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**TWO-PHASE FLOW MEASUREMENT
BY PULSED NEUTRON ACTIVATION TECHNIQUES**

by

Paul Kehler

Components Technology Division

U of C-AUA-USDOE

for

**Nuclear Regulatory Commission
Office of Nuclear Regulatory Research**

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ABSTRACT

The Pulsed Neutron Activation (PNA) technique for measuring the mass flow velocity and the average density of two-phase mixtures is described. PNA equipment can be easily installed at different loops, and PNA techniques are non-intrusive and independent of flow regimes. These features of the PNA technique make it suitable for in-situ measurement of two-phase flows, and for calibration of more conventional two-phase flow measurement devices.

Analytic relations governing the various PNA methods are derived. The equipment and procedures used in the first air-water flow measurement by PNA techniques are discussed, and recommendations are made for improvement of future tests.

In the present test, the mass flow velocity was determined with an accuracy of 2%, and average densities were measured down to 0.08 g/cm^3 with an accuracy of 0.04 g/cm^3 . Both the accuracy of the mass flow velocity measurement and the lower limit of the density measurement are functions of the injected activity and of the total number of counts. By using a stronger neutron source and a larger number of detectors, the measurable density can be decreased by a factor of 12 to $.007 \text{ g/cm}^3$ for 12.5 cm pipes, and to even lower ranges for larger pipes.

1.0 INTRODUCTION

Nuclear safety test programs, such as the Loss of Fluid Test or the Upper Plenum Separate Effects (3-D) Test, are being conducted to collect experimental data required for the verification of computer codes assessing the safety of nuclear power plants. The measurement of mass flow rates and fluid properties is required to verify the accuracy with which the computer codes can model a loss of coolant accident and subsequent reflooding of the core by emergency cooling systems.

The measurement of transient mass flow rates of two-phase flow is performed with conventional equipment such as turbines, drag disks or pitot tubes, but is complicated by the need to identify the flow regime and to measure the average density over the cross section of the flow channel.

At the present time, the accuracy of conventional two-phase flowmeters is not considered to be adequate for reactor safety studies. Conventional instruments must be calibrated under controlled conditions and for different flow regimes. One way to calibrate two-phase flowmeters is by use of radioactive tracers ^(1,6,7). Radioactive tracers can be produced in situ by neutron activation, and Pulsed Neutron Activation (PNA) techniques, which were used for the measurement of single phase flow velocities ⁽⁹⁾ and for the calibration of liquid sodium flowmeters ^(2,3,4,5), can also be used for the calibration of two-phase flowmeters.

The present report describes the analytic methods, experimental techniques, and results of the first two-phase flow measurement performed by the PNA technique.

2.0 ANALYTIC MODELING

In water flow measurements by the Pulsed Neutron Activation (PNA) technique, a D,T neutron source is used to activate oxygen by irradiating the water (and steam) with a short burst of 14 MeV neutrons. These neutrons produce a short-lived radioactive isotope of nitrogen by the reaction $O^{16}(n,p)N^{16}$. The half-life of N^{16} is 7.24 sec, and its emitted gamma ray has an energy of 6.1 MeV.

A NaI detector located downstream of the source (see Fig. 1) detects the induced activity as it flows past. After amplification and energy discrimination, the individual counts registered by the detector are stored in individual "time channels" Δt of a multichannel analyzer, operated in a multiscaler mode. The time channel in which the individual counts are stored indicates the "transit time" of the activities causing these counts. Figure 2

Fig. 1 Geometry, PNA Technique

Fig. 2 Example, Multiscaler Output

illustrates such a distribution of counts with time. Since some of the activity decays during transit between the source and the detector, the number of counts $c(t)$, as registered by the detector, must be corrected for this decay prior to any data processing, according to

$$C(t) = c(t) e^{\lambda t} \quad (1)$$

where

$$\begin{aligned} C(t) &= \text{decay corrected number of counts,} \\ \lambda &= \ln 2/T_{1/2} = \text{decay constant of } N^{16}, \text{ and} \\ t &= \text{time from activation to detection.} \end{aligned}$$

Whenever $C(t)$ is mentioned in the present report, the decay-corrected number of counts is to be understood.

Different methods can be used for the measurement of mass flow velocity and average density by PNA techniques. These methods are discussed, and the basic equations to be used for PNA data reductions are derived below.

2.1 Average Velocity by Transit-Time Method

When a slug of fluid is "tagged" at the source location in Fig. 1, and its transit time T between source and detector is known, then its velocity V is

$$V = Z_o \frac{1}{T} \quad , \quad (2)$$

where

$$Z_o = \text{the distance between the source and the detector.}$$

Tagging of the fluid can be done by injection of salts with easily detectable properties (as was done as far back as in the early 1920's), by injection of radioactive tracers, or by neutron activation as in our PNA technique.

A large number of studies (including the classical work by Taylor) dealt with the dispersion of the injected tracers in time, and with numerical methods for the derivation of an "average transit-time" suitable for use in Eq. 2. These methods derive an average transit-time from the time distributed

number of counts $C(t)$, by using one of the following:
the mode t_0 , where

$$d C(t_0)/dt = 0 , \quad (3)$$

the median τ , where

$$\int_0^{\tau} C(t) dt = \int_{\tau}^{\infty} C(t) dt , \quad (4)$$

the mean $\bar{t}$, where

$$\bar{t} = \frac{\int_0^{\infty} t C(t) dt}{\int_0^{\infty} C(t) dt} , \quad (5)$$

or the reciprocal mean $\left(\frac{1}{t}\right)'$, where

$$\left(\frac{1}{t}\right)' = \frac{\int_0^{\infty} \left(\frac{1}{t}\right) C(t) dt}{\int_0^{\infty} C(t) dt} . \quad (6)$$

In our previous work, dealing with single phase flow measurement of liquid sodium, we have used the count distribution weighted reciprocal mean, Eq. 6.

None of these evaluation schemes was found to be sufficiently accurate for application to two-phase flow conditions, where the distribution of counts is, in most cases, significantly different from normal distributions. In annular flows, for example, the liquid ring close to the pipe wall flows much slower than the mass at the centerline of the pipe. In many situations, there is a distinct separation of the velocities of the two phases and the concept of "slip" can be used. For these complex two-phase flow conditions, a transit-time equation was derived directly from the definition for average mass flow, as shown below:

Let's assume that the neutron source activates uniformly the oxygen contained in a disk opposite the source. This oxygen may be contained in water in its liquid or gaseous phase. Furthermore, let's assume that all of the activated mass (liquid or gas) can be divided into small mass elements dm ,

where each element dm has an average axial velocity (averaged over z_0) of V . Then, the mass averaged velocity V_M of all the activated mass elements dm is

$$V_M = \frac{\int V \, dm}{\int dm} \quad (7)$$

It should be pointed out at this place that Eq. 7 is the definition of the mass averaged flow velocity and, as such, generally applies to all flow regimes. In particular, it also applies to annular flow regimes with distinctly separate phase velocities and very low flow velocities of the water film adhering to the pipe wall.

Integration of Eq. 7 can be done either in space or in time, as long as all mass elements dm are covered by the integral. In single phase flow situations, the velocity V of the individual mass elements is commonly assumed to be a function of the radius only, $V = V(r)$. In these cases, the mass elements can be assumed to be concentric rings, $dm = 2\pi r \, dr \, \Delta z \, \rho$, and Eq. 7 assumes the well known form for the mass averaged flow velocity for radial velocity distributions:

$$V_M = \frac{\int_0^r V(r) \, 2\pi r \, dr}{\int_0^r 2\pi r \, dr} \quad , \quad \text{or} \quad (8)$$

$$V_M = \frac{1}{a} \int_0^r V(r) \, 2\pi r \, dr \quad , \quad (9)$$

where

a = the cross sectional area of the pipe.

Although some two-phase velocity measuring systems are capable of measuring radial velocity distributions (e.g., "rakes" of pitot tubes, drag disks, or small turbines), the PNA technique can not do so. Equation 9, therefore, does not apply to the PNA technique. Instead, the transient time method of the PNA technique integrates Eq. 7 over time, by measuring the mass and velocity of each mass element dm as it passes the detector. The mass measurement is done through the measurement of the activity of the mass element dm , and the velocity measurement is done through the measurement of the transit time.

Assuming that the neutron fluence is constant over the diameter of the

pipe opposite the source, then the activity (in decays/sec) of each mass element dm will be proportional to its mass. In large-diameter pipes, uniformity of the neutron fluence can be improved by irradiating the flow with more than one neutron source from more than one direction. With proportionality between mass and activity of the individual mass elements, the mass flowing past the detector during the time interval dt will be

$$dm \propto A(t) dt, \quad (10)$$

where $A(t)$ = the activity "seen" by the detector at the time t .

For ease of understanding, let's assume that the "window" ΔZ of the detector is very small, and that the time of passage of the activity $A(t)$ past this window, Δt , is very short:

$$\Delta t = \frac{\Delta Z}{V} < dt. \quad (11)$$

Under this assumption, all counts $C(t)$ due to the activity $A(t)$ will be registered by the detector within the time interval dt , with

$$C(t) \approx A(t) \Delta t, \quad (12)$$

or

$$C(t) = \alpha \frac{A(t)}{V}, \quad (13)$$

where α is a constant.

The condition of Eq. 11 limits in no way the validity of the transit-time method of the PNA technique. It is only stated to simplify the assumptions for ease of understanding. Should, for example, for a given detector window ΔZ , dt be chosen to be shorter than Δt , or

$$\Delta t = n dt, \quad (14)$$

where $n \geq 1$,

then the total number of counts, $C(t)$ of Eq. 13, would simply be distributed over n time intervals dt instead of one time interval, and dm of Eq. 10 would

appear to be lower by a factor $\frac{1}{n}$ in each of the n time intervals dt . However, integration over the n time intervals would still result in the same value for $\int dm$. Also, the transit time, averaged over n time intervals, would be the same as the transit time for the case of only one time interval. Expressing $A(t)$ in Eq. 10 by Eq. 13 yields

$$dm = \frac{1}{\alpha} V C(t) dt \quad (15)$$

which, when inserted into Eq. 7, gives the following definition of the mass averaged flow velocity:

$$V_M = \frac{\int V^2 C(t) dt}{\int V C(t) dt} \quad (16)$$

The transit time T of the mass elements "seen" by the detector at the time t is $T = t$, and their velocity is

$$V = \frac{Z_0}{t} \quad (17)$$

Substituting this value for V in Eq. 16 yields

$$V_M = Z_0 \frac{\int \frac{1}{t^2} C(t) dt}{\int \frac{1}{t} C(t) dt} \quad (18)$$

The integrals in this definition of the mass averaged flow velocity can be broken down into sums of integrals over small time periods Δt :

$$\int_0^{\infty} \frac{1}{t^2} C(t) dt = \sum_{i=1}^{\infty} \int_{(i-1)\Delta t}^{i\Delta t} \frac{1}{t^2} C(t) dt, \text{ and} \quad (19)$$

$$\int_0^{\infty} \frac{1}{t} C(t) dt = \sum_{i=1}^{\infty} \int_{(i-1)\Delta t}^{i\Delta t} \frac{1}{t} C(t) dt \quad (20)$$

Integration of counts over preset time increments Δt is performed by the PNA equipment, and the resulting total number of counts C_i is stored in channel i :

$$c_i = \int_{(i-1)\Delta t}^{i\Delta t} C(t) dt \quad (21)$$

Assuming an average time t_i for the time between $t = (i-1)\Delta t$ and $t = i\Delta t$

$$t_i = (i-1)\Delta t + \frac{1}{2}\Delta t, \quad (22)$$

and considering decay correction, Eq. 21 becomes

$$c_i e^{\lambda t_i} = \int_{(i-1)\Delta t}^{i\Delta t} C(t) dt \quad (23)$$

Insertion of Eqs. 22 and 23 into Eqs. 19 and 20 yields

$$\int_0^{\infty} \frac{1}{t^2} C(t) dt = \sum_{i=1}^{\infty} \frac{1}{t_i^2} c_i e^{\lambda t_i}, \text{ and} \quad (24)$$

$$\int_0^{\infty} \frac{1}{t} C(t) dt = \sum_{i=1}^{\infty} \frac{1}{t_i} c_i e^{\lambda t_i}, \quad (25)$$

and the definition of the mass averaged flow velocity, Eq. 18, reads in terms measurable by PNA equipment:

$$v_M = z_0 \frac{\sum_{i=1}^{\infty} \frac{1}{t_i^2} c_i e^{\lambda t_i}}{\sum_{i=1}^{\infty} \frac{1}{t_i} c_i e^{\lambda t_i}}. \quad (26)$$

Being the definition of the mass averaged flow velocity, Eq. 26 has no systematic error. The fundamental errors (due primarily to the finite collimation of the source and the detector), and the experimental errors (due to errors in measurement of times and distance, as well as to statistical errors),

however, do effect the accuracy of the flow velocity measurement by the transit time method of the PNA technique.

The physical meaning of Eq. 16 can be understood by inserting Eqs. 10, 15 and 17 into Eq. 18 which then reads:

$$V_M = Z_0 \frac{\int \frac{1}{t} A(t) dt}{\int A(t) dt} \quad (27)$$

The fraction by the two integrals in this equation is the definition of the activity averaged inverse of the transit time, $\left(\frac{1}{t}\right)$. Using this definition, Eq. 27 can be written

$$V_M = Z_0 \left(\frac{1}{t}\right) . \quad (28)$$

The equation used by us for the calibration of liquid sodium flowmeters^(2,3,4,5) was

$$\bar{V} = Z_0 \frac{\int \frac{1}{t} C(t) dt}{\int C(t) dt} , \text{ or} \quad (29)$$

$$\bar{V} = Z_0 \frac{\int A(t) dt}{\int t A(t) dt} . \quad (30)$$

In this equation, the fraction by the two integrals defines the inverse of the activity averaged transit time $\frac{1}{t}$,

$$\frac{1}{t} = \frac{\int \frac{1}{t} C(t) dt}{\int C(t) dt} , \quad (31)$$

and the average velocity of sodium was calculated by

$$\bar{V} = Z_0 \frac{1}{t} . \quad (32)$$

In the case of single-phase sodium flow, with almost normally distributed activities,

$$\left(\frac{1}{t}\right) \sim \frac{1}{t} \quad , \quad (33)$$

and the error due to the incorrect data reduction technique was negligible. In two-phase flow situations, where the activities are not at all normally distributed, the activity-weighted average inverse transit-time can not be assumed to be approximately equal to the inverse of the activity-weighted average transit-time, and Eq. 26 must be used for data reduction.

2.2 Average Density by Transit-Time Method

The most promising potential of PNA techniques is the calibration of conventional two-phase flow measuring devices installed in calibration loops. In most calibration facilities, the mass flow of the gas and the liquid are measured separately and quite accurately prior to the mixing of the two phases. With the pipe diameter of the test loop known, the mass flows can be expressed in terms of superficial velocities, where superficial velocity is defined as the velocity that a phase would have in the pipe if the other phase were not present. When the superficial velocity of the gas is V_{GS} and the superficial velocity of the liquid is V_{LS} , then the superficial velocity of the total mass flow, V_{MS} , can be calculated to be

$$V_{MS} = V_{LS} + \frac{\rho_G}{\rho_L} V_{GS} \quad , \quad (34)$$

Since air is often used instead of steam in calibration loops, and since PNA techniques measure mass flow in terms of flow of oxygen atoms, this equation must be modified by inclusion of terms for the weight fraction of oxygen in the gas, F_G , and the weight fraction of oxygen in the liquid, F_L . The equation for the superficial velocity of oxygen flow (simulating water flow) then becomes

$$V_{MS} = V_{LS} + \frac{\rho_G}{\rho_L} \frac{F_G}{F_L} V_{GS} \quad , \quad (35)$$

where

$$\frac{F_G}{F_L} = 1 \text{ for steam-water mixtures, and}$$

$$\frac{F_G}{F_L} = .262 \text{ for air-water mixtures.}$$

Now, when all the mass flowing in the pipe is in liquid form, then $V_{MS} = V_M$, where V_M is determined by Eq. 26. On the other hand, when two-phase flow conditions prevail, and when the average density in the pipe, ρ_P , is not equal to the density of water, ρ_O , then the following equation is true because of mass balance considerations:

$$\rho_P V_M = \rho_O V_{MS} \quad , \quad (36)$$

and the average density ρ_P , averaged over the length of pipe between the source and the detector, can be determined as

$$\rho_P = \rho_O \frac{V_{MS}}{V_M} \quad . \quad (37)$$

Supplemental mass flow data for the two-phases, generally supplied by the loop operator from readings of single-phase flow measuring equipment, are necessary for the determination of the average density by the transit-time method. An alternative method to determine density, based on the total activity method (Paragraph 2.3), depends on PNA supplied data only.

