TWO-WAY TIME TRANSFERS BETWEEN NRC/NBS AND NRC/USNO VIA THE HERMES (CTS) SATELLITE

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ABSTRACT

Two-way time transfers via the Hermes (CTS) satellite between NRC, Ottawa and NBS, Boulder and between NRC and USNO, Washington, D.C., began once a week in July 1978. At each station the differences were measured between the local UTC seconds pulse and the remote UTC pulse received by satellite. The difference between the readings, if station delays are assumed to be symmetrical, is two times the difference between the clocks at the two ground station sites. Over a 20-minute period, the precision over the satellite is better than 1 ns. The time transfer from NRC to the CRC satellite terminal near Ottawa and from NBS to the Denver HEW terminal are still subject to larger uncertainties which are being examined. The absolute measure of UTC differences also depends on the measurement of station delays, which in present circumstances will be difficult to carry out.

Two years ago, discussions were started on the possibility of two-way time transfer between the NRC and LPTF in France using the Symphonie satellite. A year ago, the possibility of participating in the third year of experiments on the Canadian-USA Hermes satellite arose, and the NRC applied to the Canadian Committee for an allocation of 1/2 hour a week. This experiment received final approval by the Minister of the Canadian Department of Communications in April 1978. The approved schedule, with NBS Boulder as partner, was for 16:00-16:30 ET on Fridays to September 31, and on Thursdays until December 31. The usage of the satellite alternates daily between Canada and the USA. Early in the experiment, the USNO was included, and in October an additional 1/2 hour in the Canadian schedule was allocated, 12:00-12:30 ET on Tuesdays, for time transfer between NRC/USNO.

It is perhaps necessary to state that the very short lead time, the shortage of manpower and equipment, and the operation through host terminals, has for all three laboratories placed constraints on the program.

Figure 1 is a schematic of the mini network. It shows a) the NRC/NBS link, and b) the NRC/USNO link. It was intended at one time to operate a USNO/NBS link, but this project was abandoned for technical reasons which will be evident later.

The Hermes satellite operates in the 12-14 GHz bands, and has two transmitters, one 200 W and one 20 W. Each channel has a steerable 2° beam which can be boresighted on a particular station as desired. The beams cannot normally be changed during an experiment, particularly since the failing telemetry on Hermes requires a large NASA antenna for acquisition of telemetry, and telemetry status of the satellite is rarely available these days.

All satellite terminals use a standard TV channel which requires a 1 volt peak-to-peak video input. The 1 pps and the TV horizontal sync pulses simulate the TV video and maintain proper video levels. It is realized that using a 1 pps is not the most efficient way to use the 6 MHz bandwidth, but NRC was already committed to using this format with France. It is also an easy format to put into operation quickly since all have 1 pps clock pulses available.

Because the NRC uses the master terminal at the Communications Research Center (CRC) with a 30-foot antenna, the 20 W beam is directed to Ottawa, and the 200 W to Denver or to Washington.

In Denver, NBS has the use of a terminal owned and operated by the Department of Health, Education and Welfare (HEW). It has an 8-foot antenna and 400 W transmitter power. This gives, at CRC in Ottawa, a received carrier of 40 db S/N with a 300 kHz bandwidth in the television channel.

In Washington the story is more complicated. In late July, experiments started with USNO using a NASA terminal at Goddard, but unfortunately we had no success. Initially the boresight was directed not to Ottawa, but halfway between Ottawa and Goddard. The signal to noise, down about 3 db, seemed adequate, but a later slide will show some of the difficulties. Trials began again some seven weeks later, after NASA had been off the air to make changes at the site, but the experiments were not successful. The additional time allocation was used, but NRC and USNO computer failure and interface problems compounded to frustrate the experiment.

At the Hermes Users Meeting in Wingspread, Wisconsin, September 19-21, 1978, Mr. K. Kaiser suggested that it might be possible to put a COMSAT Hermes terminal at the USNO. Since this had the enormous

advantage of avoiding the requirement for a time transfer from the laboratory to the terminal, and saves so much time in travel and equipment displacement, this was followed up with some enthusiasm by the USNO, and the COMSAT terminal was placed at the USNO. Successful transfers for the past three weeks have been achieved.

The time transfer from NBS to the HEW Denver terminal has been done by carrying two Cs standards to the terminal (Fig. 2), using one as the station clock, and obtaining closure after the experiment at NBS (Fig. 3). This has given 1-2 ns accuracy, and has shown that there are large and variable errors in the new TV Line-10 receivers.

In Ottawa, the NRC has been relying on the TV Line-10 receivers. CRC is about 32 kilometers (20 miles) from NRC, and both sites have a clear line of sight to the TV transmitter. The path difference has been indexed with portable clocks. Often, 1 ns standard deviation for 300 readings is obtained, but variations over 200 ns have been seen. It is usually possible to tell when the readings are reliable, but there is no doubt at the moment that the NRC/CRC link gives the largest source of error in the transfer, and NRC will convert to the NBS type of operation as soon as possible.

The principle of the measurements is shown in Fig. 4. At each station, the counter is started with the local UTC pulse and stopped with the pulse received from the satellite. The transit times are about 0.255 s for CRC/Denver, and 0.258 s for CRC/USNO. To obtain the difference between the two station clocks, the readings T_1 and T_2 for each second must be subtracted and divided by two. In fact, it is preferable to fit a cubic equation to the 1000-odd measurements and then exchange and subtract the equations.

There are the two other terms in the equation, hopefully small and constant. The terms t_1 and r_1 are the delays in the transmitter and receiver at station 1, and t_2 and r_2 the delays at station 2. It is fairly easy to measure the sum of t_1 and r_1, and this is done daily at some stations as a check on the constancy. To measure one or both individually is difficult, and this will be discussed later.

Figure 5 is a typical result from an early run in Ottawa. Part of the plot of the data-equation is given and also a histogram of the difference between the data and the equation. It is not a gaussian, but by selecting the gate for the data, it is possible to center the apparent gaussian at zero offset.

However, this same day NBS reported a standard deviation of 1.4 ns on all points, and NRC should have an advantage in signal to noise, with a factor of 25 in antenna gain to offset the factor of 0.10 in power. At this point, suspicions arose of the off-boresight operation (with the boresight between Ottawa and Goddard) even though the signal

was less than 3 db down. The boresight was returned to Ottawa. The result is shown in Fig. 6 with a standard deviation of 1.4 ns for 1091 points. Needless to say, the experiment has been run since that time only with the antennas boresighted on the stations.

The degradation of the pulse off the boresight was puzzling, and satellite engineers found the effect difficult to believe. However, in Fig. 7, the worst example shows the reception in Ottawa with the antenna boresight on Washington, where most of the pulses appear to arrive 150 ns late.

Consequently, a three-hour experiment was set up in Ottawa for a loop test through the satellite, with various off-boresight settings of both satellite and ground antenna. No effects were seen except for an increased standard deviation as the signal to noise decreased, and no delayed pulses distorted the gaussian.

