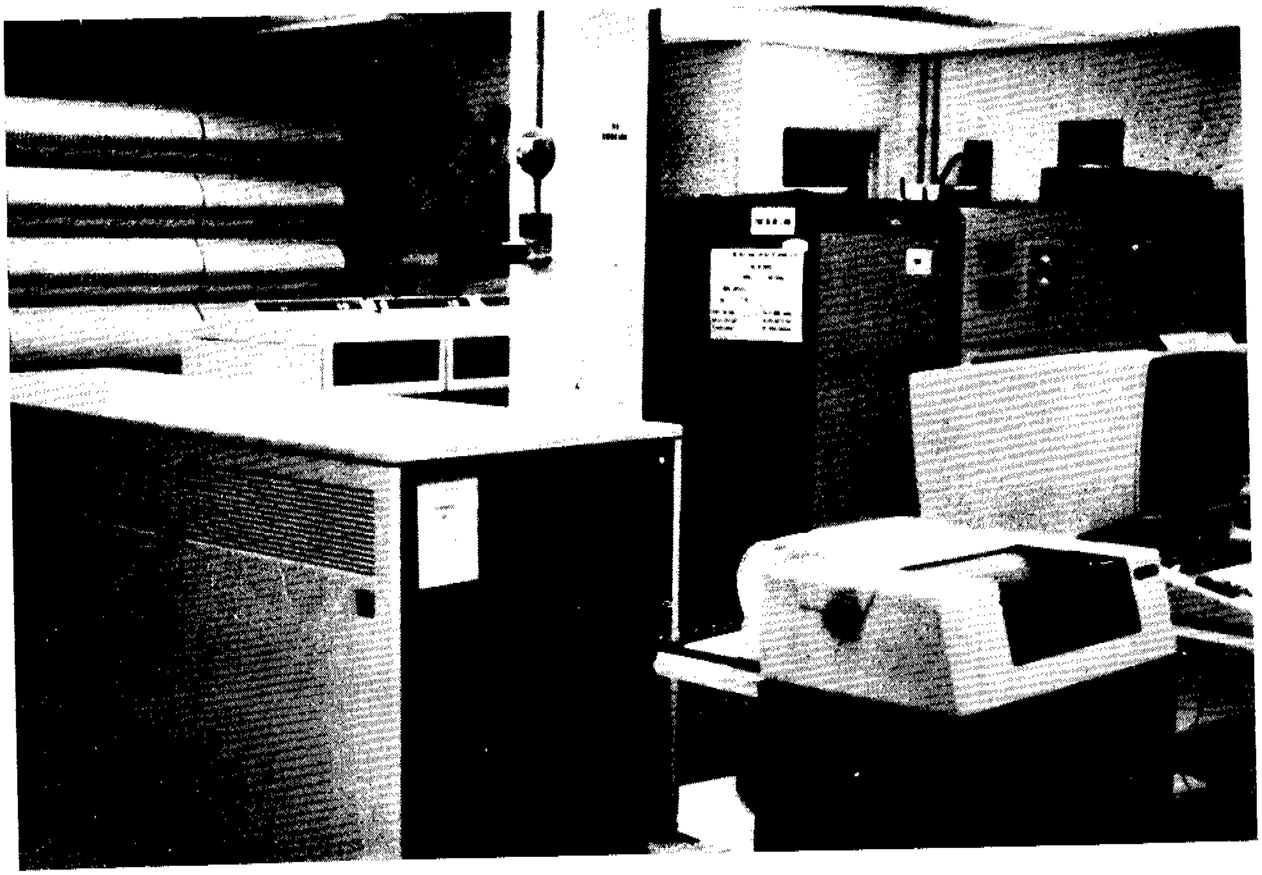

FIGURE 8

USNO AUTOMATED DATA SERVICE

TABLE OF MOST FREQUENTLY USED CODES (@TCO)
(FOR MORE CODES SEE EXPLANATIONS IN EACH CATEGORY)

SERIES EXPLANATIONS (SER4,5,7,8,9) .... @SERXP
SERIES 4: Notes of the last SER4 Bulletin .... @SER49
SERIES 5: LAST MESSAGE (AIG 100) .... @SER50
Older messages may be obtained by appending the digit 1-9 for data age
for example: 5 day old message ..... @SER55
SERIES 7: Explanations for Extrapolation ..... @SER70
PREDICTION OF UT, X-Y .... @SER71
PRELIMINARY MC-UTC(USNO) .... @SER73