2.3 Density by Total-Activity Method

When, at a time t , an activity $A(t)$ moves past the detector window ΔZ with a velocity V , then the number of counts registered by the detector will be

$$c(t) = \beta A(t) \frac{\Delta Z}{V(t)} \quad (38)$$

where $\beta =$ a constant.

After correction of the counts for decay (according to Eq. 1), this number of counts can be used as an indication for the amount of activity $A(t)$

passing the detector at any time t ,

$$A(t) = \frac{1}{\beta \Delta Z} C(t) V(t), \quad (39)$$

and the total amount of activity passing the detector can be obtained by integration:

$$A = \int_0^{\infty} A(t) dt = \frac{1}{\beta \Delta Z} \int_0^{\infty} C(t) V(t) dt. \quad (40)$$

Since

$$V(t) = Z_0 \left(\frac{1}{t} \right),$$

$$A = \frac{Z_0}{\beta \Delta Z} \int_0^{\infty} \left(\frac{1}{t} \right) C(t) dt. \quad (41)$$

Assuming a uniform distribution of neutron fluence over the diameter of the pipe opposite the source, the total activity introduced into the flowing medium is proportional to the average density ρ_S opposite the source:

$$A = A_0 \frac{\rho_S}{\rho_0} = \frac{Z_0}{\beta \Delta Z} \int_0^{\infty} \left(\frac{1}{t} \right) C(t) dt, \quad (42)$$

where

ρ_0 = density of water, and

A_0 = the activity introduced in a water filled pipe.

Thus,

$$\rho_S = \frac{Z_0}{\beta A_0 \Delta Z} \int_0^{\infty} \left(\frac{1}{t} \right) C(t) dt. \quad (43)$$

Introducing a constant k that describes the properties of the detector (sensitivity β and width of collimation angle, ΔZ),

$$\rho_S = k \frac{Z_0}{A_0} \int_0^{\infty} \left(\frac{1}{t} \right) C(t) dt. \quad (44)$$

In any given series of experiments the source-detection spacing Z_0 is kept constant and the neutron output can be either kept constant or be normalized to yield a constant A_0 , and a new constant K can be defined

$$\frac{1}{K} = k \frac{Z_0}{A_0} , \quad (45)$$

with which Eq. 44 takes the form:

$$K = \frac{1}{\rho_S} \int_0^{\infty} \left(\frac{1}{t} \right) C(t) dt \quad (46)$$

The integral $\int \left(\frac{1}{t} \right) C(t) dt$ can be obtained from PNA data. The constant K is determined by performing measurements with water filled pipes, where the density is known to be $\rho_S = \rho_0$. Once K is determined, Eq. 46 can be used for the measurement of the density for two-phase flow conditions.

2.4 Velocity By Total-Count Method

The total-count method for flow velocity measurement has been used frequently in the past ^(1,2,7,9). Its usefulness in measuring two-phase flow is discussed in this paragraph. The relation of A , the total induced activity, to the counts registered by the detector, was found to be (Eq. 40)

$$A = \frac{1}{\alpha} \int_0^{\infty} C(t) V(t) dt ,$$

where $\alpha = \beta \Delta Z = \text{a constant}$.

When an average velocity $\bar{V}$ is defined such that

$$A = \frac{1}{\alpha} \bar{V} \int_0^{\infty} C(t) dt , \quad (47)$$

then

$$A = \frac{1}{\alpha} \bar{V} C , \quad (48)$$

where

$$C = \int_0^{\infty} C(t) dt = \text{the total number of decay corrected counts.}$$

Combination of Eqs. 40 and 47 yields

$$\bar{V} = \frac{\int_0^{\infty} V(t) C(t) dt}{\int_0^{\infty} C(t) dt} \quad (49)$$

Since (Eq. 2)

$$V(t) = z_0 \left(\frac{1}{t} \right),$$

$$\bar{V} = z_0 \frac{\int_0^{\infty} \left(\frac{1}{t} \right) C(t) dt}{\int_0^{\infty} C(t) dt},$$

This is the equation (Eq. 29) previously used in a single-phase situations, where the transit-time was determined by the count-weighted average of the inverse of the time^(2,3,4,5).

Application of the PNA technique to these single-phase flow situations has shown that in these cases, where the count distributions were found to be skewed but not too different from normal distributions, the count weighted inverse averaging technique yielded results that were accurate to within a few percent. This means that the total count method as expressed in Eq. 48 can be expected to be just as accurate as our early liquid sodium flow tests, and average flow velocities can be determined by

$$\bar{V} = \alpha \frac{A}{C}, \quad (50)$$

where

- α = a constant reflecting the sensitivity and geometry of the detector,
- A = the total activity injected into the system, and
- C = the total number of decay-corrected counts.

For two-phase flow velocity measurements by the total count method, it

must be considered that the induced activity A is proportional to the density (Eq. 42),

$$A = \frac{\rho}{\rho_0} A_0 ,$$

where

ρ = average density of two-phase flow,

ρ_0 = density of water, and

A_0 = activity induced in water filled pipe.

Thus, Eq. 50 becomes for two-phase flow:

$$\bar{V} = \rho \frac{\alpha A_0}{\rho_0} \frac{1}{C} . \quad (51)$$

Introducing the same constant

$$K = \frac{\alpha A_0}{\rho_0 Z_0} \quad (52)$$

as in Paragraph 2.3, Eq. 51 becomes

$$\bar{V} = \rho Z_0 K \frac{1}{C} \quad (53)$$

or, with $\bar{V} = (1/\bar{t}) Z_0$,

$$\boxed{K = \frac{1}{\rho \bar{t}} \int_0^{\infty} C(t) dt} \quad (54)$$

where (See Eq. 31)

$$\frac{1}{\bar{t}} = \frac{\int \frac{1}{t} C(t) dt}{\int C(t) dt} .$$

Comparison of Eq. 54 with Eq. 46 reveals their relation and illustrates their differences. As mentioned above, the total count method, Eq. 54, should only be applied to situations where the count distributions are not too different from normal. Applied to two-phase flow problems, this means that the total

count method should only be used in calibration runs with water-filled pipes, as a double-check on the transit-time method.

3.0 AIR-WATER LOOP TESTS

In August - September 1977, LOFT two-phase instrumentation systems were calibrated in the air-water loop located at the Semiscale facility of the Idaho National Engineering Laboratory. Subsequent to this calibration, the LOFT instrumentation was shipped to Karlsruhe, Germany, for calibration in a steam-water loop. The test plan for the Karlsruhe tests called for a comparison of the LOFT instrumentation systems with German equipment, and for a calibration of the LOFT equipment by radioactive tracer techniques.

The air-water loop at the Semiscale facility has a water flow capability of up to 25 l/sec and an air flow capability of up to 100 l/sec. PNA tests were not originally planned for the LOFT instrument test series. Thus, the PNA geometry could not be optimized. Instead of one optimum spacing between the source and the detector, two spacings of about 1m and 5m were used. In two-phase tests, the air and water were separated (in a separation tank) after passage through the test section. While the water was recirculated, the air was vented to the atmosphere. New air was injected at the mixing nozzle at a pressure of about 5.5 b (80 psi). The pressure at the LOFT instrumentation spool piece was maintained at 4 b (58 psi). Only this pressure at the spool piece was recorded and maintained by the loop operator. The inlet pressure and the back pressure in the separation tank were not recorded.

A first series of tests was performed in 7.5 cm pipes, and a second series of tests in 12.5 cm pipes. Prior to two-phase testing, the LOFT instruments were calibrated by pumping water only (and no air) through the loop.

The individual runs of these test series were identified by four-digit numbers XYZZ, where the first digit identified the nature of a run (X = 3 for two-phase test and X = 4 for an all-water calibration run), the second digit indicated the pipe diameter (Y = 0 for 7.5 cm pipes and Y = 5 for 12.5 cm pipes), and the last two digits (ZZ) were running numbers of the two series. This numbering system is kept throughout the present report.

The loop operator measured the flows of water and air by turbine meters. These data are the only ones used for support of the PNA data. Other data taken in these LOFT test series (three-beam densitometer, scanning

densitometer, flow momentum and flow velocity) were not available at the time of the writing of this report.

PNA derived values for the densities and mass flow velocities of the individual runs, tabulated in the Tables 19 and 20, can be used for comparison with the "conventional" flow data gathered at INEL and in Karlsruhe as soon as the latter data become available.

3.1 Test Setup

The geometries of the two test series are illustrated in Figs. 3 and 4. In these tests, the NaI detectors were shielded by 15 cm of lead. The neutron source was shielded by 10 cm of lead and 15 cm of borated polyethylene.

A block diagram of the equipment is shown in Fig. 5. Table 1 identifies the more important pieces of equipment.

3.2 Data Reduction Technique

PNA data are evaluated in terms of the sums $\sum \frac{1}{t^2} C$, $\sum \frac{1}{t} C$ and $\sum C$, where the C's are counts at the time t, corrected for background and for decay. Decay corrections were done according to Eq. 1, and the background was assumed to be

$$B = BZ + BE e^{-BLAM t} \quad (55)$$

where

BZ = the constant background,

BE = the short-lived background induced by the pulsed neutron source in the environment of the detector and in the detector itself, and

BLAM = the decay constant of the induced background.

BZ, BE and BLAM were calculated from the count distributions accumulated by the multichannel analyzer. Prior to the evaluation of the test data, printer plots were generated for the uncorrected count distributions, and limits L1 and L2 of the distributions were selected visually (see Fig. 6). Then, BZ was assumed to be equal to the number of counts at the end of the record (around channel 256), and BE and BLAM were calculated from the numbers of counts

Fig. 3 Test Setup, 7.5 cm Test

Fig. 4 Test Setup, 12.5 cm Test

Fig. 5 Block Diagram of Equipment

TABLE 1
LIST OF PNA EQUIPMENT

S : Pulsed neutron source on loan from SANDIA.
3 x 10⁹ neutron/pulse.
Repetition rate: 1 pulse/minute

D1 : 12.5 cm dia. x 7.5 cm NaI detector

D2 : 7.5 cm dia. x 7.5 cm NaI detector

A : Common amplifier

STAB1: Canberra Model 1720 Stabilizer

STAB2: Harshaw Model NA-23 Stabilizer

MCA : ND100, Four Input Multiscaler

TAPE : Pertec Model 7 x 40 recorder

PRINT: Centronics Model 306 Printer

TRIG : ANL built trigger circuit

DCV : Common DVM

MON : He³ detector (ionization chamber mode) in 15 cm
of wax.

INT : ANL built current integrator

Fig. 6 Background Model

around the channels L1 and L2, i.e., N1 and N2, according to:

$$BLAM = \frac{1}{GAIN (L1-L2)} \ln \left(\frac{N2 - BZ}{N1 - BZ} \right), \text{ and} \quad (56)$$

$$BE = \frac{N1 - BZ}{\exp. (BLAM \cdot GAIN \cdot L1)} + BZ, \quad (57)$$

where

GAIN = the width of the channels L (Δt) .

L1, L2, BLAM, BZ, BE and GAIN are tabulated in Tables 2 and 3.

Net counts were obtained by subtracting the background from the gross counts N:

$$C = N - B \quad (58)$$

and were then corrected for decay according to Eq. 1, yielding background and decay corrected numbers of counts, C.

Other columns tabulated in Tables 2 and 3 are:

NEUT = The reading of the neutron monitor,

$$BKG = \sum_{L1}^{L2} B,$$

$$COUNTS = \sum_{L1}^{L2} N,$$

$$SUM Y/NEUT = \sum_{L1}^{L2} C/NEUT,$$

$$SUM (1/T) * Y/NEUT = \sum_{L1}^{L2} \left(\frac{1}{t} \right) C,$$

$$TINV = \frac{\sum_{L1}^{L2} \left(\frac{1}{t^2} \right) C}{\sum_{L1}^{L2} \left(\frac{1}{t} \right) C}$$