There was only one change made in the CRC terminal facilities between the two experiments, and it was significant. The NRC equipment is housed in the Symphonie terminal at CRC, and for the Hermes experiment, the pulses are sent and received over 2.4 km (1.5 mi) of triax cables to the Hermes terminal. Before the experiment started, the cable terminations or equalizers were very carefully adjusted to reproduce or reconstruct the 1 pps signal. Unknown to NRC, a severe lightning storm burned out those equalizers which were, of course, replaced. The new equalizers overemphasize the high frequencies; in fact, there is an overshoot and ringing on both the rise and fall of the pulse. Because the results are better, we have not requested adjustment of the equalizers.

It still appears that there was a serious degradation of the pulse, a loss of high frequencies when off-axis which has now been over-compensated. But the question must be settled, and it is intended to carry out an experiment with the full bandwidth of 70 MHz of Hermes, with 20 ns pulses and a high repetition rate, to see if diffraction and refraction do cause pulse degradation off-axis of the beam. If this does occur, and some say it must, it will place a serious limitation on the bit rate that can be transmitted off the boresight of any beam.

The results of the time transfer between NRC and NBS are given in Fig. 8. It must be emphasized that no measurements and no corrections have been made for terminal delays, and therefore all quoted values for the differences in the UTC(i) obtained by satellite must be corrected by the portable clock results. The standard deviation of the points from the two straight lines is 9 ns, a figure that is inclined to inspire confidence. It was immediately assumed at NRC that the change of 1.5×10^{-13} was the result of evaluation of CsV on September 15-16, even though the change in frequency was three times the expected error.

However, there is now evidence to show that CsV did not change in frequency by this amount. There is no evidence of a change in the rate in the direct UTC(NRC) - UTC(USNO) transfer via Loran-C. Further, a change of 1.5×10^{-13} would have resulted in a 0.5 µs error in the USNO portable clock value on October 31, 1978.

NBS evaluated their NBS-6 primary cesium standard around the end of October 1978 and obtained a normalized frequency difference in UTC(NBS) - NBS-6 (sea level) of 0.6×10^{-13}. Over this period, from Fig. 8, the normalized frequency difference of the two time scales UTC(NRC) - UTC(NBS) was 1×10^{-13}. The frequency of UTC(NRC) is the frequency of CsV corrected to sea level, and therefore the normalized frequency difference for the primary standards CsV (sea level) and NBS-6 (sea level) was 1.6×10^{-13}. This is the same order as the difference observed over the past few years, which indicates that there was not a large change in the CsV frequency on September 15, 1978.

Some uncertainty was introduced by the changes at CRC that were made necessary by the lightning damage during the week of August 25, 1978. However, the internal consistency of the satellite time transfer is such that it is concluded that changes in one or probably both time scales produced the observed 1.5×10^{-13} change in the normalized frequency difference.

The NRC/USNO preliminary results for November 14, 21, and 28, are respectively 4938, 5033, and 5053 ns. These give a frequency difference similar to the NRC/NBS results for the same period.

The experiment has not yet quite matched the precision achieved by Chi (1975) and Saburi (1976) in experiments by NASA and the Radio Research Laboratory of Japan, but the main virtue of this experiment is the transfer over a long period between very stable time scales. It has been exciting in the potential that it shows, and instructive in the weaknesses that have become evident in the present setup. In an operational mode, the following three steps should yield 1 ns precision and an accuracy of a few nanoseconds:

1. The acquisition of matched PRN code generators by all participants. The 1 pps system used in this experiment is too vulnerable to changes in transmission, trigger levels, etc, and the advantage of averaging over many pulses is lost.

2. The acquisition by all participants of "private" terminals to operate at the laboratories. It is essential to eliminate the errors in the transfer of time from the laboratory to the terminal. It is also essential to measure and monitor the terminal delays, which is very difficult to do when the "host" terminal is being used for many experiments.

3. A fully automatic computerized operation will be necessary to operate in short burst during the night to take advantage of unused satellite time.

An experiment has been approved for the Anik B satellite which is expected to be launched in December 1978. This is primarily a VLBI experiment between the NRC radio astronomy stations in Penticton, British Columbia, Algonquin Park, Ontario, and the Naval Research Laboratory station in Maryland. It is intended to maintain coherence among the local oscillators at these stations by exchanging side tones through the Anik B satellite. Professor Yen of the University of Toronto is predicting 10 ps precision for this experiment, and the NRC Time Laboratory has been invited to join with a fourth station in Ottawa as a time station only. It is hoped that this will be possible and that a 12 - 14 GHz terminal can be acquired for this purpose as the first stage of the three requirements given earlier.

There are not many results to report as yet from the NRC/LPTF time transfer via the Symphonie satellite. This is to run from July 1, 1978 to July 1, 1979 on a daily basis, except for outages of about 6 weeks during eclipse periods. The data are being processed in France, except for some 30 readings exchanged daily by the voice channel. They expect to improve their data handling capacity in the near future. The terminal used in Ottawa, operated by NRC, has a 30-foot antenna. The France terminal is the main control center at Pleumeur Bodou in Brittany. There is an uncertainty of about 30 ns in the time transfer via the TV network to Paris. The preliminary figures give a normalized frequency difference between UTC(NRC) and UTC(OP) of $1 \times 10^{-13} \pm 0.2 \times 10^{-13}$ for July and August 1978.

In support of the time transfer, several portable clock trips have been made. In particular, in the last week of October, there were successful clock trips to NRC from Observatoire de Paris, USNO and NBS.

We must acknowledge a great deal of assistance in carrying out this experiment. The NRC has had the use of the CRC terminal and the fullest support from the Hermes group at CRC and others of the Department of Communication, from the experiment controller John Brookfield, the engineers, programmers and scientists. The NBS is pleased to acknowledge the weekly loan of the Denver terminal of HEW, the assistance of Mr. Earl Henderson, National Library of Medicine in Bethesda, Maryland, and of Mr. Bernie Lackey, who operates the Denver terminal so efficiently. The USNO has had the cooperation of NASA Goddard, and now of Kim Kaiser and Wes Venstra of COMSAT with their terminal at the USNO.

REFERENCES

1. Chi, A. R., and Byron, E., "A Two-Way Time Transfer Experiment Using a Synchronous Satellite," Proc. of the 7th Precise Time and Time Interval (PTTI) Applications and Planning Meeting, pp. 357-376 (December 1975).