EXPLANATIONS, GENERAL ..	@EXP	PTTI CONFERENCE NEWS ...	@TTI
SPECIAL DAILY MESSAGE ..	@DME	TIME SERVICE DIRECTORY .	@DIR
GENERAL PTTI MESSAGE ...	@MES	MAILBOX INFORMATION	@MBXXP
VLF STATUS	@VLF	VLF MAINTENANCE SCHED ..	@VLFD2
VLF EXPLANATIONS	@VLFXP		
OMEGA STATUS	@ONS	OMEGA MONITOR DATA	@ONSD1
OMEGA EXPLANATIONS	@ONSXP	OMEGA OFF-TIMES SCHED ..	@ONSD2
GPS STATUS	@GPS	GPS TRACKING SCHEDULE ..	@GPSD2
GPS EXPLANATION FOR DATA	@GPSXP	GPS EXTRAPOLATION	@GPSD4
GPS LATEST TIME DATA ...	@GPSD1	GPS FILE DATA	@GPSSL
TRANSIT STATUS	@TRA	**TRANSIT** SER17	@TRAD7
TRANSIT EXPLANATIONS ...	@TRAXP	TRANSIT FILE DATA	@TRASL
TRANSIT TIME DATA	@TRAD1	TRANSIT SAT. VISIBILITY	@TRAVS
TRANSIT NOVA DATA	@TRAD2		
LORAN STATUS	@LOR	LORAN REAL TIME MEAS ..."	@MLO
LORAN EXPLANATIONS	@LORXP	LORAN PROPAGATION TIME, DIRECTION & DISTANCE ...	@LDX
TOC FOR LORAN OR TV .... (TIME OF COINCIDENCE)	@TOC	TV EXPLANATIONS	@TVKXP
		WTTG-TV CH-5, MEAS	@TVL
		NETWORK TV MEASUREMENTS	@TVK
PORTABLE CLOCK DATA:			
MEASUREMENTS	@MPC	SCHED. OF NEXT TRIP	@MPX
SCHED. OF CURRENT TRIP .	@MPN	TENT. PC TRIP PLANS	@MPT
NBS DATA:		OPERATIONS CONTROL:	
NBS EXPLANATIONS	@NBSXP	FOR DETAILS AND CODES ..	@OPSXP
NBS STATUS OF GOES	@NBSGO	USNO PUBLIC INFORMATION:	@STAXP
REAL TIME MEASUREMENTS:		PREDICTIONS & COMPUTATIONS:	
EXPLANATIONS	@RTMXP	SIDERIAL TIME	@STI
LORAN (4 CHAINS)	@MLO	MJD/WEEKDAY	@DAT
UTC TO +/- 50MS	@TIM	SUNRISE, SUNSET,	
TIME SIGNAL EXPL	@TSF	TWILIGHT FOR ANY POINT .	@SRI
		SUNRISE PROG. EXPLAN ...	@SRIXP
TV READINGS (AVERAGES):		LORAN PROPAGATION TIME,	
WTTG WASHINGTON, DC	@TVM	DIRECTION & DISTANCE ...	@LDX
NBC "	@TVN	STANDARD TIME ANYWHERE .	@STTXP