TABLE 2

COMPUTER PRINTOUT, 7.5 cm TEST

RUN	ARRAY	INVT	SUM (1/73)Y/NEUT	SUM Y/NEUT	COUNTS	HRG	BLAM	RZ	HE	NEUT	L1	L2	GAIN
4001	1	0.16719E-01	0.20586E-04	0.12672E-05	16635	1499	0.77391E-01	0.60000E-01	0.45000E-02	0.21770E-01	8	85	0.2500
4001	203	0.32600E-01	0.01826E-04	0.12622E-05	18435	414	0.40130E-02	0.40000E-01	0.86042E-01	0.21770E-01	80	175	0.2500
4002	1	0.20800E-01	0.29086E-04	0.10034E-05	4868	432	0.55545E-01	0.31333E-02	0.13635E-02	0.72700E-01	8	50	0.2500
4002	203	0.43698E-01	0.43581E-04	0.10456E-05	814	49	0.0	0.1475E-01	0.0	0.72700E-01	70	140	0.2500
4003	1	0.36978E-01	0.20398E-04	0.55522E-05	2368	572	0.97150E-01	0.46000E-01	0.3333E-02	0.14690E-01	8	55	0.1000
4003	203	0.75771E-01	0.41620E-04	0.55522E-05	2368	120	0.0	0.15625E-01	0.0	0.14690E-01	80	185	0.1000
4004	1	0.66774E-01	0.29735E-04	0.2495E-05	1064	179	0.67142E-01	0.12600E-01	0.5172E-01	0.36520E-01	13	50	0.0050
4004	203	0.17298E-01	0.44013E-05	0.25540E-05	950	67	0.0	0.11167E-01	0.0	0.36520E-01	40	155	0.0050
4005	1	0.20212E-01	0.21118E-04	0.10657E-05	21480	1815	0.71594E-01	0.41613E-02	0.28049E-02	0.5000E-01	145	250	0.0640
4005	203	0.41357E-01	0.40537E-05	0.10449E-05	3251	460	0.0	0.46125E-01	0.0	0.5000E-01	14	85	0.1300
4006	1	0.41357E-01	0.41633E-05	0.49655E-05	12085	1024	0.11101E-01	0.64333E-01	0.15150E-02	0.24490E-01	13	80	0.0640
4006	203	0.81355E-01	0.41333E-05	0.51073E-05	4714	272	0.0	0.20125E-01	0.0	0.24490E-01	145	250	0.0640
4007	1	0.40189E-01	0.21756E-04	0.24004E-05	5428	391	0.23400E-01	0.20000E-01	0.34159E-01	0.22040E-01	15	75	0.0340
4007	203	0.16035E-01	0.45372E-05	0.24743E-05	3527	95	0.0	0.63750E-01	0.0	0.22040E-01	140	250	0.0340
4008	1	0.77331E-01	0.21055E-04	0.27623E-05	2266	400	0.29425E-01	0.12600E-01	0.26051E-01	0.66640E-01	20	70	0.0034
4008	203	0.15272E-01	0.44331E-05	0.24733E-05	1417	103	0.0	0.14625E-01	0.0	0.66640E-01	145	250	0.0034
4009	1	0.39194E-01	0.26210E-04	0.54231E-05	3734	387	0.0	0.17600E-01	0.0	0.66640E-01	145	250	0.0034
4009	203	0.77776E-01	0.42594E-05	0.54942E-05	3060	201	0.0	0.21875E-01	0.0	0.66640E-01	17	75	0.0067
3001	1	0.20001E-01	0.17011E-04	0.41073E-05	4007	2631	0.64422E-01	0.20400E-02	0.10000E-03	0.22050E-01	40	135	0.0000
3001	203	0.35038E-01	0.0	0.41073E-05	6281	0	0.0	0.0	0.0	0.22050E-01	0	0	0.0000
3002	1	0.35038E-01	0.0	0.26634E-05	6281	2582	0.0	0.54635E-02	0.0	0.22050E-01	32	115	0.5000
3002	203	0.0	0.0	0.26634E-05	0	0	0.0	0.0	0.0	0.22050E-01	0	0	0.5000
3003	1	0.40398E-01	0.46233E-05	0.24204E-05	2477	676	0.7712E-01	0.72000E-01	0.29470E-02	0.74000E-01	22	85	0.5000
3003	203	0.0	0.0	0.24204E-05	0	0	0.0	0.0	0.0	0.74000E-01	0	0	0.5000
3020	1	0.40217E-01	0.30492E-04	0.45402E-05	11879	931	0.26190E-01	0.72607E-01	0.59447E-01	0.24240E-01	13	80	0.0500
3020	203	0.3697E-01	0.41323E-05	0.45402E-05	4936	363	0.0	0.57500E-01	0.0	0.24240E-01	145	250	0.0500
3022	1	0.10269E-01	0.60233E-05	0.11043E-05	5530	1131	0.40880E-01	0.12000E-02	0.98105E-01	0.45120E-01	10	85	0.0500
3022	203	0.17119E-01	0.41202E-05	0.45271E-05	2509	305	0.15452E-01	0.19000E-01	0.7342E-01	0.45120E-01	90	240	0.0500
3023	1	0.12037E-01	0.37407E-05	0.47697E-05	6437	1262	0.0	0.2500E-02	0.0	0.7342E-01	10	75	0.0250
3023	203	0.23933E-01	0.11092E-05	0.47697E-05	2702	395	0.0	0.26875E-01	0.0	0.7342E-01	10	75	0.0250
3024	1	0.14103E-01	0.54665E-05	0.33375E-05	2126	1336	0.35894E-01	0.22000E-02	0.52700E-01	0.11510E-02	8	75	0.0250
3024	203	0.32651E-01	0.66610E-05	0.33375E-05	2194	374	0.0	0.68750E-01	0.0	0.11510E-02	90	230	0.0200
3025	1	0.16115E-01	0.20357E-04	0.12414E-05	4628	308	0.0	0.50125E-01	0.0	0.35920E-01	15	75	0.0100
3025	203	0.33335E-01	0.29515E-05	0.16759E-05	2647	252	0.0	0.26125E-01	0.0	0.35920E-01	150	250	0.0100
3026	1	0.17049E-01	0.17721E-04	0.10665E-05	4764	429	0.0	0.76125E-01	0.0	0.42940E-01	12	75	0.0100
3026	203	0.34795E-01	0.25584E-05	0.12618E-05	2403	216	0.0	0.21250E-01	0.0	0.42940E-01	140	250	0.0100
3027	1	0.22290E-01	0.13860E-04	0.65194E-05	5047	981	0.29517E-01	0.12533E-02	0.38434E-01	0.65250E-01	15	85	0.0110
3027	203	0.45510E-01	0.22291E-05	0.49021E-05	5078	404	0.0	0.46075E-01	0.0	0.65250E-01	143	250	0.0110
3028	1	0.38659E-01	0.27935E-05	0.21433E-05	5841	1400	0.0	0.23125E-02	0.0	0.11521E-02	14	90	0.0000
3028	203	0.0	0.0	0.21433E-05	0	0	0.0	0.0	0.0	0.11521E-02	0	0	0.0000
3029	1	0.39832E-01	0.19989E-04	0.51602E-05	3402	482	0.2610E-01	0.72600E-01	0.35644E-01	0.54030E-01	12	70	0.0070
3029	203	0.74911E-01	0.13355E-05	0.55170E-05	3011	178	0.0	0.23125E-01	0.0	0.54030E-01	145	230	0.0070
3030	1	0.40910E-01	0.13492E-04	0.47856E-05	3148	499	0.11208E-01	0.69433E-01	0.23170E-01	0.50720E-01	15	70	0.0070
3030	203	0.81507E-01	0.39460E-05	0.47856E-05	2616	168	0.0	0.19375E-01	0.0	0.50720E-01	140	235	0.0070
3031	1	0.40652E-01	0.10903E-04	0.37500E-05	3266	611	0.85944E-01	0.12333E-02	0.44051E-01	0.72450E-01	15	70	0.0000
3031	203	0.94100E-01	0.35367E-05	0.37877E-05	2679	207	0.0	0.19125E-01	0.0	0.72450E-01	135	250	0.0000
3032	1	0.70666E-01	0.12467E-04	0.16440E-05	2468	845	0.43603E-01	0.13600E-02	0.64000E-01	0.84420E-01	17	75	0.0040
3032	203	0.14892E-01	0.25562E-05	0.16440E-05	7136	221	0.0	0.18125E-01	0.0	0.84420E-01	120	250	0.0040
3019	1	0.1056E-01	0.25562E-05	0.16440E-05	7136	359	0.26093E-01	0.3007E-02	0.24920E-02	0.1536E-02	10	75	0.0300
3019	203	0.20586E-01	0.3102E-05	0.16440E-05	2609	816	0.0	0.57500E-01	0.0	0.1536E-02	100	250	0.0300
3018	1	0.56033E-01	0.64193E-05	0.12775E-05	42310	7311	0.17510E-01	0.55667E-02	0.5717E-02	0.15424E-02	10	100	0.0550
3018	203	0.11103E-01	0.9619E-05	0.2142E-05	7887	2107	0.0	0.14125E-02	0.0	0.15424E-02	90	250	0.0550
3018	203	0.11103E-01	0.9619E-05	0.2142E-05	7887	3393	0.20384E-01	0.57467E-02	0.17720E-02	0.11584E-02	9	85	0.6400
3019	1	0.66643E-01	0.19403E-05	0.21367E-05	6084	587	0.0	0.70250E-01	0.0	0.11584E-02	105	250	0.0400
3019	203	0.12332E-01	0.17645E-05	0.14361E-05	1394	485	0.15594E-01	0.49000E-02	0.53712E-02	0.11707E-02	24	90	0.0700
3009	1	0.33490E-01	0.62760E-05	0.25230E-05	7077	485	0.15594E-01	0.49000E-02	0.53712E-02	0.11707E-02	24	90	0.0700
3009	203	0.77337E-01	0.62760E-05	0.25230E-05	1612	1281	0.0	0.1138E-02	0.0	0.11707E-02	120	240	0.0700
3005	1	0.11344E-01	0.34059E-05	0.32049E-05	17406	7793	0.14763E-01	0.44213E-02	0.46042E-02	0.74160E-01	32	185	0.1000
3005	203	0.0	0.0	0.32049E-05	0	0	0.0	0.0	0.0	0.74160E-01	0	0	0.1000

TABLE 3

COMPUTER PRINTOUT, 12.5 cm TEST

RUN	ARRAY	TINY	SUM (17/187)NEUT	SUM Y/NEUT	COUNTS	HKU	BLAN	BZ	BE	NEUT	L1	L2	GAIN								
4510	1	0.22993E	00	0.24450E	04	0.11033E	05	30321	2516	0.40065E-01	0.14400E	02	0.4129E	02	0.39290E	01	10	70	0.1300		
4511	203	0.55331E-01	0.4530E	03	0.8116E	04	6076	516	0.0	0.53175E	01	0.0	0.39290E	01	0.39290E	01	105	200	0.1300		
4512	1	0.52149E	00	0.24067E	04	0.44816E	04	14039	1153	0.20284E	00	0.13000E	02	0.1234E	02	0.34170E	01	8	70	0.0650	
4513	203	0.12409E	00	0.4135E	04	0.36104E	04	6007	558	0.0	0.43750E	01	0.0	0.34170E	01	0.34170E	01	90	180	0.0650	
4514	1	0.60815E	00	0.26218E	04	0.33191E	04	8045	579	0.11941E	00	0.59533E	01	0.57703E	01	0.26910E	01	10	80	0.0300	
4515	203	0.20909E	00	0.60261E	03	0.22195E	04	3987	222	0.0	0.25625E	01	0.0	0.26910E	01	0.26910E	01	120	215	0.0300	
4516	1	0.35008E	01	0.24800E	03	0.7257E	05	5470	806	0.64539E	00	0.91333E	01	0.5525E	01	0.85270E	01	11	80	0.0078	
4517	203	0.64254E	00	0.47604E	03	0.50451E	05	3510	208	0.94531E-01	0.71333E	00	0.15896E	01	0.65270E	01	110	215	0.0078		
4518	1	0.20195E	01	0.25625E	04	0.12196E	05	4214	388	0.57805E	00	0.4333E	01	0.34033E	01	0.36270E	01	14	75	0.0140	
4519	203	0.47512E	00	0.36625E	03	0.62681E	05	3167	87	0.0	0.10000E	01	0.0	0.36270E	01	0.36270E	01	115	210	0.0140	
4520	1	0.4951E	00	0.46074E	03	0.50422E	04	10049	1954	0.61274E-01	0.13000E	02	0.25702E	02	0.27000E	01	11	65	0.1300		
4521	203	0.54533E-01	0.4530E	03	0.27755E	04	1718	454	0.13150E	00	0.44000E	01	0.55454E	01	0.27000E	01	90	180	0.1300		
4522	1	0.33112E	00	0.69269E	03	0.25744E	04	12606	4159	0.1084E	00	0.19133E	02	0.5340E	02	0.49750E	01	4	100	0.1300	
4523	203	0.79970E-01	0.63320E	02	0.92755E	05	2242	994	0.40725E-01	0.60000E	01	0.18030E	01	0.45750E	01	0.45750E	01	35	195	0.1300	
4524	1	0.33780E	00	0.17000E	04	0.55356E	04	41288	6527	0.47504E-01	0.54533E	02	0.34025E	02	0.67740E	01	8	95	0.0600		
4525	203	0.77394E-01	0.27139E	03	0.35133E	04	4955	826	0.0	0.27350E	01	0.0	0.67740E	01	0.67740E	01	110	230	0.0600		
4526	1	0.11108E	01	0.32020E	03	0.36163E	05	3483	1946	0.30641E	00	0.22600E	02	0.15045E	02	0.73760E	01	4	70	0.0400	
4527	203	0.16790E	00	0.74119E	02	0.49000E	05	2450	608	0.0	0.56875E	01	0.0	0.73760E	01	0.73760E	01	95	210	0.0400	
4528	1	0.11808E	01	0.10119E	04	0.39104E	05	3490	537	0.0	0.13433E	02	0.0	0.36240E	01	7	55	0.0340			
4529	203	0.16295E	00	0.15029E	03	0.12140E	05	2553	227	0.0	0.21250E	01	0.0	0.36240E	01	0.36240E	01	135	250	0.0340	
4530	1	0.30942E	01	0.47311E	03	0.71605E	05	5362	670	0.0	0.46738E	00	0.91333E	01	0.46191E	01	0.43760E	01	7	70	0.0250
4531	203	0.22606E	00	0.21366E	03	0.93474E	05	5001	289	0.0	0.28734E	00	0.23750E	01	0.4534E	01	0.44020E	01	8	20	0.0200
4532	1	0.21210E	01	0.74854E	03	0.39244E	05	2327	680	0.0	0.28734E	00	0.70000E	01	0.4534E	01	0.44020E	01	8	20	0.0200
4533	203	0.30942E	01	0.47311E	03	0.16133E	05	1627	257	0.0	0.17500E	01	0.0	0.4534E	01	0.44020E	01	8	20	0.0200	
4534	1	0.30942E	01	0.47311E	03	0.16133E	05	1004	512	0.0	0.94000E	00	0.49000E	01	0.21441E	01	0.36900E	01	11	100	0.0370
4535	203	0.72637E	00	0.45463E	02	0.91607E	05	361	184	0.0	0.16125E	01	0.0	0.36900E	01	0.36900E	01	140	250	0.0370	
4536	1	0.32515E	01	0.15635E	02	0.42635E	05	3524	571	0.0	0.6276E	00	0.72000E	01	0.47343E	01	0.44360E	01	7	70	0.0170
4537	203	0.69725E	00	0.47092E	02	0.73321E	05	414	137	0.0	0.10000E	01	0.0	0.44360E	01	0.44360E	01	35	180	0.0170	
4538	1	0.37640E	01	0.12333E	04	0.34240E	05	2721	840	0.0	0.10000E	02	0.0	0.56390E	01	12	100	0.0070			
4539	203	0.75912E	00	0.26602E	03	0.37976E	05	2205	321	0.0	0.30000E	01	0.0	0.56390E	01	0.56390E	01	135	250	0.0070	
4540	1	0.39804E	01	0.11894E	04	0.28012E	05	2174	572	0.0	0.49065E	00	0.90667E	01	0.34052E	01	0.56600E	01	11	65	0.0080
4541	203	0.46183E	00	0.23221E	03	0.29370E	05	1669	212	0.0	0.24375E	01	0.0	0.56600E	01	0.56600E	01	115	210	0.0080	
4542	1	0.49331E	01	0.84021E	03	0.18120E	05	2002	753	0.0	0.15063E	02	0.0	0.56600E	01	0.56600E	01	115	210	0.0080	
4543	203	0.93317E	00	0.19013E	03	0.20695E	05	1598	287	0.0	0.25625E	01	0.0	0.70420E	01	0.70420E	01	12	70	0.0070	
4544	1	0.49747E	01	0.13417E	04	0.28700E	05	3218	1413	0.16788E	01	0.17667E	02	0.13504E	02	0.71390E	01	12	75	0.0073	
4545	203	0.3602E	00	0.23111E	03	0.31460E	05	3605	559	0.0	0.39375E	01	0.0	0.71390E	01	0.69420E	01	85	235	0.0073	
4546	1	0.36102E	01	0.26244E	04	0.70203E	05	3379	476	0.0	0.24080E	01	0.84000E	01	0.10021E	01	0.69420E	01	17	75	0.0080
4547	203	0.46397E	00	0.40184E	03	0.54533E	05	2392	133	0.37411E	00	0.12607E	01	0.18365E	00	0.46920E	01	110	215	0.0080	
4548	1	0.38000E	01	0.24809E	04	0.6715E	05	4261	732	0.0	0.11434E	02	0.0	0.53640E	01	0.53640E	01	18	90	0.0060	
4549	203	0.90109E	00	0.42129E	03	0.47040E	05	2535	680	0.0	0.26874E	01	0.0	0.53640E	01	0.53640E	01	145	250	0.0060	
4550	1	0.36015E	01	0.23022E	04	0.62662E	05	2535	254	0.0	0.26250E	01	0.0	0.53640E	01	0.53640E	01	145	250	0.0060	
4551	203	0.60994E	00	0.40653E	03	0.44980E	05	2435	1226	0.16790E	00	0.17000E	02	0.10220E	02	0.57710E	01	10	65	0.0340	
4552	1	0.11314E	00	0.12175E	04	0.11214E	05	7143	478	0.0	0.46873E	01	0.0	0.57710E	01	0.57710E	01	140	250	0.0340	
4553	203	0.15592E	00	0.13778E	03	0.12134E	05	4238	1419	0.35018E-01	0.21607E	02	0.26197E	01	0.79410E	01	8	65	0.0300		
4554	1	0.13408E	01	0.43499E	03	0.66533E	05	5296	404	0.0	0.31675E	01	0.0	0.79410E	01	0.79410E	01	105	240	0.0300	
4555	203	0.20209E	00	0.17725E	03	0.94003E	05	5237	936	0.0	0.6659E	00	0.9667E	01	0.40042E	01	0.60090E	01	11	100	0.0150
4556	1	0.22203E	01	0.63761E	03	0.31724E	05	2745	480	0.0	0.56250E	01	0.0	0.60090E	01	0.60090E	01	120	250	0.0150	
4557	203	0.36289E	00	0.14971E	03	0.32100E	05	2156	1170	0.0	0.17250E	02	0.0	0.74610E	01	11	60	0.0120			
4558	1	0.26608E	01	0.46845E	03	0.17531E	05	2438	427	0.0	0.25625E	01	0.0	0.74610E	01	0.74610E	01	75	250	0.0120	
4559	203	0.56296E	00	0.10656E	03	0.26224E	05	1685	1481	0.0	0.16163E	02	0.0	0.75110E	01	10	100	0.0090			
4560	1	0.47801E	01	0.25047E	03	0.60204E	05	1923	455	0.0	0.25000E	01	0.0	0.75110E	01	0.75110E	01	60	250	0.0090	
4561	203	0.63691E	00	0.57534E	02	0.74952E	05	947													

ARRAY 1 lists the data gathered by the detector at the short spacing. ARRAY 203 lists the sum of the data gathered by the two detectors (2 and 3) at the long spacing (see Figs. 3 and 4).

The raw data gathered by the multichannel analyzer (the counts N for the channel L) are listed in Appendix B. This Appendix also shows the background-corrected count distributions for all the runs tabulated in Tables 2 and 3.

The computer program used for the reduction of PNA data is listed in Appendix A.

3.3 Accuracy of the Test Data

The two basic equations used for the evaluation of the PNA data are the Eqs. 26 and 46. The validity of assumptions made in the derivation of these equations is discussed in Section 4. The uncertainty of the equation relating flow velocity and transit time (Eq. 28),

$$V_M = Z_0 \left(\overline{\frac{1}{t}} \right),$$

was studied in detail for our past sodium flow measurements^(3,4).