2. Saburi, Yoshikazu, Yamamoto, Minoru, and Harada, Kikuo, "High-Precision Time Comparison via Satellite and Observed Discrepancy of Synchronization," IEEE Trans. Instr. & Meas., IM-25, No. 4, pp. 473-477 (December 1976).
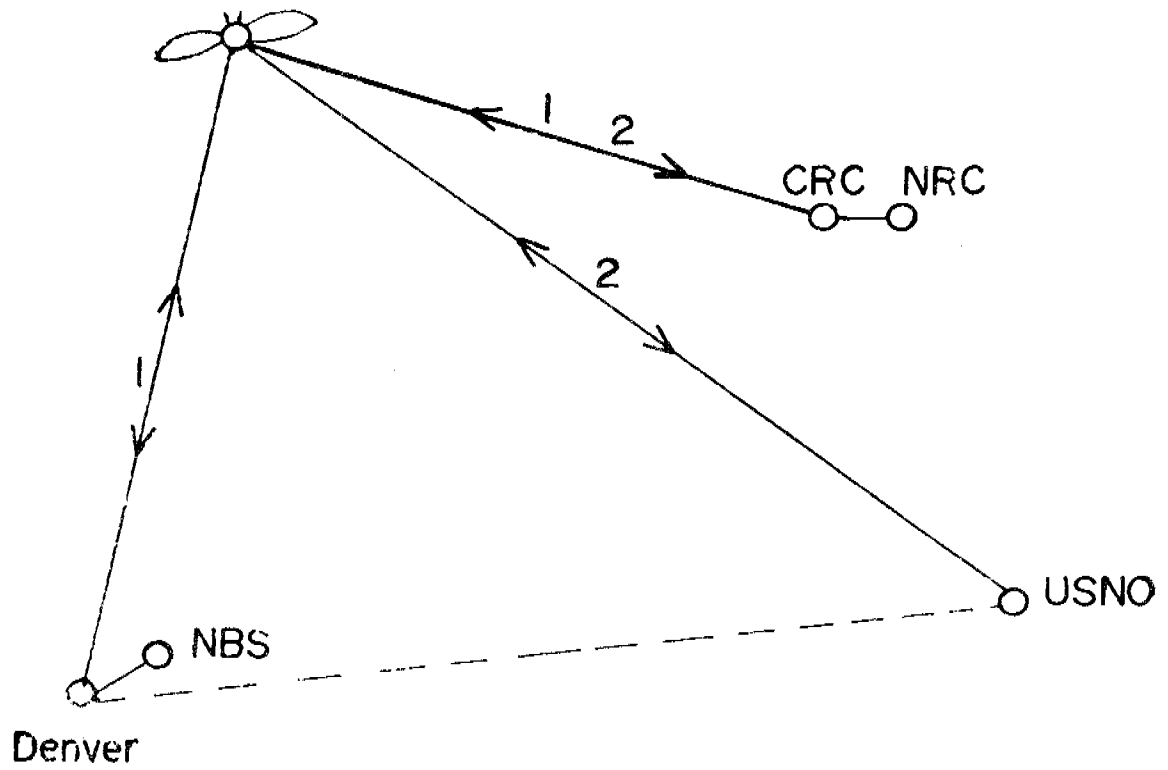
FIG. 1a. TWO-WAY TIME TRANSFER PATHS FOR NRC/NBS AND NRC/USNO
USING THE HERMES (CTS) GEOSTATIONARY SATELLITE.
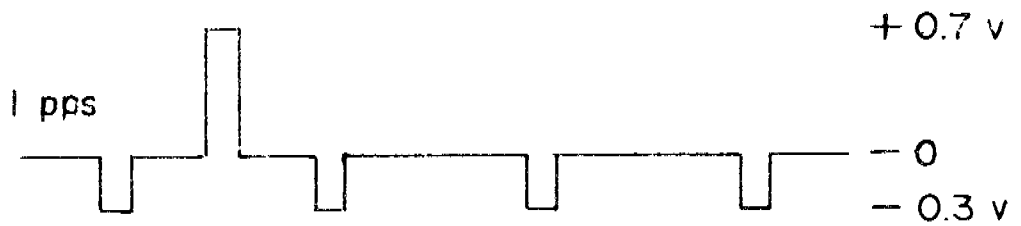
FIG. 1b. VIDEO FORMAT WITH 1 pps TIME PULSES AND THE
15,625 Hz TV HORIZONTAL SYNC PULSES.

MASTER CLOCK
UTC(NBS)

NBS LABORATORIES
BOULDER, COLORADO

PORTABLE CLOCK TIME TRANSFER
USING 2 CESIUM BEAM ATOMIC CLOCKS

HEW/CTS TERMINAL
DENVER, COLORADO

TV LINE 10
16 MILES

TV LINE 10
18 MILES

CHANNEL 4 TELEVISION
TRANSMITTER & ANTENNA
GOLDEN, COLORADO
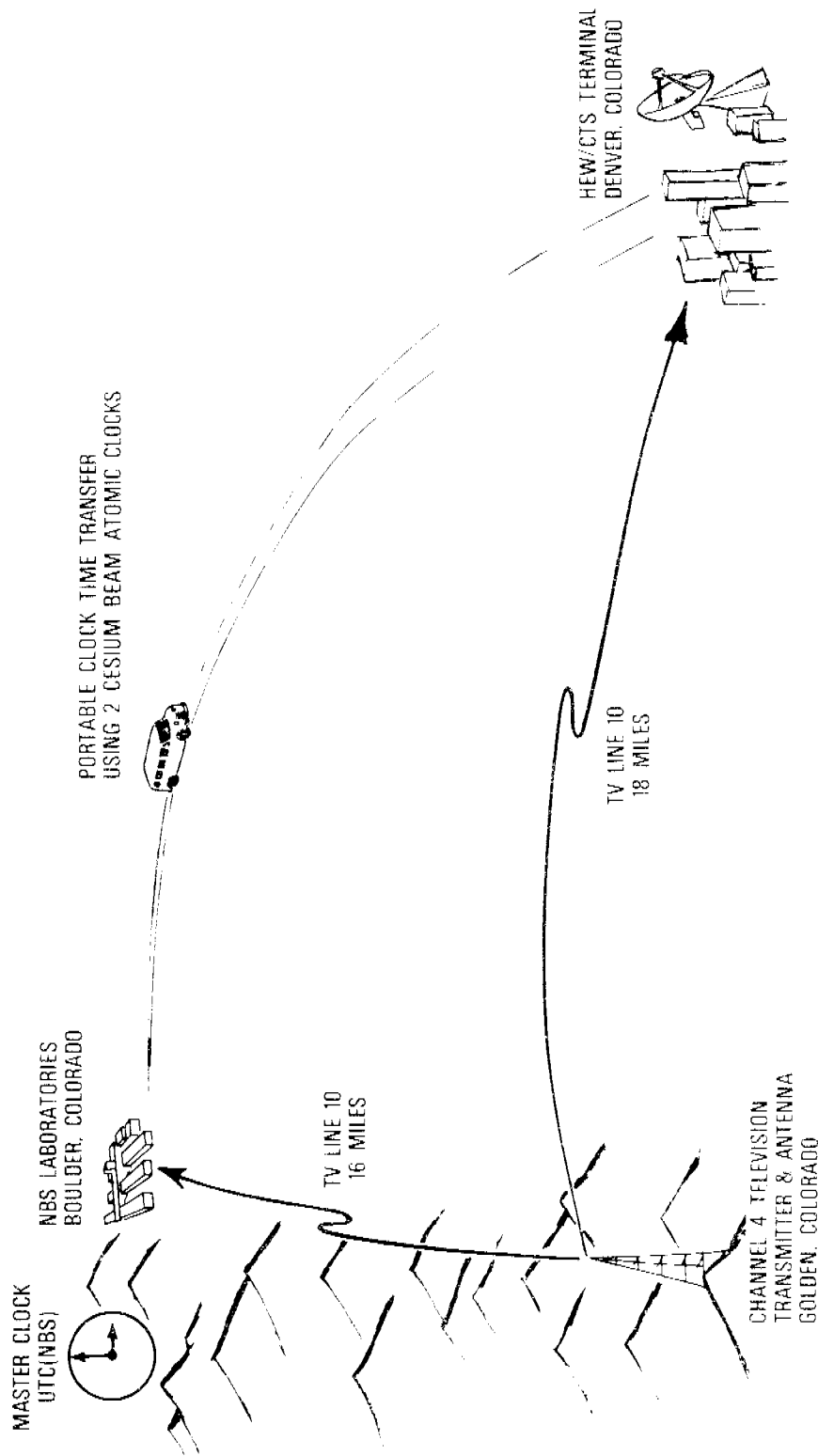
FIG. 2. TIME TRANSFER FROM NBS BOULDER TO THE HEW TERMINAL,
DENVER, VIA PORTABLE Cs CLOCKS AND TV LINE 10.