FIGURE 9

CURRENT CONFIGURATION

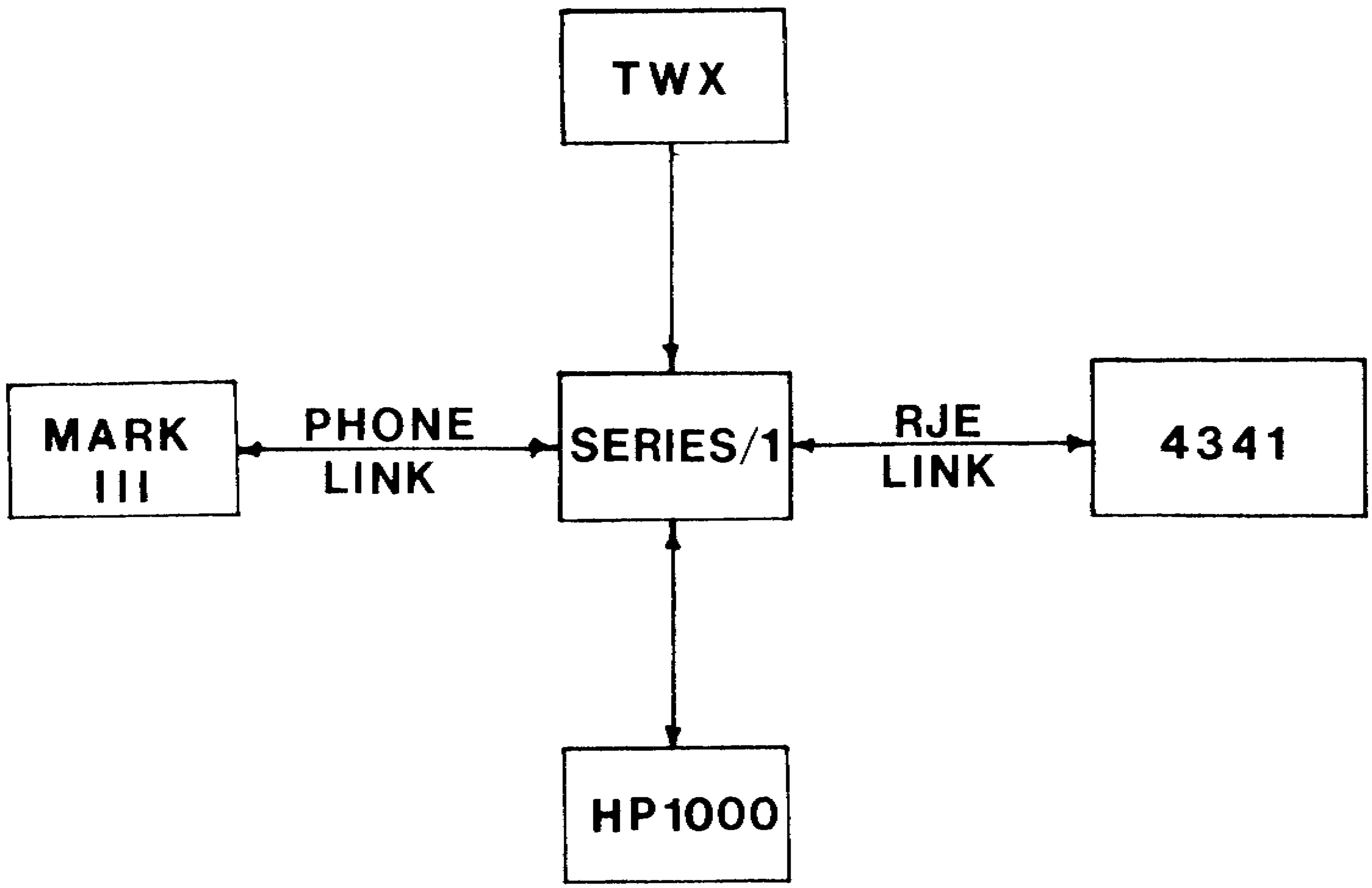

FIGURE 10

QUESTIONS AND ANSWERS

MR. WARD:

Sam Ward, J.P.L., again. For the users who get poor quality telephone lines, such as I do, before I get any useful data the thing times out, this happens to me frequently.

MRS. WITHINGTON:

You are referring to the Automated Data System?

MR. WARD:

That's right. I don't know how we solve that one, either. I worked on the telephone company but the length of time that is programmed in should be longer.

DR. WINKLER:

I appreciate hearing such comments. You are the first one who has made that request. That can easily be done. The waiting time of the computer has been set for forty-five seconds, in the interest of making the telephone line available as quickly as possible; but if there are such problems, it's a matter of one minute to increase that to one-and-a-half minutes. So we appreciate hearing from the users about such difficulties. The local telephone lines can be somewhat improved if you request from your telephone company a data line. It can be espcially equalized. We had a considerable amount of trouble before our system was working reliably. Also, there is a difference between a hard connected modem, a wire connected modem compared to the acoustic couplers. Acoustic couplers are generally poorer because it depends on the microphone that you have. There are special microphones available that you can put in. So there are lots of little tricks you can put in; we will be very happy to assist a user.

MR. CAMP:

Bob Camp from Synox. I have a question. Who should one get in touch with for further information about the mechanism of accessing all this data?

MRS. WITHINGTON:

Well, for the Automated Data Service, Myron Moranian of the Naval Observatory is the one to call. For the G.E. Mark III, I'm the one to call on that. My name is Neville Withington.