Due to the small diameter of the pipes in the present test, the errors in velocity due to the mixing of the flow and to the non-uniformity of distribution of activity over the diameter of the pipe can be neglected. The statistical error due to the number of background counts can also be assumed to be negligibly small for most of the present runs. Thus, the error equation derived for PNA measurements^(3,4) is reduced to

$$\left[\frac{\epsilon(V_M)}{V_M} \right]^2 = \left[\frac{\epsilon(Z)}{Z_0} \right]^2 + \left[\frac{\sigma(Z)}{Z_0} \right]^4 + \frac{1}{N} \left[\frac{\sigma(1/t)}{1/t} \right]^2, \quad (59)$$

where

$$\frac{\epsilon(V_M)}{V_M} = \text{The uncertainty of the PNA derived average mass flow velocity,}$$

$$\epsilon(Z) = \text{The uncertainty of the measurement of the source detector spacing } Z_0,$$

$\sigma (Z)$ = The standard deviation of the distribution of the transit distance between the source and the detector, due to the finite collimation angles of the source and the detectors,

N = The total number of counts, and

$\sigma (1/t)$ = The standard deviation in the distribution of the inverse of the transit times, (or velocities).

In the present tests, the distances between the source and the detectors was measured within $\epsilon (Z) = 0.5$ cm.

Since $\sigma (Z)$ is dependent on both the source and the detector collimation, and since the pipe diameters in these tests were small, a good estimate for $\sigma (Z)$ is given by the square root of the square of the source diameter ΔZ_S and the detector diameter ΔZ_D :

$$\sigma (Z) = \sqrt{(\Delta Z_D)^2 + (\Delta Z_S)^2} \quad . \quad (60)$$

N , the total number of counts, is tabulated in Tables 2 and 3. In Table 4, average values for N are listed for the various conditions.

In two-phase flow situations, the velocities of the individual mass elements are not distributed normally. Therefore, an estimate for $\sigma (1/t)$ was derived from the distribution plots of Appendix B.

Table 4 lists the individual contributions to the uncertainty in the PNA measurement of the velocity, and the calculated uncertainty. According to this Table, the major contributions to the uncertainty are the size of the source and of the detectors. The overall uncertainty is about 4% for the short source-detection spacings, and about .5% for the long source-detection spacings.

According to Eq. 46, the density ρ_S at the source location can be derived by

$$\rho_S = \frac{1}{K} \int_0^{\infty} \left(\frac{1}{t} \right) C(t) dt \quad , \quad (61)$$

Since the error due to the uncertainty of $\left(\frac{1}{t} \right)$ is less than the error of the

TABLE 4

UNCERTAINTY OF PNA DERIVED VELOCITIES

ASSUMPTION	ϵ^2	7.5 cm Test		12.5 cm Test	
		$Z_0 = 1.190$	$Z_0 = 5.994$	$Z_0 = 1.081$	$Z_0 = 4.578$
$\epsilon(Z) = .005 \text{ m}$	$\left(\frac{\epsilon(Z)}{Z_0}\right)^2$	1.6×10^{-5}	7.0×10^{-7}	1.9×10^{-5}	1.2×10^{-6}
$\Delta Z_S = .18 \text{ m}$	$\left(\frac{\Delta Z_S}{Z_0}\right)^2$	2.3×10^{-2}	9.0×10^{-4}	2.8×10^{-2}	1.5×10^{-2}
$\Delta Z_D = .13 \text{ m}$	$\left(\frac{\Delta Z_D}{Z_0}\right)^2$	1.2×10^{-2}		1.4×10^{-2}	3.1×10^{-4}
$\Delta Z_D = .08 \text{ m}$			1.8×10^{-4}		
$\left[\left(\frac{\Delta Z_S}{Z_0}\right)^2 + \left(\frac{\Delta Z_D}{Z_0}\right)^2\right]^2$	$\left(\frac{\sigma(Z)}{Z_0}\right)^4$	1.2×10^{-3}	1.2×10^{-6}	1.8×10^{-3}	3.3×10^{-6}
Runs 4001-4009	N	8300	2500		
Runs 4510-4514	N			13000	4600
Appendix B	$\frac{\epsilon(T)}{T}$	.382	.155	.378	.170
	$\frac{1}{N} \left(\frac{\epsilon(T)}{T}\right)^2$	1.8×10^{-5}	9.6×10^{-6}	1.1×10^{-5}	6.3×10^{-6}
$\left(\frac{\epsilon(V_M)}{V_M}\right)^2 = \sum \epsilon^2$		1.2×10^{-3}	1.2×10^{-5}	1.8×10^{-3}	1.1×10^{-5}
$\epsilon(V), \%$		4	.5	4	.5

velocity reading, most of the uncertainty of the density reading is due to the statistical fluctuations of the total number of counts, C, used in Eq. 61:

$$\left(\frac{\epsilon(\rho_S)}{\rho_S} \right)^2 = \left(\frac{\epsilon(K)}{K} \right)^2 + \left(\frac{\epsilon(C)}{C} \right)^2 \quad (62)$$

$$\text{Since } C = N - B, \quad (63)$$

where

N = number of gross counts and

B = number of background counts ,

$$(\epsilon(C))^2 = (\epsilon(N))^2 + (\epsilon(B))^2 = N + B, \text{ and} \quad (64)$$

$$\left(\frac{\epsilon(C)}{C} \right)^2 = \frac{N + B}{(N - B)^2}, \quad (65)$$

and the overall uncertainty of the density reading is

$$\left(\frac{\epsilon(\rho_S)}{\rho_S} \right)^2 = \left(\frac{\epsilon(K)}{K} \right)^2 + \frac{N + B}{(N - B)^2} \quad (66)$$

Values for N and B are listed in Tables 2 and 3 (N = COUNTS , B = BKG). The constant K was determined experimentally (see Section 3.6) with an accuracy of about 3.5%.

3.4 Calibration of Water Flowmeters

Besides the PNA data, the only other information available for this report were the water-and air-flow rates, as measured by the loop operator with turbine meters. For calibration runs with water filled pipes (Run Nos. 4YZZ), the flow velocities measured by the loop's turbine meters and by the PNA transit time method can be compared directly.

Since data from the short-spaced detectors are expected to be less accurate than those from the long-spaced detectors (because of the large dimensions of the source and the detector and of their short spacings, see Table 4), the turbine meter readings were first compared with the PNA data

derived with long-spaced detectors;

Table 5 and Fig. 7 show the superficial water flow velocities as derived from the loop flow data, the mass flow velocities as derived by the PNA transit time method, and the difference between these sets of data. With the exception of two runs (Run Nos. 4511 and 4001), the agreement is quite good. The reason for the deviation of these two runs from proportionality must be an error by the loop operator, since the data derived by the PNA transit time method and the data derived independently by the PNA total count method agree quite well (see Fig. 9) and are, therefore, probably correct. The deviation of the turbine meter readings from the PNA derived mass flow velocities are plotted versus the mass flow rate in Fig. 8. This Figure does not include the Runs 4511 and 4001 and shows that, for all other runs, the deviation of the turbine meter readings is different for the two turbines used in the loop. Slow flow rates in the loop (up to 4 l/sec) were measured by a small turbine. Averaging the deviations shown in Fig. 8 shows that the small turbine deviates by $(+ 1.4 \pm 0.7)\%$ from the PNA data.

A large turbine is used in the loop to measure flow rates over 4 l/sec. Averaging the deviations of Fig. 8 indicates that the large turbine deviates by $(+ 5.2 \pm 0.8)\%$ from the PNA data. The accuracy of PNA transit time data is expected to be better than 1% (see Table 4). Therefore, the measured deviation of the turbine meters is believed to be realistic, and all turbine meter measured water flow data were corrected by a factor 0.986 for the small turbine and a factor of 0.948 for the large turbine.

Table 4 shows that, due to the large diameter of the source (.18 m), the large diameter of the detector (.13 m) and the relatively short source-detector spacing (~ 1 m), the accuracy of the short spaced transit time data can not be expected to be high. The accuracy of the two-phase data can be improved by derivation of an effective spacing between the source and the detection from the all-water calibration runs. In Table 6, an effective source-detector spacing of 1.190 m is derived for the 7.5 cm test and an effective source-detector spacing of 1.081 m for the 12.5 cm test. These effective spacings are by 6.1% shorter than the actually measured spacing in the 7.5 cm test (1.27 m) and by 5.4% shorter than the actually measured spacing in the 12.5 cm test (1.14 m).

As shown in Table 7, the mass flow velocities $V_M(S)$ calculated with these effective spacings deviate from the mass flow velocities calculated from the

TABLE 5

COMPARISON OF TURBINE METER READINGS TO PNA TECHNIQUE

RUN#	GPM	ℓ/sec	V _{LS} (m/s)	V _M (m/s)	Δ(%)
4001	1.424	.090	.026	.196	-86.8
4002	13.62	.859	.246	.243	+1.2
4003	25.52	1.610	.461	.452	+2.0
4004	600.	37.853	10.842	10.368	+4.9
4005	13.68	.863	.246	.241	+2.1
4006	27.52	1.736	.497	.488	+1.8
4007	54.43	3.434	.984	.962	+2.3
4008	551.	34.762	9.807	9.127	+7.5
4009	275.	17.349	4.969	4.662	+6.6
4510	33.07	2.086	.250	.253	-1.2
4511	63.6	4.012	.482	.568	-14.4
4512	131.8	8.315	.998	.960	+4.0
4513	528.8	33.361	4.005	3.858	+3.8
4514	301.1	18.996	2.280	2.178	+4.7

Notes:

GPM : Flow velocity measured by loop operator

V_{LS} : Superficial liquid flow velocity, from GPM and pipe diameter

V_M : Mass flow velocity, (from Tables 11 and 13)

Δ(%) : $\frac{V_{LS} - V_M}{V_M} \times 100$

Fig. 7 Comparison of Turbine Meter Readings to PNA Data

Fig. 8 Deviation of Turbine Meter Readings from Mass Flow Velocities

TABLE 6

MASS FLOW VELOCITIES MEASURED BY SHORT-SPACED DETECTORS

RUN#	$V_{LS}^{(1)}$ (m/s)	$\left(\frac{1}{\tau}\right)^{(2)}$ (m/s)	Z_{eff} (m)
4001	.026	.16719	-
4002	.243	.20800	1.168
4003	.455	.38978	1.167
4004	10.278	8.6774	1.184
4005	.243	.20212	1.202
4006	.490	.41367	1.185
4007	.970	.80189	1.210
4008	9.297	7.7331	1.202
4009	4.711	3.9194	1.202
Average, Z_0			1.190
4510	.247	.22993	1.074
4511	.457	.52149	-
4512	.946	.86815	1.090
4513	3.797	3.5060	1.083
4514	2.161	2.0105	1.075
Average, Z_0			1.081

(1) From Tables 8 and 9

(2) From Tables 2 and 3

TABLE 7

MASS FLOW VELOCITIES BY PNA TRANSIT-TIME METHOD IN WATER-FILLED PIPES

RUN#	(1) $V_M(S)$	(2) $V_M(L)$	$\frac{V_M(S) - V_M(L)}{V_M(L)}$	(3) V_{LS}	$\frac{V_{LS} - V_M(L)}{V_M(L)}$
	(m/s)	(m/s)		(m/s)	
4001	.199	.196	1.5%	.026	-
4002	.248	.243	2.1	.243	.0%
4003	.464	.452	2.7	.455	.7
4004	10.326	10.368	-.3	10.278	-.9
4005	.241	.241	.0	.243	.8
4006	.492	.488	.8	.490	.4
4007	.954	.962	-.8	.970	.8
4008	9.202	9.154	.5	9.297	1.6
4009	4.664	4.662	.0	4.711	1.1
4510	.249	.253	-1.6	.247	-2.4
4511	.564	.568	-.7	.457	-
4512	.938	.960	-2.3	.946	-1.5
4513	3.790	3.857	-1.7	3.797	-1.6
4514	2.173	2.178	-.2	2.161	-.8
Average			.0		-.2

(1) From Tables 10 and 12

(2) From Tables 11 and 13

(3) From Tables 8 and 9

long spacing data, $V_M(L)$, by less than 2.7% in all measured cases, and by 0.0% in the average. The (corrected) flow velocities measured by the turbine meter, V_{LS} , deviate from the long-spacing PNA data by less than 2.4%. Average deviation is 0.2%.

3.5 Two-Phase Measurements by the Transit-Time Method

Mass flow velocities can be calculated from the transit time and the distance between the source and the detector. Transit times $\left(\frac{1}{t}\right)$, calculated according to Eq. 26 by computer and tabulated in Tables 2 and 3, are also listed in the Tables 10 to 13 next to their corresponding mass flow velocities V_M . Average densities (averaged over the length of the pipe) were calculated from the mass flow velocities V_M and the superficial mass flow velocities V_{MS} , according to Eq. 37. The superficial mass flow velocities V_{MS} were calculated from loop operator supplied superficial water-and air-flow velocities, according to Eq. 35. These superficial flow velocities are listed in Tables 8 and 9.

3.6 Two-Phase Measurements by the Total-Activity Method

The relation between local density (at the source location) and the sum of the count distribution weighted transit-times is given in Eq. 46. The proportionality constant K in this equation can be read directly from the column $SUM (1/t) * Y/NEUT$ of the Tables 2 and 3, for the water calibration runs that have a known density of $\rho = 1$.

Average values for K are derived in Table 14 for the four different test setups (two different pipe sizes and two different spacings). With K known, local densities were calculated for the individual test runs, as listed in the Tables 15 and 16. The accuracy of these local density values can be derived from the accuracy of K (listed in Table 14) and from the total number of counts, according to Eq. 66.

3.7 Measurements by the Total-Count Method

For activity distributions (at the PNA detector) that are not significantly different from normal distributions, there exists an inverse relation between the mass flow velocity and the total number of counts, as shown in Eq. 54. The proportionality constant K governing this relation is the same as the K derived for the calculation of the density from the total

TABLE 8
SUPERFICIAL FLOW VELOCITIES (in m/s)
7.5 cm TEST

RUN #	$V_{LS}^{(1)}$	$V_{LS}^{(2)}$	$V_{GS}^{(1)}$	V_{MS}
4001	.026	.026	0	.026
4002	.246	.243	0	.243
4003	.461	.455	0	.455
4004	10.800	10.238	0	10.238
4005	.246	.243	0	.243
4006	.497	.490	0	.490
4007	.984	.970	0	.970
4008	9.807	9.297	0	9.297
4009	4.969	4.711	0	4.711
3001	.0222	.0219	.10	.0220
3002	.0250	.0247	.25	.0250
3003	.0249	.0246	.50	.0252
3020	.4970	.490	.10	.490
3022	.4995	.493	1.00	.494
3023	.4995	.493	2.60	.496
3024	.4995	.493	4.66	.499
3025	2.004	1.900	.10	1.900
3026	2.004	1.900	.24	1.900
3027	2.004	1.900	1.00	1.901
3028	2.004	1.900	4.86	1.906
3029	4.987	4.728	.10	4.728
3030	4.987	4.728	.21	4.728
3031	4.987	4.728	1.02	4.729
3032	5.011	4.750	5.11	4.756
3019	.2523	.249	5.11	.255
3018	.2523	.249	1.03	.250
3016	.0970	.0956	4.99	.1016
3006	.0248	.0245	5.01	.0306
3005	.0248	.0245	2.60	.0276

(1) Loop Instrumentation Data

(2) Data corrected according to Paragraph 3.4

TABLE 9
SUPERFICIAL FLOW VELOCITIES (in m/s)

12.5 cm TEST

RUN#	$V_{LS}^{(1)}$	$V_{LS}^{(2)}$	$V_{GS}^{(1)}$	V_{MS}
4510	.250	.247	0	.247
4511	.482	.457	0	.457
4512	.998	.946	0	.946
4513	4.005	3.797	0	3.797
4514	2.280	2.161	0	2.161
3514	.100	.099	.284	.099
3515	.101	.100	1.052	.101
3517	.250	.247	.260	.247
3518	.250	.247	.943	.248
3520	.489	.464	.081	.464
3521	.496	.470	.267	.470
3522	.503	.477	.976	.478
3523	.509	.483	2.515	.486
3524	.496	.470	5.152	.476
3525	2.003	1.899	.083	1.899
3526	1.997	1.893	.239	1.893
3527	1.983	1.880	.967	1.881
3528	1.997	1.893	1.481	1.895
3529	3.972	3.765	.102	3.765
3530	3.993	3.785	.256	3.785
3531	3.966	3.760	.389	3.760
3533	.489	.465	.086	.465
3534	.489	.464	.251	.464
3535	.523	.496	1.017	.497
3536	.498	.472	2.432	.475
3537	.496	.470	4.195	.475