593
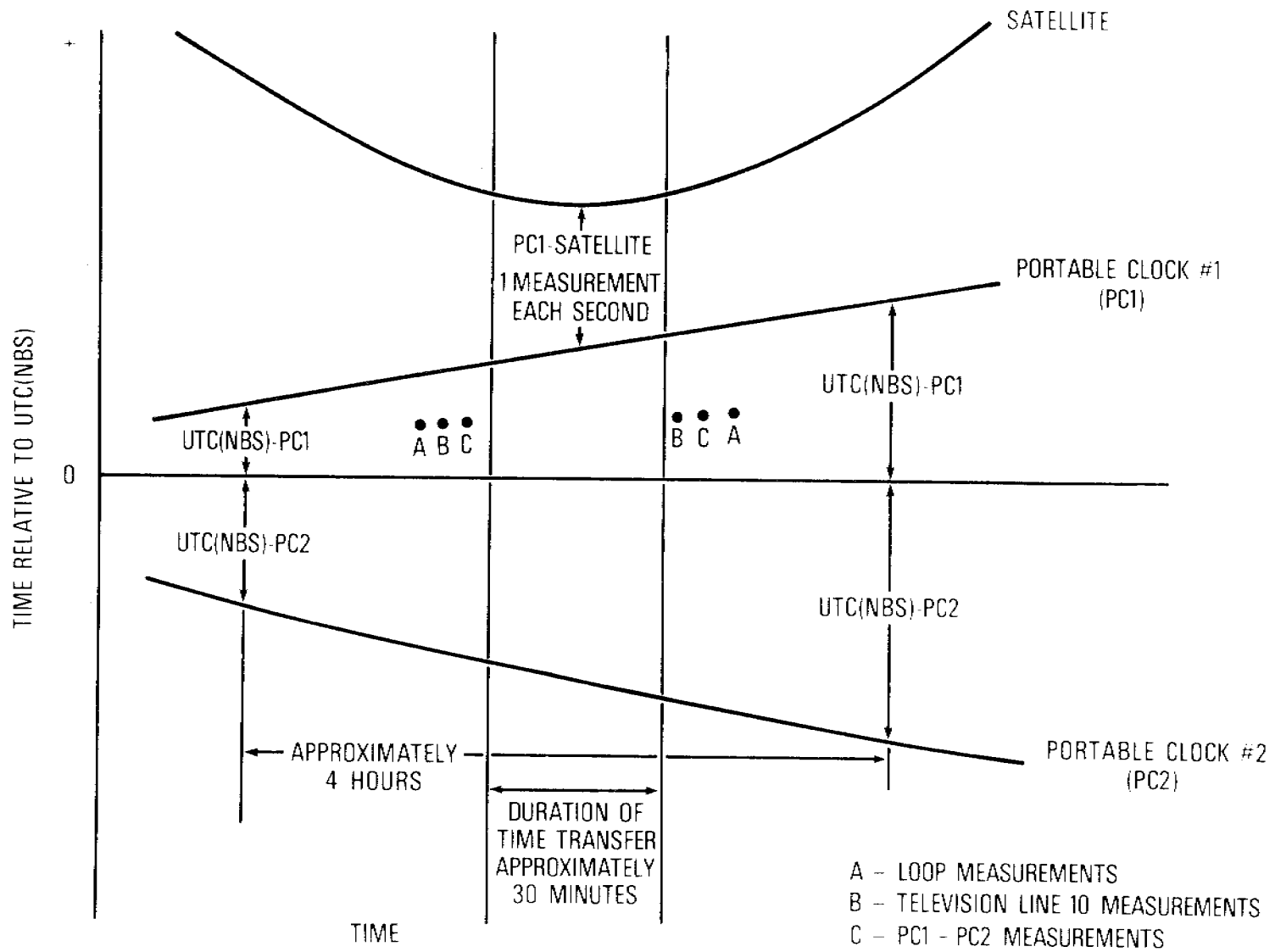
FIG. 3. DETAILS OF THE NBS/HEW TIME TRANSFER.

$$\Delta t = \frac{T_1 - T_2}{2} + \frac{t_1 - r_1}{2} - \frac{t_2 - r_2}{2}$$
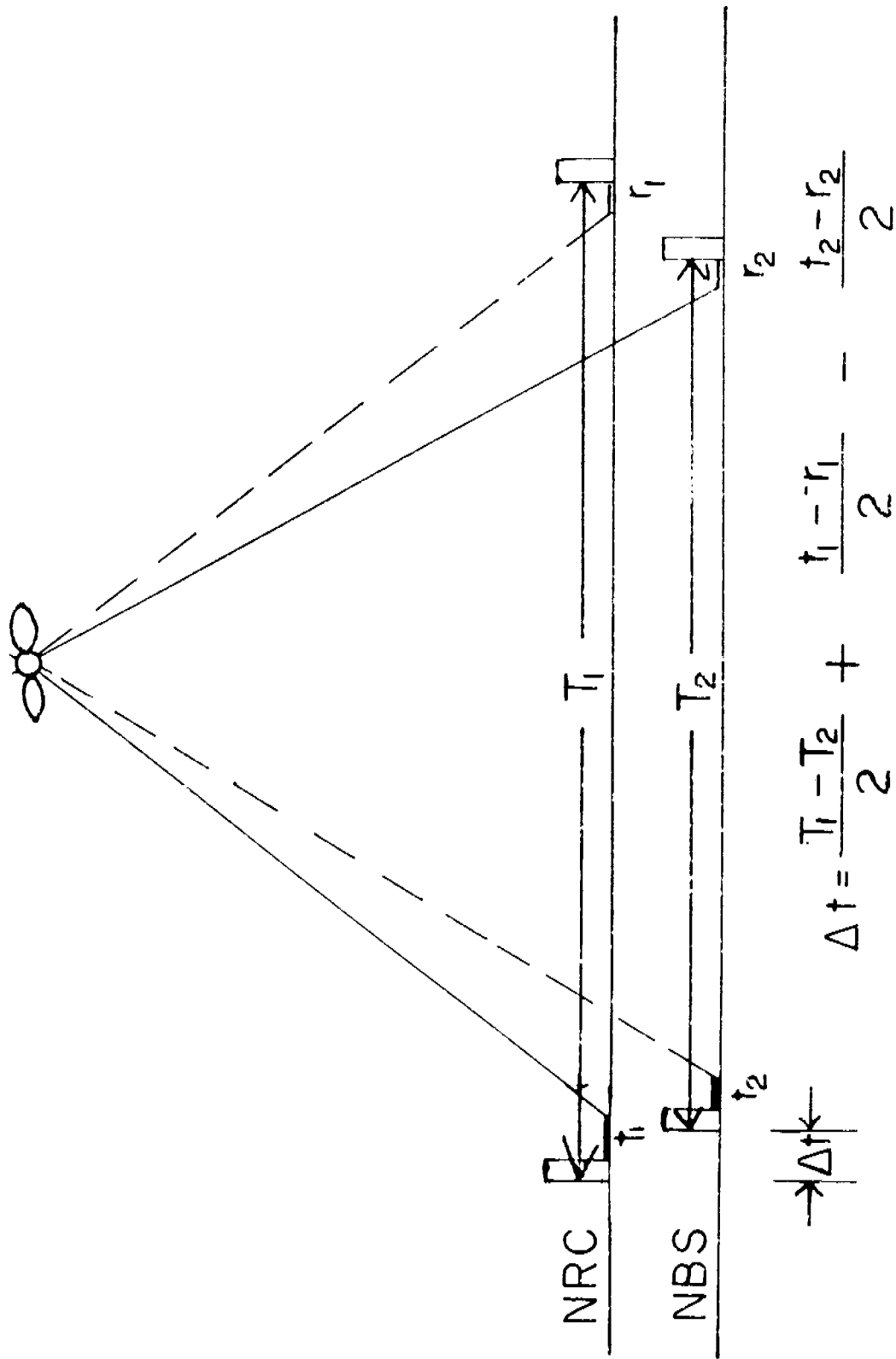
FIG. 4. TWO-WAY SATELLITE TIME TRANSFER MEASUREMENTS.

```
200700:

200800:

200900:

201000:

201100:

201200:

201300:
- 20                                                        +60
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```
Histogram : scale =  1:1,computed from 195550 to 201321
AT >24 :     40 |●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
AT  24 :      2 |●●
AT  23 :      3 |●●●
AT  22 :      2 |●●
AT  21 :      4 |●●●●
AT  20 :      3 |●●●
AT  19 :      9 |●●●●●●●●●
AT  18 :      7 |●●●●●●●
AT  17 :      9 |●●●●●●●●●
AT  16 :      4 |●●●●
AT  15 :     16 |●●●●●●●●●●●●●●●●
AT  14 :     17 |●●●●●●●●●●●●●●●●●
AT  13 :     22 |●●●●●●●●●●●●●●●●●●●●●●
AT  12 :     26 |●●●●●●●●●●●●●●●●●●●●●●●●●●
AT  11 :     21 |●●●●●●●●●●●●●●●●●●●●●
AT  10 :     21 |●●●●●●●●●●●●●●●●●●●●●
AT   9 :     42 |●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
AT   8 :     44 |●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
AT   7 :     57 |●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
AT   6 :     55 |●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
AT   5 :     56 |●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
AT   4 :     68 |●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
AT   3 :     62 |●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
AT   2 :     66 |●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
AT   1 :     63 |●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
AT   0 :     87 |●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
AT  -1 :     79 |●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
AT  -2 :     70 |●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
AT  -3 :     43 |●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
AT  -4 :     35 |●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
AT  -5 :     10 |●●●●●●●●●●
AT  -6 :      7 |●●●●●●●
AT  -7 :      1 |●
AT<-24 :      1 |●
```
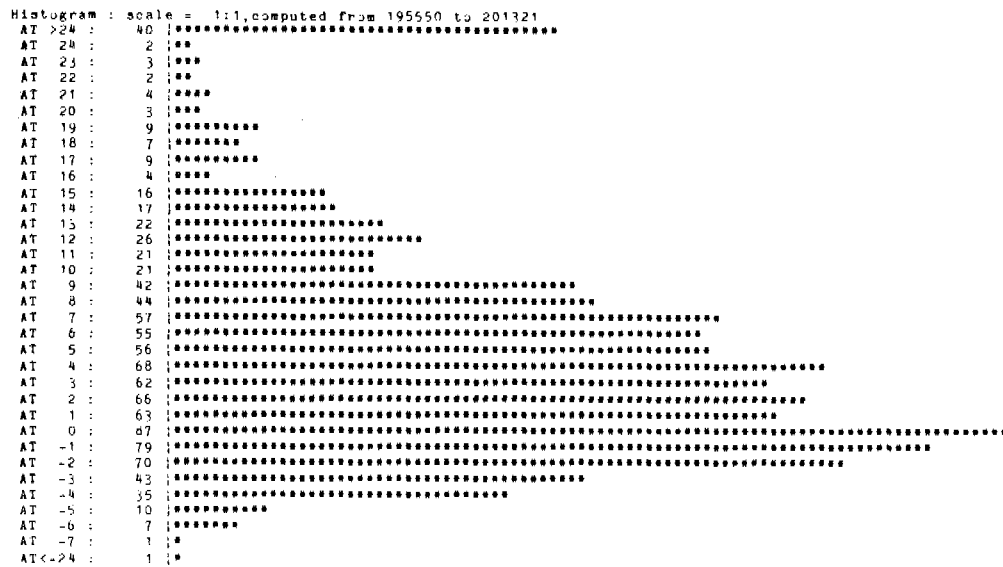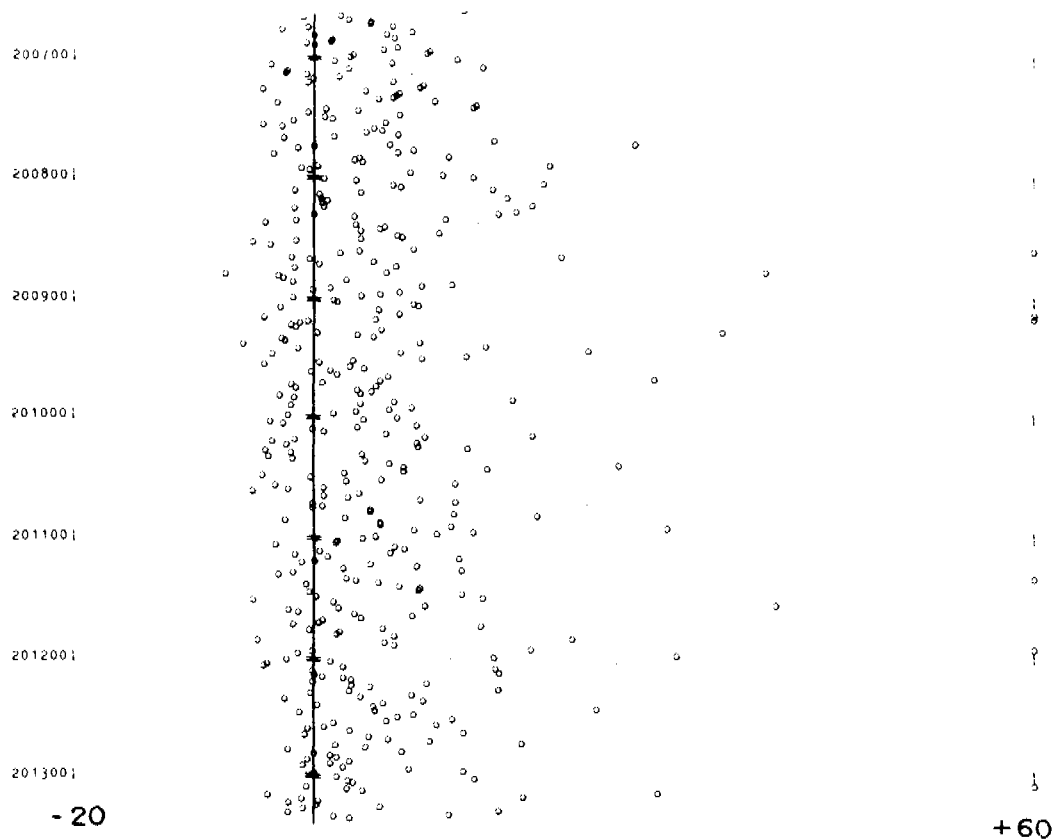
```
The file is sp230195548
Time index is 200000
Yit)(ns) =   255594062.396 -2.1353568194363E+01*t +1.8252224804267E-03*t*t +1.6942143317262E-09*t*t*t
Computed from 195550 to 201321
 Standard deviation =        1.401 in a window of       5 ns.
  687 points discarded on a total of  1052.
```