(1) Loop Instrumentation Data

(2) Data corrected according to paragraph 3.4

TABLE 10
AVERAGE DENSITY BY TRANSIT-TIME METHOD,
7.5 cm TEST, SHORT SPACING

RUN#	$V_{MS}^{(1)}$ (m/s)	$\frac{1}{t}^{(2)}$ (s ⁻¹)	$V_M^{(3)}$ (m/s)	$\rho_p^{(4)}$ (g/cm ³)
4001	.026	.16719	.199	-
4002	.243	.20800	.248	.982
4003	.455	.38978	.464	.981
4004	10.238	8.6774	10.326	.991
4005	.243	.20212	.241	1.010
4006	.490	.41367	.492	.995
4007	.970	.80189	.954	1.017
4008	9.297	7.7331	9.202	1.010
4009	4.711	3.9194	4.664	1.010
3001	.0220	.020001	.024	.924
3002	.0250	.035048	.042	.599
3003	.0252	.046388	.055	.457
3020	.490	.46217	.550	.891
3022	.494	1.0289	1.224	.403
3023	.496	1.2097	1.440	.345
3024	.499	1.8163	2.161	.231
3025	1.900	1.6415	1.953	.973
3026	1.900	1.7049	2.029	.936
3027	1.901	2.2260	2.649	.718
3028	1.906	3.8658	4.600	.414
3029	4.728	3.9842	4.741	.997
3030	4.728	4.0910	4.868	.971
3031	4.729	4.6652	5.552	.852
3032	4.756	7.0686	8.412	.565
3019	.255	1.0526	1.253	.204
3018	.250	.56003	.666	.375
3016	.1016	.66483	.791	.128
3006	.0306	.33890	.403	.076
3005	.0276	.11344	.135	.204

(1) From Table 8

(2) From Table 2, Array 1

(3) $V_M = 1.190 \times (1/t)$

(4) According to Eq. 37

TABLE 11
AVERAGE DENSITY BY TRANSIT-TIME METHOD,

7.5 cm TEST, LONG SPACING

RUN #	V_{MS} ⁽¹⁾ (m/s)	$\frac{1}{t}$ ⁽²⁾ (s ⁻¹)	V_M ⁽³⁾ (m/s)	ρ_p ⁽⁴⁾ (g/cm ³)
4001	.026	.032640	.196	-
4002	.243	.040468	.243	1.002
4003	.455	.075471	.452	1.006
4004	10.238	1.7298	10.368	.987
4005	.243	.040175	.241	1.009
4006	.490	.081355	.488	1.005
4007	.970	.16045	.962	1.009
4008	9.297	1.5272	9.154	1.016
4009	4.711	.77786	4.662	1.010
3001	.0220	-	-	-
3002	.0250	-	-	-
3003	.0252	-	-	-
3020	.490	.093967	.563	.870
3022	.494	.17119	1.026	.481
3023	.496	.23983	1.438	.345
3024	.499	.32651	1.957	.255
3025	1.900	.33385	2.001	.949
3026	1.900	.34795	2.086	.911
3027	1.901	.45162	2.707	.702
3028	1.906	-	-	-
3029	4.728	.78911	4.730	1.000
3030	4.728	.81567	4.889	.967
3031	4.729	.94108	5.641	.838
3032	4.756	1.4884	8.921	.533
3019	.255	.20589	1.234	.207
3018	.250	.11048	.662	.378
3016	.1016	.12332	.739	.137
3006	.0306	.071537	.429	.071
3005	.0276	-	-	-

(1) From Table 8

(2) From Table 2, Array 203

(3) $V_M = 5.994 \times (1/t)$

(4) According to Eq. 37

TABLE 12
AVRAGE DENSITY BY TRANSIT-TIME METHOD,

12.5 cm TES₁, SHORT SPACING

RUN 3	V_{MS} (1) (m/s)	$\frac{1}{t}$ (2) (s ⁻¹)	V_M (3) (m/s)	ρ_P (4) (g/cm ³)
4510	.247	.22993	.249	.994
4511	.457	.52149	.564	-
4512	.946	.86815	.938	1.008
4513	3.797	3.5060	3.790	1.002
4514	2.161	2.0105	2.173	.994
3514	.099	.19521	.211	.469
3515	.101	.33112	.358	.282
3517	.247	.33780	.365	.676
3518	.248	1.1108	1.201	.207
3520	.464	1.1848	1.281	.362
3521	.470	1.3922	1.505	.312
3522	.478	2.1216	2.293	.208
3523	.486	3.0942	3.345	.145
3524	.476	3.2515	3.515	.135
3525	1.899	3.7444	4.048	.469
3526	1.893	3.9804	4.303	.440
3527	1.881	4.9301	5.329	.353
3528	1.895	4.9747	5.378	.352
3529	3.765	3.6162	3.909	.963
3530	3.785	3.8080	4.116	.919
3531	3.760	3.8015	4.109	.915
3533	.465	1.1314	1.223	.380
3534	.464	1.3408	1.457	.318
3535	.497	2.2203	2.400	.207
3536	.475	2.8608	3.093	.154
3537	.475	4.7201	5.102	.093

(1) From Table 9

(2) From Table 3, Array 1

(3) $V_M = 1.081 \times (1/t)$

(4) According to Eq. 37

TABLE 13

AVERAGE DENSITY BY TRANSIT-TIME METHOD,

12.5 cm TEST, LONG SPACING

RUN#	$V_{MS}^{(1)}$ (m/s)	$\frac{1}{t}^{(2)}$ (s ⁻¹)	$V_M^{(3)}$ (m/s)	$\rho_p^{(4)}$ (g/cm ³)
4510	.247	.055331	.253	.975
4511	.457	.12409	.568	-
4512	.946	.20980	.960	.985
4513	3.797	.84254	3.857	.984
4514	2.161	.47572	2.178	.992
3514	.099	.054153	.248	.399
3515	.101	.079670	.365	.277
3517	.247	.077304	.354	.698
3518	.248	.16790	.769	.323
3520	.464	.16295	.746	.622
3521	.470	.22686	1.039	.453
3522	.478	.35802	1.639	.292
3523	.486	.72687	3.328	.146
3534	.476	.69725	3.192	.149
3525	1.899	.75912	3.475	.546
3526	1.893	.81613	3.736	.507
3527	1.881	.93317	4.272	.440
3528	1.895	.93662	4.288	.442
3529	3.765	.86397	3.955	.952
3530	3.785	.90149	4.172	.917
3531	3.760	.90994	4.166	.903
3533	.465	.15592	.714	.651
3534	.464	.20249	.927	.501
3535	.497	.36289	1.661	.299
3536	.475	.56246	2.257	.184
3537	.475	.83891	3.841	.124

(1) From Table 9

(2) From Table 3, Array 203

(3) $V_M = 4.578 \times (1/t)$

(4) According to Eq. 37

TABLE 14
THE CONSTANT K

RUN#	$Z_0 = 1.190 \text{ m}$	$Z_0 = 5.994 \text{ m}$
4001	2059	418.3
4002	2006	435.8
4003	2040	416.3
4004	2074	440.2
4005	2112	405.4
4006	1988	413.0
4007	2176	453.7
4008	2106	443.4
4009	2213	425.9
Average	$2086 \pm 74 \text{ } (\pm 3.6\%)$	$428.0 \pm 16.1 \text{ } (\pm 3.8\%)$
4510	2446	445.4
4511	2447	444.6
4512	2634	462.6
4513	2485	476.1
4514	2363	466.2
Average	$2475 \pm 99 \text{ } (\pm 4.0\%)$	$459.0 \pm 13.7 \text{ } (\pm 3.0\%)$

TABLE 15AVERAGE DENSITY BY TOTAL-ACTIVITY METHOD,7.5 cm TEST

RUN#	$Z_0 = 1.190$ $K = 2.086$		$Z_0 = 5.994$ $K = 428.0$	
	EC/t	ρ_D	EC/t	ρ_D
4001	2059	.99	418.2	.98
4002	2006	.96	435.8	1.02
4003	2040	.98	416.3	.97
4004	2074	.99	440.2	1.03
4005	2112	1.01	405.4	.95
4006	1988	.95	413.0	.96
4007	2176	1.04	453.7	1.06
4008	2106	1.01	443.4	1.03
4009	2213	1.06	425.9	1.00
3001	1701.1	.815	-	-
3002	912.0	.437	-	-
3003	802.3	.423	-	-
3020	2049.2	.982	410.2	.958
3022	882.4	.423	142.0	.332
3023	874.1	.419	110.8	.259
3024	538.6	.258	64.6	.151
3025	2035.7	.976	295.2	.690
3026	1772.4	.850	285.8	.668
3027	1386.6	.665	223.0	.521
3028	783.6	.376	-	-
3029	1998.9	.958	433.5	1.013
3030	1909.6	.915	394.6	.922
3031	1690.3	.810	353.9	.827
3032	1246.7	.598	265.7	.621
3019	272.4	.131	38.1	.089
3018	628.2	.301	98.6	.230
3016	164.0	.079	17.6	.041
3006	82.8	.040	7.67	.018
3005	344.6	.165	-	-

TABLE 16AVERAGE DENSITY BY TOTAL-ACTIVITY METHOD,12.5 cm TEST

RUN#	$Z_0 = 1.081$ $K = 2475$		$Z_0 = 4.578$ $K = 459$	
	$\Sigma C/t$	ρ_D	$\Sigma C/t$	ρ_D
4510	2446	.99	445.4	.97
4511	2447	.99	444.6	.97
4512	2634	1.06	462.6	1.01
4513	2485	1.00	476.1	1.04
4514	2363	.95	466.2	1.02
3514	926.8	.374	148.9	.324
3515	692.7	.280	69.3	.151
3517	1700.0	.687	271.4	.591
3518	320.2	.129	74.1	.161
3520	1011.5	.428	196.3	.409
3521	939.7	.388	213.7	.466
3522	748.5	.302	142.4	.310
3523	447.3	.181	65.9	.144
3524	130.4	.052	47.1	.103
3525	1233.5	.498	286.0	.623
3526	1108.8	.448	239.2	.521
3527	840.2	.339	190.1	.414
3528	1341.7	.542	293.1	.639
3529	2462.4	.995	461.8	1.006
3530	2488.9	1.006	421.3	.918
3531	2302.2	.930	406.5	.886
3533	1217.5	.492	187.8	.409
3534	839.5	.339	197.2	.430
3535	637.6	.258	115.0	.251
3536	466.5	.188	108.6	.237
3537	257.0	.104	57.5	.125

activity (Eq. 46),

Calibration runs with water filled pipes were found to have activity distributions close to normal (see Appendix B). Therefore, the total count method can be applied to these calibration runs. Using the K's derived in Table 14, and assuming a density of $\rho = 1$ for water filled pipes, the mass flow velocities V_{MC} is calculated by

$$V_{MC} = \frac{Z_o K}{C}, \quad (67)$$

and are listed in Table 17.

A comparison of these velocities derived by the total count method to the velocities derived by the transit time method, V_{MT} , is made in Table 18 and Fig. 9. These two sets of data, derived independently from the transit time and from the total number of counts, agree quite well. In particular, there is a good agreement of the data for the Runs 4001 and 4511, which leads to the conclusion that the PNA derived velocity data are accurate for these two runs. The difference between these PNA derived data and the velocity data recorded by the loop operator, shown in Fig. 7, must therefore be explained by an error in the reading of the loop instrumentation.

4.0 TEST RESULTS

As is common for new techniques, the application of PNA methods to the measurement of two-phase flow has solved some problems but has also revealed the existence of phenomena not previously considered. As anticipated, PNA techniques were found to be useful for the measurement of mass flow velocities and average densities. The major advantage of PNA techniques is that they are not intrusive and not dependent on flow regimes.

The capability of PNA methods to identify flow regimes has also been demonstrated. Figure 10 shows, for example, how more and more mass is being transferred from the liquid phase (moving at lower velocity) to the gas phase (moving at higher velocity), as the amount of air mixed with water is increased in a 7.5 cm pipe.

In Run 3020, the two-phase flow can be described as a homogeneous mixture (bubbly flow), flowing at a uniform velocity. As the amount of air is increased for Run 3021, a slight separation of the two-phase velocities becomes apparent. Run 3022 shows a very distinct slip of the two flow velocities.

TABLE 17

FLOW VELOCITY FROM TOTAL NUMBER OF COUNTS

RUN#	$C^{(1)}$ $V_{MC}^{(2)}$		$C^{(1)}$ $V_{MC}^{(2)}$	
	$Z_0 = 1.190$ $K = 2086$		$Z_0 = 5.994$ $K = 428.0$	
4001	12870	.193	12922	.199
4002	10034	.247	10856	.236
4003	5402	.460	5552	.462
4004	245	10.132	256	10.021
4005	10857	.229	10149	.253
4006	4964	.500	5107	.502
4007	2800	.887	2845	.902
4008	279	8.897	292	8.786
4009	582	4.265	550	4.664
	$Z_0 = 1.081$ $K = 2.475$		$Z_0 = 4.578$ $K = 462.4$	
4510	11033	.242	8119	.261
4511	4882	.548	3611	.586
4512	3119	.858	2200	.962
4513	726	3.685	569	3.720
4514	1215	2.202	987	2.145

(1) SUM Y/NEUT., from Tables 2 and 3

(2) From Eq. 53, for $\rho = 1.0$

TABLE 18

COMPARISON OF TOTAL-COUNT VELOCITIES V_{MC}
 TO TRANSIT-TIME VELOCITIES V_{MT}

RUN #	$V_{MT}^{(1)}$	$V_{MC}^{(2)}$	$\Delta, \%$
4001	.198	.196	- 1.0
4002	.246	.242	- 1.6
4003	.458	.461	.7
4004	10.347	10.077	- 2.6
4005	.241	.241	.0
4006	.490	.501	2.2
4007	.958	.894	- 6.7
4008	9.178	8.842	- 3.7
4009	4.663	4.465	- 4.2
4510	.251	.252	.4
4511	.566	.567	.2
4512	.949	.910	- 4.1
4513	3.824	3.703	- 3.2
4514	2.176	2.173	- .1

AVERAGE DIFFERENCE

- 1.7

(1) Average values from Tables 10 to 13

(2) Average value from Table 17

Fig. 9 Comparison of Total-Count Velocities, V_{MC} , to Transit-Time Velocities, V_{MT}

Fig. 10 Slip of Phase Velocities

The flow regime of this run is probably slug flow with strong interaction of the liquid and the gas phase, and with a large number of water droplets entrained in the gas phase that moves at about three times the velocity of the liquid at the bottom of the pipe. In Run 3024, the flow is again homogenized, and the whole water mass is flowing as mist at a single velocity.

It should be very interesting to study such changes in flow regime in detail, by correlating PNA measured flow distributions with visual observations through transparent pipe sections. Neutron sources with higher output than the 3×10^9 neutrons/pulse available for the present tests should be used, and stronger collimation of the detector should be chosen to enhance the resolution of the measured flow profiles.

Figure 10 is redrawn from data listed in Appendix B. It is interesting to note that Run 3022 did not show phase separation at the long source-detector spacing (5.99 m). This change in flow regimes could be due to the homogenizing effect of the LOFT instrumentation package (see Fig. 3 for geometry), to a change in pressure along the test section, or to both. The implications of changing flow regimes on the PNA technique are discussed in Paragraph 4.2. The limitations of the PNA technique, using presently available equipment, are also discussed in that Paragraph, as well as in Paragraph 4.1.

4.1 Water Flow Measurements

Individual measurements of the flow velocity of water by the PNA transit time method, in pipes 7.5 cm and 12.5 cm in diameter, were found to be accurate to about 2%. Averaging of the velocity measurements performed at different flow velocities reduced this uncertainty to under 1%. Measurements performed on all water calibration runs were sufficiently accurate to calibrate the turbine meters used by the loop operator to measure water flow rates through the test section. The PNA data revealed that the small turbine, used to measure water flow rates up to 4 l/sec through the loop located at the Semiscale facility, reads $1.4\% \pm 0.7\%$ too high. The large turbine meter, used to read higher flowrates, reads $5.2\% \pm 0.8\%$ too high. Mass flow velocity readings taken with the total count method were compared to the readings taken with the transit-time method. The total count method is less accurate than the transit-time method. Its major merit lies in verifications of the transit-

time method in cases where there is a large disagreement between PNA data and velocity data taken by conventional instruments.