FIG. 5. NRC/NBS TRANSFER. AN NRC PLOT AND HISTOGRAM OF DATA-
EQUATION, IN ns, WITH ANTENNA BORESIGHT BETWEEN
OTTAWA AND WASHINGTON.

202400.

202500.

202600.

202700.

202800.

202900.

203000.
-20   **+20**

Histogram : scale = 3:1,computed from 201149 to 203001
```
AT   16 :        1 |
AT   15 :        0 |
AT   14 :        0 |
AT   13 :        0 |
AT   12 :        0 |
AT   11 :        0 |
AT   10 :        0 |
AT    9 :        0 |
AT    8 :        0 |
AT    7 :        0 |
AT    6 :        0 |
AT    5 :        0 |
AT    4 :       10 |***
AT    3 :       28 |*********
AT    2 :      125 |*****************************************
AT    1 :      232 |***********************************************************************
AT    0 :      292 |*******************************************************************************************************************
AT   -1 :      243 |****************************************************************************
AT   -2 :      116 |*************************************
AT   -3 :       39 |*************
AT   -4 :        6 |**
AT   -5 :        0 |
AT   -6 :        0 |
AT   -7 :        0 |
AT   -8 :        0 |
AT   -9 :        0 |
AT  -10 :        0 |
AT  -11 :        0 |
AT  -12 :        0 |
AT  -13 :        0 |
AT  -14 :        0 |
AT  -15 :        0 |
AT  -16 :        0 |
AT  -17 :        0 |
AT  -18 :        0 |
AT  -19 :        0 |
AT  -20 :        0 |
AT  -21 :        0 |
AT  -22 :        * |
```
The file is sp24420146
Time index is 200000
 Y(t)(ns) = 255932665.594 -1.35473992509OE+01*t +1.064046517714BE-03*t*t +4.4774508220204E-09*t*t*t
Computed from 201149 to 203001
 Standard deviation =   1.418 in a window of   20 ns.
     2 points discarded on a total of 1093.

FIG. 6. NRC/NBS TRANSFER. AN NRC PLOT AND HISTOGRAM OF DATA-
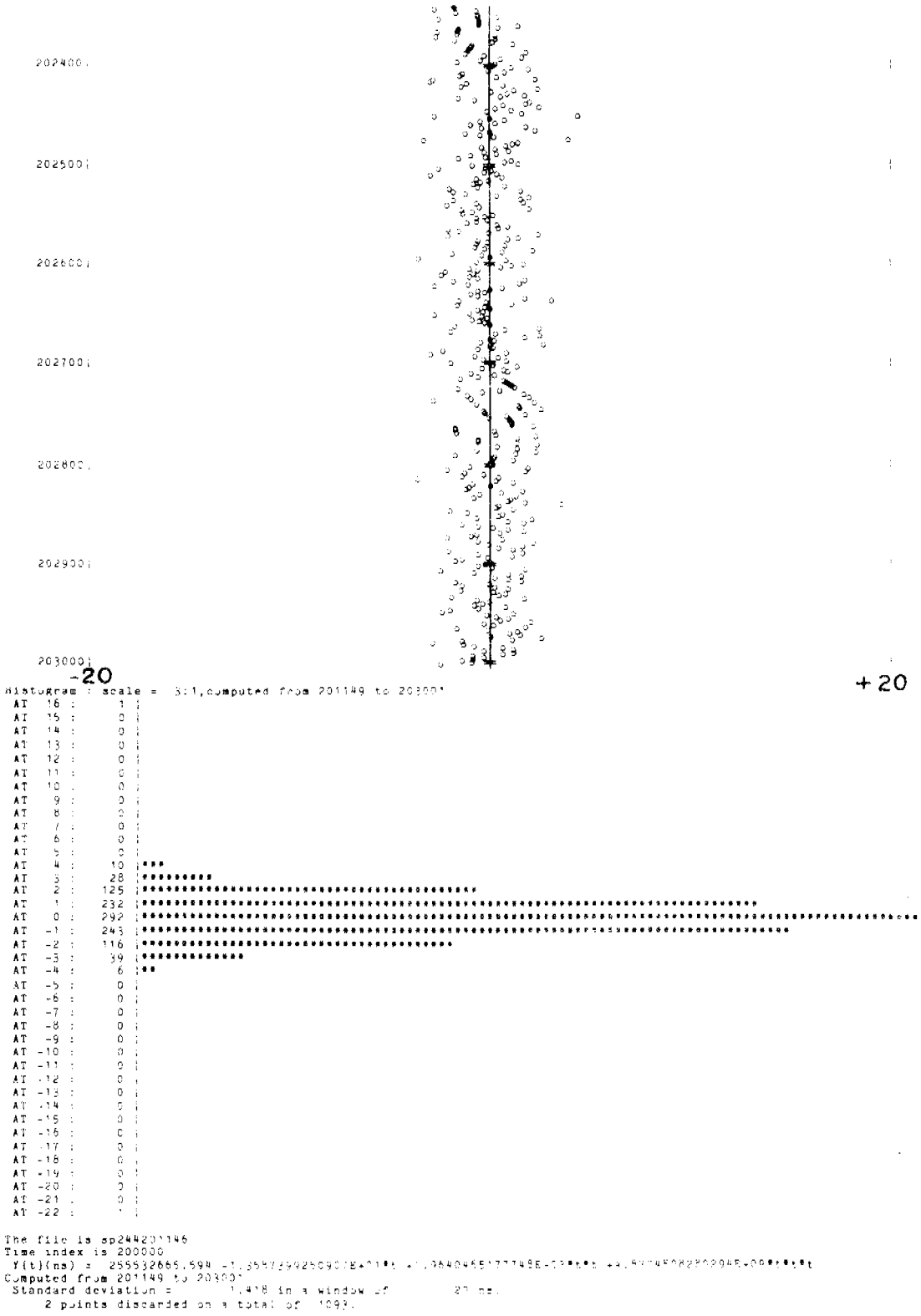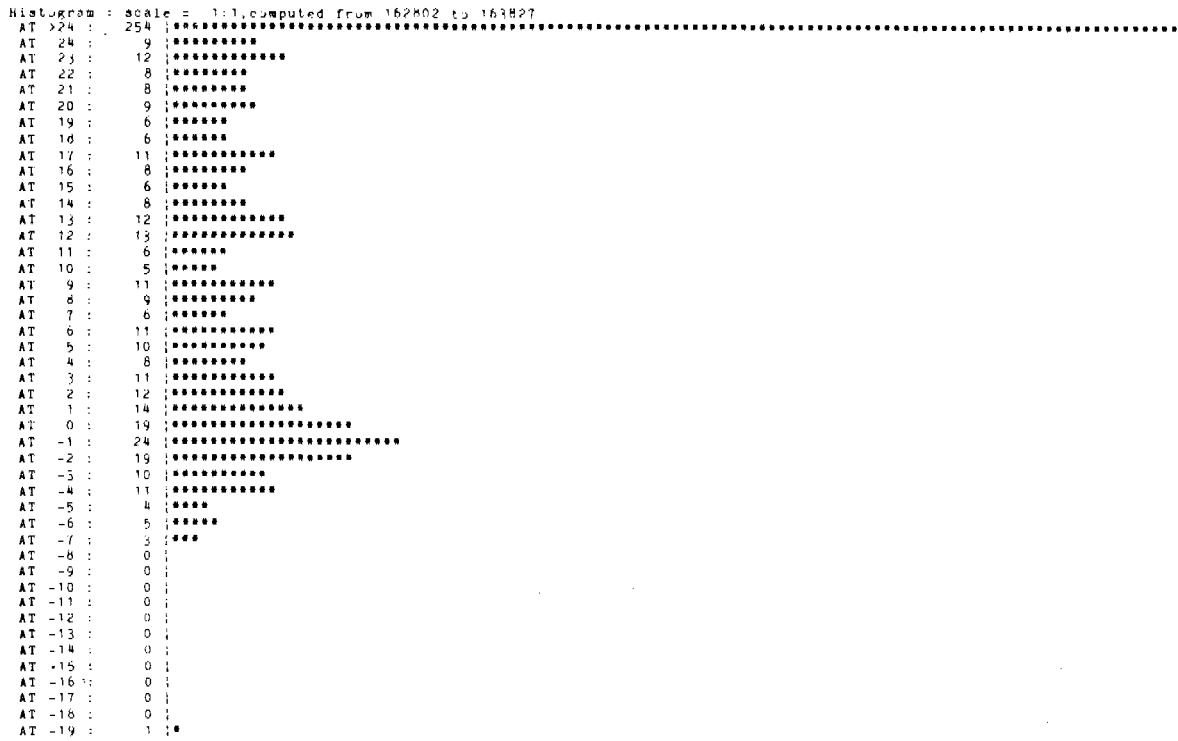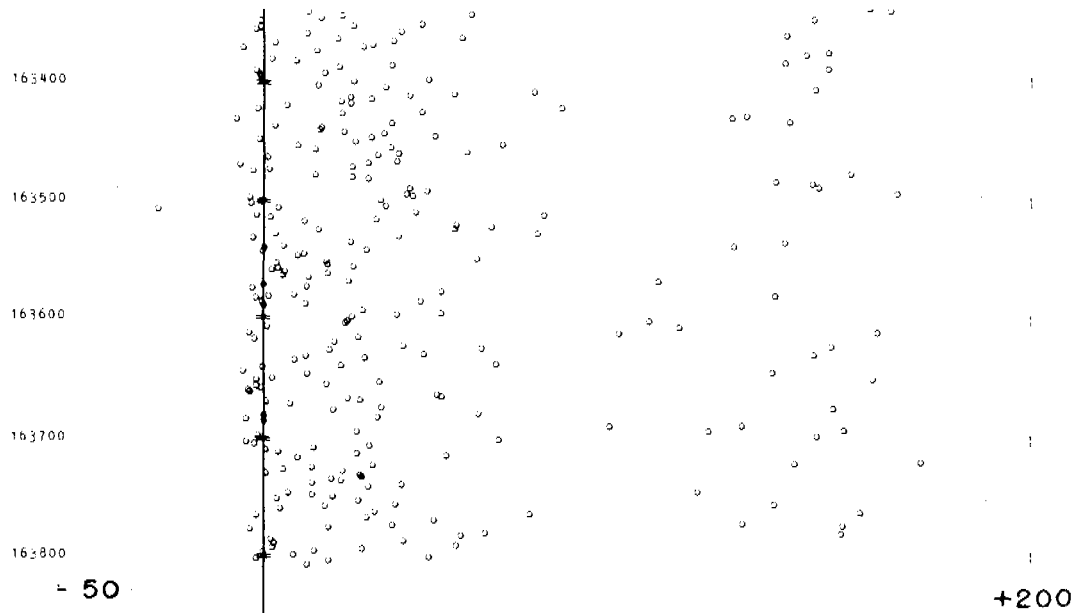   EQUATION, IN ns, WITH ANTENNA BORESIGHT ON OTTAWA.