The average deviation of total count derived velocity data from transit-time derived data was found to be less than 4%, except in Run 4007 where the difference was 6.7%.

4.2 Two-Phase Flow Measurements

When the present test series was planned, little thought was given to the effects of changes of flow regime over the length of the test section. It was also assumed that, for the writing of this report, density and velocity data taken by the LOFT instrumentation being tested would be available, and that an assessment of the PNA technique, as well as a description of the flow conditions could be based on the LOFT instrumentation data. Unfortunately, to meet program schedules, this report had to be written prior to the availability of the LOFT instrument data (turbine, drag disk, three-beam densitometer). Thus, the only check on the accuracy and validity of the PNA data must be based on comparison of data derived independently by the transit-time method and the total-activity methods of the PNA technique.

The transit-time method measures the mass flow velocity V_P , averaged over the length of pipe between the source and the detector. The average density ρ_P can then be derived from

$$V_{MS} \rho_O = V_P \rho_P \quad , \quad (68)$$

where

$$\begin{aligned} V_{MS} &= \text{the superficial mass flow velocity, and} \\ \rho_O &= 1 \text{ g/cm}^3 = \text{density of water.} \end{aligned}$$

The subscript P in Eq. 68 stands for "averaged over length of Pipe". The total activity method measures ρ_D , the average density at the location of the detector, as shown in Section 5. The local mass flow velocity V_D can then be derived from

$$V_{MS} \rho_O = V_D \rho_P \quad . \quad (69)$$

The subscript D in this equation stands for "averaged over the pipe cross section at the location of the Detector".

In compressible flow, or in two-phase flow with constant average density and uniform flow regime over the length of the test section, the two mass flow velocities derived by these two independent methods should be identical ($V_P = V_D$), as should the two densities ($\rho_P = \rho_D$). This was not found to be the case in the present test series.

The Figs. 11 to 14 are plots of ρ_D , the total-activity derived local densities, versus ρ_P , the transit-time derived pipe-averaged densities, for the two pipe sizes and the two source-detector spacings used in the present test series. These Figures indicate that the agreement between ρ_P and ρ_D is quite good for the short source detector spacings, but that a significant difference can be found at the long spacing. No explanation for the difference in local and average densities, at the long spacings, can be given at the present time. Several explanations are possible, however:

First of all, a change of densities over the length of the test section can be caused by a changing flow regime. In stratified flow, for example, the void fraction could easily change over a length of pipe of 6 m, even if the flow regime would be unchanged.

A second reason for density changes along the test section is found in pressure changes that are likely to exist in the Semiscale water loop. As mentioned in Section 3, air is injected into the mixing nozzle at a pressure of about 5.5 b. The loop terminates in a separation tank which is vented to the atmosphere. Although the pressure was maintained at about 4 b at the location of the LOFT instrument spool, the pressure gradient along the whole test section is not known. Also, the pressure drop across the LOFT instrument spool is not known.

Much time was spent in reviewing the experimental and analytical methods used for the present test series, to assess the possibility that the density difference shown in the Figs. 11 to 14 are not caused by flow conditions in the test section, but are due to incorrect PNA data gathering and/or data reduction methods. No experimental or analytical explanations were found, however, for the apparent density gradient. Among the error sources considered were the reading of the neutron monitor, and the possibility of loss of counts at the leading edge or at the trailing edge of the count distributions shown in Appendix B.

Fig. 11 Comparison of Local Density ρ_D to Average Density ρ_P

Fig. 12 Comparison of Local Density ρ_D to Average Density ρ_P

Fig. 13 Comparison of Local Density ρ_D to Average Density ρ_P

Fig. 14 Comparison of Local Density ρ_D to Average Density ρ_P

The neutron monitor, a He^3 detector surrounded by 15 cm of paraffin and operated as an ionization chamber, was sensitive to thermal neutrons. It was positioned about 1.5 m from the front of the neutron source. The test section was located between the source and the monitor, close to the source (see Fig. 5). The neutron source was surrounded on all sides (with the exception of the side facing the pipe) by 10 cm of lead and by 15 cm of borated polyethylene. 10 cm of polyethylene were placed between the source and the neutron monitor. It was assumed that this bulk of material surrounding the source would uniformly slow down and scatter the neutrons emitted by the source, independent of the void fraction of the flow in the pipe. Should there have been an effect of the void fraction in the pipe on the reading of the neutron monitor, then the neutron monitor would have read higher for higher void fractions, the normalized total number of counts would appear lower at higher void fractions, and a lower density could indeed have been indicated by the total activity method. If this had been the case, then the local densities read by the short spaced detector and by the long spaced detector should have been reduced by the same factor. However, according to the Figs. 11 to 14, the total activity derived densities are much lower at the long spacings than at the short spacings for both the 7.5 cm and the 12.5 cm tests. In addition, if the indicated density gradients were due to incorrect readings of the neutron monitor, then the error should be larger for the larger pipe (12.5 cm) than for the smaller pipe (7.5 cm). Figs. 11 to 14 show, however, that the opposite is true. Therefore, sensitivity of the neutron monitor to varying void fractions in the test section can be eliminated as cause for the apparent density gradient along the test section.

Exclusion of some fractions of activity from integration according to Eq. 46 could also lead to indicated densities that are lower than the true densities at the detector locations. Such exclusion of activities could be caused, for example, by improper selection of the summation limits L1 and L2 (see Tables 2 and 3). In the present tests, the PNA equipment had to be placed at available locations on the test section. Optimization of source-detector spacings was not possible. Therefore, instead of one optimum spacing, two alternate spacings were used for each test. In the 7.5 cm test, the ratio of the spacings was $5.99/1.99 = 5.0$, and in the 12.5 cm test the ratio of the spacings was $4.58/1.08 = 4.2$. These large ratios (especially the ratio of 5 for the 7.5 cm test) made it somewhat difficult to position

the two count distributions within the 256 channels of the analyzer memory. In many runs of the 7.5 cm test series the trailing edge of the count distributions of the long-spaced detectors was set (visually) quite close to channel 256, the end of the record (see Table 2, Array 203, L2). It is conceivable that in these cases some counts were not recorded by the analyzer and were lost for integration and evaluation.

In the second test series, with the 12.5 cm pipe, not only was the ratio of spacings smaller, but also a deliberate effort was made to place the whole count distribution from the long-spaced detector well within the recorded 256 channels. Doing this, the leading edge of the short-spaced distribution was pushed to rather low channel numbers (see Table 3, Array 1, L1), which could have conceivably resulted in the loss of some counts due to the particular background model used for the background correction of the gross counts, prior to integration (see Fig. 6).

Omission of counts from our data reduction routine does not only affect the total-activity derived densities, but also the transit-time derived velocities. Losses of counts at the trailing edge of the long-spacing distributions and/or losses of counts at the leading edge of the short-spacing distributions should cause an apparent increase of the mass flow velocities at the long spacing and/or an apparent decrease of the mass flow velocity at the short spacing. The ratio of the transit-time velocities measured at the short spacing to the transit-time velocities measured at the long spacing should be less than one. A comparison of the data in the Tables 10 to 14 shows, however, that the opposite is true. Therefore, incorrect selection of the summation boundaries, L1 and L2, can be excluded as a reason for the density gradient indicated in the Figs. 11 to 14.

It is conceivable that some counts could be lost to the data reduction routine employed for this test because of the flow characteristics of certain flow regimes. In annular flow, for example, where most of the mass is entrained in the gas phase, a thin water film could be moving along the wall of the pipe at extremely low velocities, and the short-lived activity ($T_{1/2} = 7$ sec) induced in the film due to neutron activation could have decayed by the time the activated region reached the detectors. This possibility still has to be studied analytically, but it is believed that whenever the water film is so thin as to adhere so tightly to the wall of the pipe, it will not carry a significant fraction of the total mass, and the

mass flow in this film, particularly when the film moves at extremely low velocities, is negligible when compared to the total mass flowing through the pipe. Furthermore, only the runs with the very lowest densities can be expected to have flow regimes that lie somewhere between wavy flow and dispersed annular flow. The intermediate density runs shown in the Figs. 11 to 14 can be best described as elongated-bubble or slug flows. Even if loss of counts due to the slow motion of the film of dispersed annular flow would explain some of the low local densities shown in the Figs. 11 to 14, an explanation for the apparent loss of density at the intermediate density ranges still would have to be found.

Whatever is the reason for the drop of the local densities at the long spacings (be it a drop of pressure or a loss of counts), data gathered by the long-spaced detectors should not be used for comparison with data obtained by the LOFT instrumentation. Only the data gathered by the short-spaced detectors should be used for this purpose. The Figs. 11 and 12 show that the two independent sets of data, evaluated by the transit-time method and the total activity method, are in reasonably good agreement for the short-spaced detectors. Therefore, they are quite likely to be accurate.

The Tables 19 and 20 list V_P , the average velocity derived by the transit-time method and ρ_D , the local density derived by the total activity method, from test data gathered by the short-spaced detectors. Since these two sets of data were derived independently from each other, the product of V_P and ρ_D is only approximately equal to the superficial mass flow velocity V_{MS} , as derived in the Tables 8 and 9:

$$V_{MS} \rho_0 \approx V_P \rho_D \quad (70)$$

where

$$\rho_0 = 1 \text{ g/cm}^3 = \text{density of water.}$$

If desired for comparison with the flow data measured by the LOFT instrumentation, the local velocity V_D and the pipe averaged density ρ_D can be obtained by Eqs. 68 and 69.

The uncertainty of the velocities listed in the Tables 19 and 20 is, according to Paragraph 3.3, a few percent. The uncertainty of the local density values, ρ_D , can be estimated from the spread of the data in the

TABLE 19
MASS FLOW VELOCITIES AND AVERAGE DENSITIES,

7.5 cm-TEST

RUN #	$V_{LS}^{(1)}$ (m/s)	$V_{GS}^{(2)}$ (m/s)	$V_{MS}^{(1)}$ (m/s)	$V_P^{(2)}$ (m/s)	$\rho_D^{(3)}$ (g/cm ³)
4001	.026	0	.026	.199	.99
4002	.243	0	.243	.248	.96
4003	.455	0	.455	.464	.98
4004	10.238	0	10.238	10.33	.99
4005	.243	0	.243	.241	1.01
4006	.490	0	.490	.492	.95
4007	.970	0	.970	.954	1.04
4008	9.297	0	9.297	9.20	1.01
4009	4.711	0	4.711	4.66	1.06
3001	.0219	.10	.0220	.024	.82
3002	.0247	.25	.0250	.042	.44
3003	.0246	.50	.0252	.055	.42
3020	.490	.10	.490	.550	.98
3022	.493	1.00	.494	1.22	.42
3023	.493	2.60	.496	1.44	.42
3024	.493	4.66	.499	2.16	.26
3025	1.900	.10	1.900	1.95	.98
3026	1.900	.24	1.900	2.03	.85
3027	1.900	1.00	1.901	2.65	.66
3028	1.900	4.86	1.906	4.60	.38
3029	4.728	.10	4.728	4.74	.96
3030	4.728	.21	4.728	4.87	.92
3031	4.728	1.02	4.729	5.55	.81
3032	4.750	5.11	4.756	8.41	.60
3019	.249	5.11	.255	1.25	.13
3018	.249	1.03	.250	.666	.30
3016	.0956	4.99	.1016	.791	.08
3006	.0245	5.01	.0306	.403	.04
3005	.0245	2.60	.0276	.135	.16

(1) From Table 8

(2) From Table 10

(3) From Table 15 ($Z_0 = 1.190$)

TABLE 20MASS FLOW VELOCITIES AND AVERAGE DENSITIES,12.5 cm TEST

RUN #	$V_{LS}^{(1)}$ (m/s)	$V_{GS}^{(1)}$ (m/s)	$V_{MS}^{(1)}$ (m/s)	$V_P^{(2)}$ (m/s)	$\rho_D^{(3)}$ (g/cm ³)
4510	.247	0	.247	.249	.99
4511	.457	0	.457	.564	.99
4512	.946	0	.946	.938	1.06
4513	3.797	0	3.797	3.79	1.00
4514	2.161	0	2.161	2.17	.95
3514	.099	.284	.099	.211	.37
3515	.100	1.052	.101	.358	.28
3517	.247	.260	.247	.365	.69
3518	.247	.943	.248	1.20	.13
3520	.464	.081	.464	1.28	.43
3521	.470	.267	.470	1.50	.39
3522	.477	.975	.478	2.29	.30
3523	.483	2.515	.486	3.34	.18
3524	.470	5.152	.476	3.52	.05
3525	1.899	.083	1.899	4.05	.50
3526	1.893	.239	1.893	4.30	.45
3527	1.880	.967	1.881	5.33	.34
3528	1.893	1.481	1.895	5.38	.54
3529	3.765	.102	3.765	3.91	1.00
3530	3.785	.256	3.785	4.12	1.01
3531	3.760	.389	3.760	4.11	.93
3533	.465	.086	.465	1.22	.49
3534	.464	.251	.464	1.46	.34
3535	.496	1.017	.497	2.40	.26
3536	.472	2.432	.475	3.09	.19
3537	.470	4.195	.475	5.12	.10

(1) From Table 9

(2) From Table 12

(3) From Table 16 ($z_0 = 1.081$)

Figs. 11 and 12: For the 7.5 cm test series, the uncertainty is about 0.04 g/cm^3 , and for the 12.5 cm test series the uncertainty is about 0.06 g/cm^3 . These uncertainties are comparable to the uncertainties of three-beam densitometers⁽⁸⁾.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Feasibility of the PNA technique for the measurement of average mass flow velocities and average densities of two-phase flows was demonstrated by tests at an air-water loop with 7.5 cm and 12.5 cm pipes. The PNA measurements were made without interference with the major tests being run at the loop, and without penetration into the pipe.

Basic equations for the derivation of mass flow velocity and average density were derived. The limitations of the PNA technique with presently available equipment were established, and recommendations for improvement of future tests are made as follows:

Basic Equations

The two basic equations applicable to two-phase flow measurements are the transit-time equation (Eq. 18)

$$V_M = Z_0 \frac{\int \frac{1}{t^2} C(t) dt}{\int \frac{1}{t} C(t) dt}$$

and the total-activity equation (Eq. 46)

$$K = \frac{1}{\rho_S} \int \frac{1}{t} C(t) dt .$$

These equations were derived from the definition of the average velocity (Eq. 16),

$$V_M = \frac{\int V^2 C(t) dt}{\int V C(t) dt}$$

and from the conservation of activity (Eq. 40):

$$A = \frac{1}{\alpha} \int V C(t) dt ,$$

In the derivation of these equations it was assumed that the mass flow velocity V_M and the density ρ_S does not change over the source-detector distance. Under these assumptions, V_M in Eq. 16 is the average mass flow velocity, averaged over the whole length of pipe between the source and the detector ($V_M = V_P$), and ρ_S in Eq. 46 is the local density (averaged over the pipe cross section) at the source.

In situations where there is a change in mass flow velocity and/or density between the source and the detector locations, due to developing flow, the two basic equations have to be interpreted as describing

$$V_M = \frac{\int V_P V_D C(t) dt}{\int V_D C(t) dt} \quad \text{and} \quad (71)$$

$$K = \frac{\rho_D}{(\rho_S)^2} \int \frac{1}{t} C(t) dt, \quad (72)$$

where

- V_P = average mass flow velocity, averaged over the length of the test section,
- V_D = local mass flow velocity, at the detector location,
- ρ_S = local average density, at the source location, and
- ρ_D = local average density, at the detector location.

All two-phase PNA tests, particularly tests with steam-water phases (with phase change) must be designed to allow meaningful interpretation of test data in terms of the Eqs. 71 and 72.

Basic Experimental Studies

Controlled experiments should be performed to measure the density gradient along a test section, between the source and the detector. The average density at the detector location can be measured by multiple beam densitometers. The feasibility of determining the average density at the source, by measuring the attenuation of fast neutrons (from the source) in the flowing medium, should be studied.

Basic Analytic Studies

Two possible error sources still must be assessed analytically (or experimentally): First, the diffusion of radioactive N^{16} atoms from the liquid phase into the gas phase must be investigated. Secondly, the error in total mass flow due to the exclusion from measurement of the thin, slowly flowing water film of certain annular flow regimes must be assessed. It is not believed that the accuracy in total mass flow measurements is affected significantly by these two phenomena.