163400

163500

163600

163700

163800

- 50   +200

Histogram : scale = 1:1,computed from 162802 to 163827
AT >24 :   254 |●●●
AT 24 :   9 |●●●●●●●●●
AT 23 :   12 |●●●●●●●●●●●●
AT 22 :   8 |●●●●●●●●
AT 21 :   8 |●●●●●●●●
AT 20 :   9 |●●●●●●●●●
AT 19 :   6 |●●●●●●
AT 18 :   6 |●●●●●●
AT 17 :   11 |●●●●●●●●●●●
AT 16 :   8 |●●●●●●●●
AT 15 :   6 |●●●●●●
AT 14 :   8 |●●●●●●●●
AT 13 :   12 |●●●●●●●●●●●●
AT 12 :   13 |●●●●●●●●●●●●●
AT 11 :   6 |●●●●●●
AT 10 :   5 |●●●●●
AT   9 :   11 |●●●●●●●●●●●
AT   8 :   9 |●●●●●●●●●
AT   7 :   6 |●●●●●●
AT   6 :   11 |●●●●●●●●●●●
AT   5 :   10 |●●●●●●●●●●
AT   4 :   8 |●●●●●●●●
AT   3 :   11 |●●●●●●●●●●●
AT   2 :   12 |●●●●●●●●●●●●
AT   1 :   14 |●●●●●●●●●●●●●●
AT   0 :   19 |●●●●●●●●●●●●●●●●●●●
AT -1 :   24 |●●●●●●●●●●●●●●●●●●●●●●●●
AT -2 :   19 |●●●●●●●●●●●●●●●●●●●
AT -3 :   10 |●●●●●●●●●●
AT -4 :   11 |●●●●●●●●●●●
AT -5 :   4 |●●●●
AT -6 :   5 |●●●●●
AT -7 :   3 |●●●
AT -8 :   0 |
AT -9 :   0 |
AT -10 :   0 |
AT -11 :   0 |
AT -12 :   0 |
AT -13 :   0 |
AT -14 :   0 |
AT -15 :   0 |
AT -16 :   0 |
AT -17 :   0 |
AT -18 :   0 |
AT -19 :   1 |●

The file is sp216162800
Time index is 162800
Y(t)(ns) = 260832707.579 -5.0377853871081E+01*t -5.8989750437129E-05*t*t +8.8965515574784E-08*t*t*t
Computed from 162802 to 163827
 Standard deviation =   2.591 in a window of   10 ns.
   489 points discarded on a total of   626.

FIG. 7.   NRC/NRC LOOP TEST.   AN NRC PLOT AND HISTOGRAM OF DATA-
          EQUATION, IN ns, WITH ANTENNA BORESIGHT ON WASHINGTON.
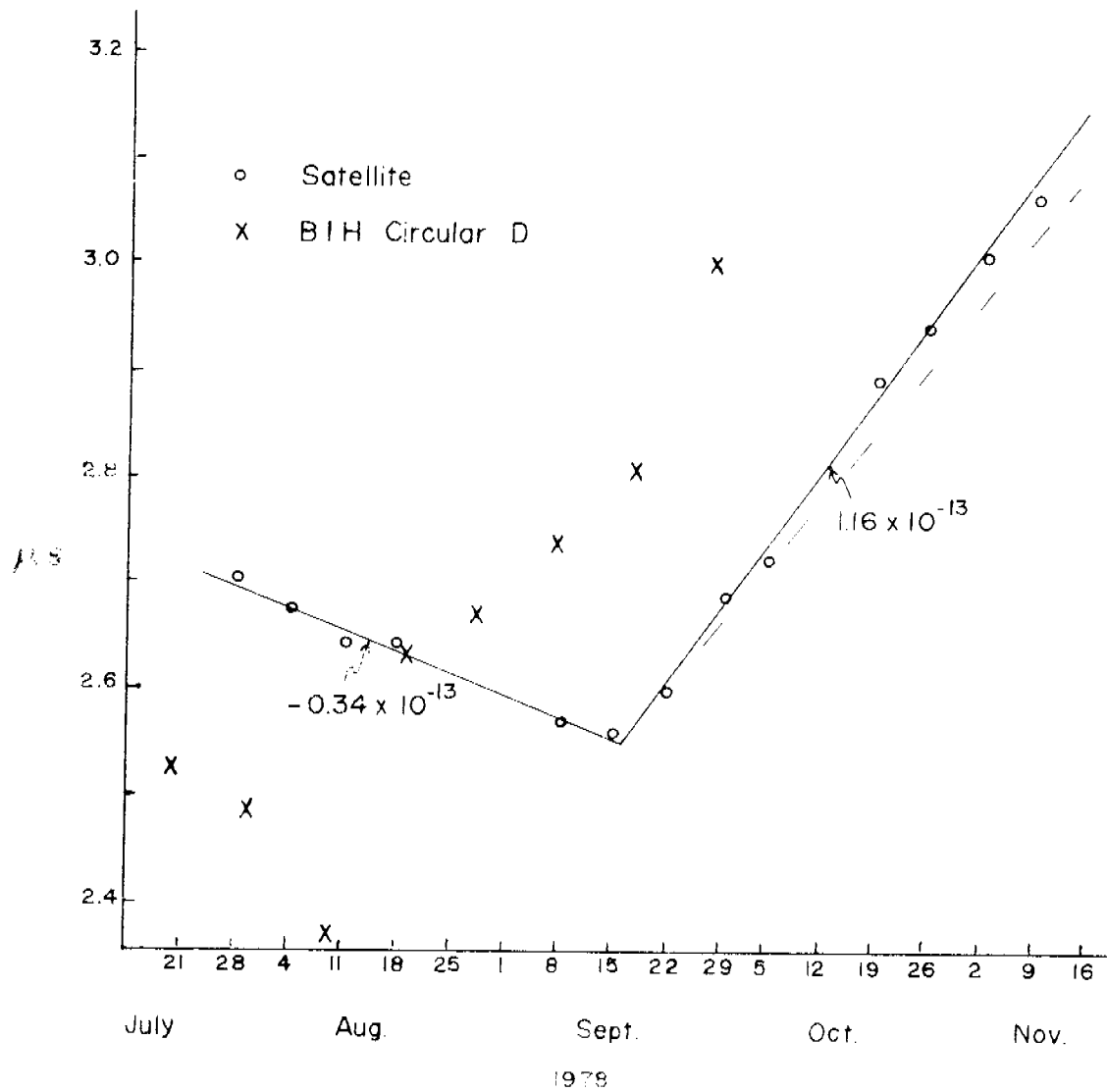
UTC(NRC) — UTC(NBS)

FIG. 8. UTC(NRC) - UTC(NBS) IN MICROSECONDS. THE CIRCLES WERE
OBTAINED FROM THE SATELLITE TIME TRANSFER, THE CROSSES
FROM BIH CIRCULAR D. THE DIFFERENCE IN SLOPE BETWEEN
THE SOLID LINE AND DASHED LINE IS 1 x 10-^{14}.

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Questions and Answers

MR. DAVID ALLAN, National Bureau of Standards:

I would like to make two comments: Number one, I'd like to give Dr. Barnes credit for having picked out that one nanosecond granularity.

DR. COSTAIN:

Belanger said it was. He couldn't convince me until May.

MR. ALLAN:

Right. The other thing is that it is interesting to note that using the equations that you wrote down, if you compare your numbers, assuming you had accuracy, via portable clock, they would differ by about 60 nanoseconds due to the rotation of the earth.

DR. COSTAIN:

I did not mention that. Certainly, if one moves to higher accuracy, that goes with the measuring of the terminal. I think you all said the figure of about eight nanoseconds to Washington and 160 to France, or something. And if we are after accuracy, we would have to do that.

I hope it is constant, although I remember in Saburi's experiment, the variation of the satellite, in fact, with his precision, was enough to see that in the variation in path. The satellite moves in our experiment. It is just going to drift a little more eliptical all the time. We get about up to 50 nanoseconds per second movement now, I think.