Range of Density Measurements

With the present neutron source, and using one detector, densities down to 0.08 g/cm^3 were measured with an accuracy of $\pm 0.04 \text{ g/cm}^3$. At these low densities, it was necessary to pulse the neutron source about a dozen times while flow conditions were kept constant. Overall time needed for velocity and density measurements at such low average densities is about 15 min. Development of a neutron source with higher output (than the presently available 3×10^9 neutrons/pulse) and with a higher repetition rate (than the presently available 1 pulse/min) will improve the accuracy and speed of low density measurements.

Development of a neutron source having an output of 10^{10} neutrons/pulse is feasible. Even if such sources should not become available in the immediate future, an increase in the neutron fluence could be obtained by increasing the number of sources with yields of 3×10^9 neutrons per pulse. For example, if three simultaneously triggered sources were clustered at the same axial location of a pipe, the measureable density range could be extended by a factor of 3. Another extension of the measureable range could be achieved by using a larger number of detectors and/or larger detectors. For example, if four 12.5 cm diameter detectors were used at the short spacing instead of the single detector in the present test, the measureable range of densities could be increased by another factor of 4. Thus, it should be possible to measure densities down to $0.08/12 = 0.007 \text{ g/cm}^3$ with presently available equipment.

In pipes larger than 12.5 cm, even more than four detectors could be used or, to simplify the problem of summing of counts, a ring-type detector could be designed that completely encircles the pipe. Such a ring detector could be built by using liquid scintillating material and two or more photomultipliers.

Neutron Monitor

A neutron monitor certain not to be affected by variation in void fraction should be used in future tests.

Data Gathering

In future tests, data from multiple detector locations should not be stored in multi-input multiscalers controlled by only one clock. Instead, a separate clock should be used for each detector spacing, and the peak of the count distributions should be placed around channel 80 of a 256 channel memory segment. Not all commercially available multichannel analyzers have the capability of separate timing of the separate inputs to separate multiscaler memory segments.

ACKNOWLEDGEMENTS

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APPENDIX A

LISTING OF COMPUTER PROGRAM

This Appendix lists the computer program used for the reduction of test data and for the generation of the Tables 2 and 3 as well as for the background - corrected distribution plots of Appendix B.

LEVEL 21.7 (JAN 73)

UN/360 FURTHER M

DATE 76.008/16.56.16

COMPILER OPTIONS -

NAMES MAIN,UP100,LINECNT=57,SIZE=000K,

SOURCE,EXCDTC,NUL1ST,NHECR,LOAD,MAP,NODEIT,ID,NUMHEF

C*****

C** THIS PROGRAM IS WRITTEN TO READ RAW DATA TAPES PRODUCED BY THE

C** NO 100 PLUS-IN MAGNETIC TAPE SYSTEM (REF. P. KENLER)

C** THE TAPE IS ASSUMED TO CONSIST OF SEVERAL FILES EACH FILE BEING

C** TERMINATED WITH A SINGLE END OF FILE MARK. EACH FILE IS ASSUMED

C** TO CONSIST OF SEVERAL RECORDS EACH HAVING A LENGTH OF

C** LESS THAN 400 BYTES. WITH 1 WORD = 3 BYTES, THE FIRST 256 WORDS

C** OF THE RECORD ARE CONSIDERED VALID.

C** THE FIRST RECORD IS ASSUMED TO HAVE A TAGWORD IN THE THIRD

C** WORD (CONTRARY TO THE DOCUMENTATION FOR THE SYSTEM WHICH SAYS THE TAG WORD

C** IS THE SECOND WORD). THE EIGHTH OF THE TAG WORD IS HEXADECIMAL.

C** EACH SUBSEQUENT RECORD IS ASSUMED TO BE A SINGLE SPECTRUM

C** OF 256 CHANNELS, EACH CHANNEL TAKING ONE WORD.

C** THE HIGH ORDER BYTE OF EACH DATA POINT IS DISCARDED DUE TO ERRORS

C** ON THE TAPE.

C*****

C** LOGICAL*1 INP(000),IUT(1020),ITAG(4)

C** INTEGER*4 IDAT1(256),IDAT2(256),IDAT3(256),IDAT23(256)

C** INTEGER*4 ITAG

C** EQUIVALENCE (IUT(1),IDAT1(1)),(ITAG(1),ITAG)

C** COMMON/COMMON/ITAG,NCITS,GAIN,INDWG

C** COMMON/LITS,IA(6),XRENT,IRUN

C** COMMON/MUNG,ATILE(12)

C** INDWG=0

C** 110 READ(5,900,END=800)NSKIP,NFILE

C** 900 FORMAT(214)

C** INDWG=0

C** IF(NSKIP.NE.0)GO TO 115

C** IF(NFILE.NE.0)GO TO 115

C** INDWG=1

C** GO TO 300

C** 115 CONTINUE

C** NREC=0

C** 200 IF(NEOF.EQ.NSKIP)GO TO 300

C** 205 CALL BUFIN(JMP)

C** CALL CRKIN(ITC,NBYTES)

C** NREC=NREC+1

C** IF(ITCC)210,205,230

C** 210 NEUF=NEUF+1

C** NREC=0

C** GO TO 200

C** 230 WRITE(6,901)NREC,NREC

C** 901 FORMAT(7H NEUF =,15,7H NREC =,15,13H PARITY ERROR)

C** GO TO 205

C** 300 CONTINUE

C** IF(NFILE.LE.0)NFILE=1

C** IF(INDWG.EQ.1)NFILE=1000

C** IF(INDWG.EQ.1)CALL STRIP1

C** DO 700 JFILE=1,NFILE

C** IF(INDWG.EQ.1)READ(5,910,FND=800)JTAG,GAIN,IPRUC,

C** C

C** 15N 0002

C** 15N 0003

C** 15N 0004

C** 15N 0005

C** 15N 0006

C** 15N 0007

C** 15N 0008

C** 15N 0009

C** 15N 0010

C** 15N 0011

C** 15N 0012

C** 15N 0013

C** 15N 0015

C** 15N 0017

C** 15N 0018

C** 15N 0019

C** 15N 0020

C** 15N 0021

C** 15N 0022

C** 15N 0024

C** 15N 0025

C** 15N 0026

C** 15N 0027

C** 15N 0028

C** 15N 0029

C** 15N 0030

C** 15N 0031

C** 15N 0032

C** 15N 0033

C** 15N 0034

C** 15N 0035

C** 15N 0037

C** 15N 0039

C** 15N 0040

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```

1 (ATITLE(1),1,1,12)
1SN 0002 910 FORMAT(28,'12',0,15,54,1240)
1SN 0003 IF(IMODE.EQ.2)IMODE=1
1SN 0004 CALL BUFIN(IND)
1SN 0005 CALL CHAIN(ICC,NBYTES)
1SN 0006 IF(ICC)005,410,415
1SN 0007 C 005 WRITE(6,302)NSKIP,JFILE
1SN 0008 005 CONTINUE
1SN 0009 902 FORMAT(8M,NSKIP=,15,8M JFILE=,15,12M END OF DATA)
1SN 0010 GO TO 400
1SN 0011 C 415 WRITE(6,403)NSKIP,JFILE
1SN 0012 415 CONTINUE
1SN 0013 903 FORMAT(8M,NSKIP=,15,8M JFILE=,15,20M PARITY ERROR IN TAG )
1SN 0014 410 CONTINUE
1SN 0015 IF(NBYTES.GE.774)GO TO 420
1SN 0016 415(6,903)NSKIP,JFILE,NBYTES
1SN 0017 904 FORMAT(8M,NSKIP=,15,8M JFILE=,15,14M TAG HAS NBYTES=,15)
1SN 0018 IF(IMODE.EQ.1)IMODE=2
1SN 0019 GO TO 000
1SN 0020 420 CONTINUE
1SN 0021 8TAG(1)=0
1SN 0022 8TAG(2)=INP(7)
1SN 0023 8TAG(3)=INP(8)
1SN 0024 8TAG(4)=INP(9)
1SN 0025 NSPEC=0
1SN 0026 IF(IMODE.EQ.0)GO TO 446
1SN 0027 IF(1TAG.NE.8TAG)IMODE=2
1SN 0028 IF(IMODE.EQ.2)GO TO 600
1SN 0029 446 CALL BUFIN(IND)
1SN 0030 CALL CHAIN(ICC,NBYTES)
1SN 0031 NSPEC=NSPEC+1
1SN 0032 IF(ICC)050,455,460
1SN 0033 C 050 WRITE(6,908)NSKIP,JFILE,NSPEC
1SN 0034 450 CONTINUE
1SN 0035 908 FORMAT(8M,NSKIP=,15,8M JFILE=,15,20M NSPEC=,15,4M EOF)
1SN 0036 GO TO 700
1SN 0037 C 460 WRITE(6,909)NSKIP,JFILE,NSPEC
1SN 0038 460 CONTINUE
1SN 0039 909 FORMAT(8M,NSKIP=,15,8M JFILE=,15,25M PARITY ERROR IN SPECTRUM,15)
1SN 0040 1)
1SN 0041 455 NCTIS=NBYTES/3
1SN 0042 NCTIS=NCTIS-2
1SN 0043 IF(NCTIS.LT.250)GO TO 456
1SN 0044 NCTIS=256
1SN 0045 456 CONTINUE
1SN 0046 IF(NSPEC.GT.3)GO TO 446
1SN 0047 00 075 1,1,NCTIS
1SN 0048 0-3*(1-1)+1
1SN 0049 K=4*(1-1)+1
1SN 0050 101(K)=0
1SN 0051 101(K+1)=INP(J+1)
1SN 0052 101(K+3)=INP(J+2)
1SN 0053 101(K+5)=INP(J+2)
1SN 0054 IF(NSPEC.EQ.1)DATA1(1)=DATA1(1)
1SN 0055 IF(NSPEC.EQ.2)DATA2(1)=DATA1(1)

```

```

ISN 0100      *75 IF(NSPEC,EQ,3)IDAT3(1)=IDATA(1)
ISN 0101      IF(NSPEC,LI,3)GO TO 446
ISN 0102      DO 477 I=1,NCTS
ISN 0103      *77 IDAT23(I)=IDAT2(I)+IDAT3(I)
ISN 0104      IF(IMODE,EQ,1)GO TO 447
ISN 0105      NO=1
ISN 0106      CALL PRINT(IDAT1,NO)
ISN 0107      NO=2
ISN 0108      CALL PRINT(IDAT2,NO)
ISN 0109      NO=3
ISN 0110      CALL PRINT(IDAT3,NO)
ISN 0111      NO=203
ISN 0112      CALL PRINT(IDAT23,NO)
ISN 0113      GO TO 446
ISN 0114      *47 CONTINUE
ISN 0115      NO=1
ISN 0116      CALL PRPTS(IDAT1,NO)
ISN 0117      IF(IPROC,EQ,1)GO TO 448
ISN 0118      NO=203
ISN 0119      CALL PRPTS(IDAT23,NO)
ISN 0120      GO TO 446
ISN 0121      *48 CONTINUE
ISN 0122      NO=2
ISN 0123      CALL PRPTS(IDAT2,NO)
ISN 0124      NO=3
ISN 0125      CALL PRPTS(IDAT3,NO)
ISN 0126      GO TO 446
ISN 0127      *600 CONTINUE
ISN 0128      ICOUNT=1
ISN 0129      *601 CALL AUFIN(INP)
ISN 0130      CALL CHKIN(ICC,NBYTES)
ISN 0131      ICOUNT=ICOUNT+1
ISN 0132      IF(ICC)700,601,602
ISN 0133      *C602 WRITE(6,1032)NSKIP,JFILE,ICOUNT
ISN 0134      *602 CONTINUE
ISN 0135      1032 FORMAT(8H NSKIP =,15,8H JFILE =,15,9H ICOUNT =,15,13H PARITY ERROR
ISN 0136      1)
ISN 0137      GO TO 601
ISN 0138      *700 CONTINUE
ISN 0139      GO TO 110
ISN 0140      *800 CONTINUE
ISN 0141      C IF(IMODE,EQ,1)CALL DUNEPL
ISN 0142      STOP
ISN 0143      END
ISN 0144

```


LEVEL 21.7 (JAN 73)

US/300 FORTWAN H

DATE 78.004/16.56.16

COMPILER OPTIONS - NAME= MAIN,UP1=00,LINECT=57,SIZE=0004K,

SOURCE,CHCUTC,NOLIST,NOCHECK,LOAD,MAP,NOEDIT,NOXREF

ISN 0002 SUBROUTINE PRPIS(IDATA,NSPEC)

ISN 0003 COMMON/TGWD/ITAG,NCIS,GAIN,IMDNG

ISN 0004 COMMON/LMT6/IA(6),XNEUT,IRUN

ISN 0005 DIMENSION XX(256),IDATA(256),DATA(256),RNG(256)

ISN 0006 IF(NSPEC.EQ.1)HEAD(5,100)XNEUT,IRUN,IA(1),I=1,6)

ISN 0008 100 FORMAT(F10.0,7I10)

ISN 0009 L1=0

ISN 0010 L2=0

ISN 0011 IF(NSPEC.EQ.1)L1=IA(1)

ISN 0013 IF(NSPEC.EQ.1)L2=IA(2)

ISN 0015 IF(NSPEC.EQ.203)I=IA(3)

ISN 0017 IF(NSPEC.EQ.203)L2=IA(4)

ISN 0019 IF(NSPEC.EQ.2)L1=IA(3)

ISN 0021 IF(NSPEC.EQ.2)L2=IA(4)

ISN 0023 IF(NSPEC.EQ.3)L1=IA(5)

ISN 0025 IF(NSPEC.EQ.3)L2=IA(6)

ISN 0027 IL1=L1-2

C ** CONVERT CHANNEL NUMBER TO INDEX

ISN 0028 IF(L1.EQ.0)GO TO 850

ISN 0030 IL1=IL1+1

ISN 0031 JL1=IL1+2

ISN 0032 JL1=JL1+1

ISN 0033 IF(IL1.LT.2)IL1=2

ISN 0035 IF(JL1.LT.1L1)JL1=1L1

ISN 0037 NCHAN1=JL1-IL1+1

ISN 0039 IHL=0

ISN 0039 DO 200 I=1,NCHAN1

ISN 0040 K=IL1+I-1

ISN 0041 IRL=IRL+IDATA(K)

ISN 0042 200 CONTINUE

ISN 0043 BL=IRL

ISN 0044 XCH=NCHAN1

ISN 0045 BL=BL/XCH

ISN 0046 IL2=L2-5

ISN 0047 IL2=IL2+1

ISN 0048 IF(IL2.LE.JL1)GO TO 850

ISN 0050 JL2=L2+5

ISN 0051 JL2=JL2+1

ISN 0052 IF(JL2.GT.256)JL2=256

ISN 0054 NCHAN2=JL2-IL2+1

ISN 0055 IRR=0

ISN 0056 DO 300 I=1,NCHAN2

ISN 0057 K=IL2+I-1

ISN 0058 IRR=IRR+IDATA(K)

ISN 0059 300 CONTINUE

ISN 0060 BR=IRR

ISN 0061 XCH=NCHAN2

ISN 0062 BR=BR/XCH

ISN 0063 IL3=242

ISN 0064 IF(IL3.LE.JL2)IL3=JL2+1

ISN 0066 IF(IL3.GT.256)GO TO 450

ISN 0068 NCHAN3=257-IL3

ISN 0069 IIR=0

```

ISN 0070      DO 400 I=1,NCHAN3
ISN 0071      K=IL3+1-1
ISN 0072      IHZ=IHZ+IDATA(K)
ISN 0073      400 CONTINUE
ISN 0074      HZ=IBZ
ISN 0075      XCH=NCHAN3
ISN 0076      HZ=HZ/XCH
ISN 0077      GO TO 500
ISN 0078      450 CONTINUE
ISN 0079      BZ=BM
ISN 0080      500 CONTINUE
ISN 0081      IF (PZ,GT,BH) HZ=BH
ISN 0082      IF (BL,GE,BH) GO TO 600
ISN 0083      550 CONTINUE
ISN 0084      BE=0.
ISN 0085      BLAM=0.
ISN 0086      BZ=IBL+IBH
ISN 0087      XCH=NCHAN1+NCHAN2
ISN 0088      HZ=BZ/XCH
ISN 0089      GO TO 700
ISN 0090      600 CONTINUE
ISN 0091      BIL=BL-HZ
ISN 0092      BIR=HR-HZ
ISN 0093      IF (RIP,LE,0.001) GO TO 550
ISN 0094      RAT=BIL/HIR
ISN 0095      RATLN=ALOG(RAT)
ISN 0096      DEL=L2-L1
ISN 0097      DELT=DEL*GAIN
ISN 0098      BLAM=RATLN/DELT
ISN 0099      XL1=L1
ISN 0100      I1=(XL1-0.5)*GAIN
ISN 0101      XLT=-I1*BLAM
ISN 0102      BE=BIL/EXP(XLT)
ISN 0103      700 CONTINUE
ISN 0104      IPL=JLI+1
ISN 0105      IPH=IL2-1
ISN 0106      THALF= 7.24
ISN 0107      INU=2.0
ISN 0108      DLAM=ALOG(1/NU)/THALF
ISN 0109      S1=0.
ISN 0110      S2=0.
ISN 0111      K=0
ISN 0112      S3=0.
ISN 0113      S4=0.
ISN 0114      S5=0.
ISN 0115      DO 800 I=TPL,IPR
ISN 0116      K=K+1
ISN 0117      TIME=T-1
ISN 0118      TIME=(TIME-0.5)*GAIN
ISN 0119      B1=EXP(-BLAM*TIME)
ISN 0120      R1=BE*B1+HZ
ISN 0121      S1=S1+B1
ISN 0122      XDAT=IDATA(I)
ISN 0123      S2=S2*XDAT
ISN 0124      WT=EXP(DLAM*TIME)*(XDAT-B1)

```

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```

ISN 0120 DATA(K)XDAT
ISN 0120 HXGN)H61
ISN 0130 XPR)TIME
ISN 0131 S3 = S3 + (WT/TIME)
ISN 0132 S4 = S4 + (WT/TIME)
ISN 0133 S5 = S5 + WT
ISN 0134 800 CONTINUE
ISN 0135 YIELD=S2-S1
ISN 0136 TINV=S4/S3
ISN 0137 PERMS3/ANEUT
ISN 0138 PERMS5/S5/ANEUT
ISN 0139 NPIS=K
C CALL PLNIC(DATA,BKG,XX,MSPEC,NPTS)
GO TO 900
ISN 0140 850 CONTINUE
ISN 0141 YIELD=-0.0
ISN 0142 TINV=-0.0
ISN 0143 PERMS=-0.0
ISN 0144 S3=-0.0
ISN 0145 S4=-0.0
ISN 0146 S5=-0.0
ISN 0147 BLAP=-0.0
ISN 0148 BE=-0.0
ISN 0149 S1=-0.0
ISN 0150 S2=-0.0
ISN 0151 900 CONTINUE
ISN 0152 IF (INDRG.EQ.0)CALL XHONG
ISN 0153 IS1=SI
ISN 0154 IS2=S2*0.5
ISN 0155 IS3=S3*0.5
ISN 0156 1 WRITE(6,Y10)IRUN,MSPEC,TINV,PERMS,
2 LI,L2,GAIN
910 FURMAT(IX,ZIS,3E12.5,2IA,4E12.5,
RETURN
END
ISN 0157
ISN 0158
ISN 0159

```

COMPILER OPTIONS = NAME= MAIN,OPT=00,LINECNT=57,SIZE=0000K,

SOURCE,FBCEDEC,NOLIST,NODECK,LOAD,MAP,NOEDIT,IO,NOMREF

ISN 0002 SUBROUTINE XHDNG

ISN 0003 COMMON/TGND/ITAG,NCTS,GAIN,IMDNG

ISN 0004 IMDNG=1

ISN 0005 WRITE(6,100)

ISN 0006 100 FORMAT(1M1, //2X, 'RUN AHHAY', 3X, 'TINV', 7X, 'SUM ', 8X, 'SUM ',

1 7X, 'COUNTS', 4X,

2 'BKG', 4X, 'PLAM', 9X, 'RZ', 12X, 'RE', 8X, 'NEUT', 6X, 'L1',

33X, 'L2', 3X, 'GAIN')

ISN 0007 WRITE(6,200)

ISN 0008 200 FOMMA (23X, '(1/T)=Y/NEUT', 4X, 'Y/NEUT//)

ISN 0009 RETURN

ISN 0010 END

LEVEL 21.7 (JAN 73)

US/360 FORTRAN H

DATE 78.002/16.56.19

COMPILER OPTIONS - NAME= MAIN,OPT=00,LINECAT=57,SIZE=8000K,

SOURCE,EMCUTC,NULIST,NODECK,LOAD,MAP,NUEOIT,LD,NULREF

SURROUTINE PLNIC(DATA,BKG,XX,NSPEC,NPTS)

COMMON/IGND/ITAG,NCTS,GAIN,LDONG

COMMON/HTS/IA(6),XHAUT,IRUN

COMMON/HOHL/ATITLE(12)

DIMENSION XX(256),DATA(256),HKG(256)

XMAX=0.0

XMIN=10000.

YMAX=0.0

YMIN=0.0

DO 100 I=1,NPTS

IF(YMAX.LT.DATA(I))YMAX=DATA(I)

IF(XMAX.LT.XX(I))XMAX=XX(I)

IF(XMIN.GT.XX(I))XMIN=XX(I)

100 CONTINUE

IHEG=1

CALL HGNPL(IHEG)

CALL NUNHON

ITITLE=48

IXNAME=100

IYNAME=100

XAXIS=0.0

YAXIS=0.0

CALL TITLE(ATITLE,ITITLE,'TIME (SEC)',IYNAME,'COUNTS',

IYNAME,XAXIS,YAXIS)

IYNAME,XAXIS,YAXIS)

XORIG=XM

YORIG=YM

XSTP=(XMAX-XMIN)/R.O

YSTP=YMAX/10.0

CALL GRAF(XORIG,XSTP,XMAX,YORIG,YSTP,YMAX)

CALL NUCRCK

YPOS=10.1

IMESS=100

IMARK=1

GO TO 950

CALL CURVE(XX,DATA,NPTS,IMARK)

IMARK=0

CALL CURVE(XX,BKG,NPTS,IMARK)

XPOS=1.0

CALL MESSAGE ('RUN = ',IMESS,XPOS,YPOS)

XPOS=2.0

CALL INTND(IYNAME,XPOS,YPOS)

XPOS=3.0

CALL MESSAGE ('ARRAY = ',IMESS,XPOS,YPOS)

XPOS=4.0

CALL INTNDINSPEC,XPOS,YPOS)

IPILOT=0

CALL EXAME

CALL ENOPL(IPILOT)

CALL HGNPL(IHEG)

CALL NUNHON

CALL TITLE(ATITLE,ITITLE,'TIME (SEC)',IYNAME,'COUNTS',

IYNAME,XAXIS,YAXIS)

CALL GRAF(XORIG,XSTP,XMAX,YORIG,YSTP,YMAX)

END

```
ISN 0056      CALL MICHEN
ISN 0057      IMARK=1
ISN 0058      950 CONTINUE
ISN 0059      DO 900 I=1,NPTS
ISN 0060      DATA(I)=DATA(I)-HKG(I)
ISN 0061      IF (DATA(I).LT.0.0)DATA(I)=0.0
ISN 0062      900 CONTINUE
ISN 0063      CALL CURVE(XX,DATA,NPTS,IMARK)
ISN 0064      XPUS=1.0
ISN 0065      CALL MESSAG('RUN = 1',IMESS,XPUS,YPUS)
ISN 0066      XPUS=2.0
ISN 0067      CALL INTND(IRUN,XPUS,YPUS)
ISN 0068      XPUS=3.0
ISN 0069      CALL MESSAG('ARRAY = 3',IMESS,XPUS,YPUS)
ISN 0070      XPUS=4.0
ISN 0071      CALL INTND(NSPEC,XPUS,YPUS)
ISN 0072      CALL FRAME
ISN 0073      CALL ENUPL(IPLT)
ISN 0074      RETURN
ISN 0075      END
ISN 0076
```

APPENDIX B**TEST DATA**

This Appendix contains tables and plots of the count distributions for the 7.5 cm test and the 12.5 cm test.

The tables are reproductions of the printout of the memory of the multichannel analyzer. The plots are background - corrected count distributions.

Identification of the data of the individual runs is consistent with the identification of runs in the main body of the report. The pages on which data for the individual runs can be found are listed in the Table of Contents of Appendix B.

TABLE OF CONTENTS OF APPENDIX B

Run Number	Array	Pages
4001	1,203	84,85
4002	1,203	86,87
4003	1,203	88,89
4004	1,203	90,91
4005	1,203	92,93
4006	1,203	94,95
4007	1,203	96,97
4008	1,203	98,99
4009	1,203	100,101
3001	1	102,103
3002	1	104,105
3003	1	106,107
3020	1,203	108,109
3022	1,203	110,111
3023	1,203	112,113
3024	1,203	114,115
3025	1,203	116,117
3026	1,203	118,119
3027	1,203	120,121
3028	1	122,123
3029	1,203	124,125
3030	1,203	126,127
3031	1,203	128,129
3032	1,203	130,131
3019	1,203	132,133
3018	1,203	134,135
3016	1,203	136,137
3006	1,203	138,139
3005	1	140,141

TABLE OF CONTENTS OF APPENDIX B (Continued)

Run Number	Array	Pages
4510	1,203	142,143
4511	1,203	144,145
4512	1,203	146,147
4513	1,203	148,149
4514	1,203	150,151
3514	1,203	152,153
3515	1,203	154,155
3517	1,203	156,157
3518	1,203	158,159
3520	1,203	160,161
3521	1,203	162,163
3522	1,203	164,165
3523	1,203	166,167
3524	1,203	168,169
3525	1,203	170,171
3526	1,203	172,173
3527	1,203	174,175
3528	1,203	176,177
3529	1,203	178,179
3530	1,203	180,181
3531	1,203	182,183
3533	1,203	184,185
3524	1,203	186,187
3535	1,203	188,189
3536	1,203	190,191
3537	1,203	192,193

10000									
578	53	46	40	42	42	43	53	43	43
46	43	32	31	72	94	122	208	306	583
817	909	1273	1350	1329	1289	1178	1105	969	788
699	572	404	366	275	222	196	140	102	90
91	68	70	68	56	52	38	51	44	36
33	32	36	30	30	34	21	27	26	28
46	28	22	17	15	17	22	21	21	19
16	22	19	29	18	24	22	12	14	22
24	19	19	15	18	18	31	19	16	17
14	18	16	15	19	17	17	21	18	12
10100									
23	17	16	14	14	14	15	9	10	7
9	16	7	9	13	17	19	10	13	19
16	19	15	12	5	11	10	16	13	6
6	14	9	11	11	11	8	15	7	17
15	8	9	15	10	7	10	12	9	13
9	15	12	16	14	11	10	10	11	14
7	8	9	10	8	17	8	9	13	12
11	13	12	13	16	13	11	11	11	9
7	11	7	7	5	8	13	7	10	13
9	8	5	9	42	67	63	62	63	62
10200									
60	56	65	72	62	68	60	20	9	8
14	6	12	9	12	9	11	13	6	10
12	7	9	12	11	9	8	3	12	11
5	7	11	5	16	9	7	7	15	7
10	9	3	3	3	9	12	7	9	9
3	8	7	4	5	8				

4001 Array 1 $\Delta t = .25$

1787									
40000									
1787	4	5	6	6	2	4	5	4	7
5	5	3	5	6	4	2	4	4	7
4	5	6	3	4	7	4	6	3	7
6	7	5	4	2	4	2	5	5	4
3	5	6	3	4	4	4	8	3	4
5	3	2	9	4	7	5	5	2	5
2	8	5	5	6	2	3	6	1	4
3	5	2	3	4	2	5	3	5	5
4	5	5	6	6	5	6	1	4	3
9	5	11	6	9	2	4	3	3	6
40100									
5	4	19	11	17	27	17	25	31	36
33	31	58	58	61	48	74	70	52	59
48	77	62	56	63	45	52	45	48	40
43	45	29	32	41	30	21	25	13	19
11	18	18	15	10	5	15	12	7	7
7	11	4	4	3	4	10	8	6	5
6	5	5	4	2	6	5	3	10	7
5	6	4	2	2	6	4	3	3	7
10	6	2	9	7	1	6	4	8	2
11	7	7	25	3	1	6	1	2	4
40200									
3	1	5	3	4	8	2	20	60	56
5	11	3	4	2	6	5	5	8	9
2	4	6	7	4	3	1	5	8	4
2	6	1	2	7	2	10	3	5	4
6	2	5	4	6	4	0	2	5	3
4	3	8	2	8	4				

4001 Array 203 $\Delta t = .25$

261									
10000									
261	31	19	21	21	27	15	15	13	17
18	31	45	55	90	19	88	349	321	342
357	358	309	346	312	92	29	125	98	73
50	44	76	26	26	21	11	9	10	14
12	8	17	8	15	16	12	9	12	5
10	11	11	9	5	11	5	8	8	8
2	4	8	11	5	9	9	8	3	8
7	9	12	5	6	7	5	4	9	7
6	6	6	4	3	6	7	3	7	5
2	5	9	2	8	2	7	7	8	6
10100									
4	2	7	1	5	3	3	8	9	6
2	3	7	4	0	3	5	6	3	10
4	4	7	0	4	7	8	4	8	4
7	5	1	3	9	9	5	6	5	6
5	4	5	5	6	5	1	3	2	2
1	0	4	2	2	5	5	6	5	2
5	1	2	5	6	4	1	2	4	2
5	4	2	4	1	4	5	6	2	4
4	3	3	3	2	2	4	2	2	4
3	1	4	4	5	2	1	5	3	4
10200									
5	4	3	3	4	1	5	5	1	3
3	0	7	0	2	2	2	4	0	7
4	6	5	1	2	4	4	2	2	4
4	2	3	2	5	4	6	2	4	7
3	2	2	3	4	5	5	2	2	4
3	4	3	3	2	3				

4002 Array 1 $\Delta t = .25$

653									
40000									
653	6	1	1	1	2	3	6	1	3
2	0	0	0	0	3	2	1	2	3
0	3	1	1	1	1	0	1	1	1
0	1	1	1	3	2	3	1	1	1
4	2	2	1	0	0	0	3	0	1
1	1	1	3	3	2	1	1	2	1
3	1	0	1	1	1	1	2	0	0
4	1	3	0	2	1	0	2	1	2
0	5	6	5	7	10	9	15	24	23
27	37	25	42	30	30	44	41	30	40
40100									
30	35	25	31	28	24	20	21	18	16
12	12	7	5	7	12	3	3	6	5
4	5	2	1	4	5	2	3	1	3
1	3	4	1	2	2	2	0	2	1
2	0	2	1	2	1	1	3	2	6
2	0	0	3	2	1	3	1	1	2
2	1	1	3	2	0	2	2	3	2
2	1	1	3	2	2	0	1	1	3
2	1	5	4	0	2	3	0	1	4
3	0	3	1	0	1	2	2	1	1
40200									
2	1	1	2	2	0	3	0	1	1
0	0	2	1	1	1	1	0	1	2
1	1	1	1	0	1	1	1	3	0
2	2	1	0	1	2	2	1	2	1
1	1	0	2	3	2	1	1	2	1
1	0	4	6	2	2				

4002 Array 203 $\Delta t = .25$

197									
10000									
197	14	14	13	20	15	21	16	13	16
19	11	14	18	16	25	37	43	56	105
150	229	362	417	462	512	493	555	562	435
361	315	290	249	206	150	138	82	81	58
55	36	44	35	17	13	14	21	11	18
13	13	10	14	11	15	11	8	12	16
14	7	9	22	10	15	8	6	8	11
11	12	13	10	8	15	11	8	16	15
8	12	5	10	6	9	7	13	6	4
5	12	13	11	10	12	12	11	7	3
10100									
8	4	4	8	9	5	9	9	8	4
8	4	12	6	8	8	3	8	9	9
13	8	8	6	8	10	6	4	10	9
7	6	6	6	3	10	6	5	9	6
7	7	5	3	6	4	14	3	5	7
7	7	6	11	5	6	7	8	1	10
6	8	5	6	4	3	6	6	1	2
6	4	7	1	8	9	14	2	2	6
9	4	3	6	2	7	4	7	8	11
6	4	4	6	6	5	5	5	4	3
10200									
4	4	10	7	3	4	3	8	4	9
7	4	4	6	4	2	7	4	5	5
7	6	1	6	5	2	3	4	3	8
3	3	4	3	3	6	2	2	1	4
3	8	2	4	4	5	7	3	3	5
2	6	4	7	3	6				

4003 Array 1 $\Delta t = .1$

395									
40000									
1390	3	2	5	0	2	0	1	1	1
2	1	2	1	0	1	0	0	0	0
0	3	0	1	0	4	1	1	1	4
0	1	0	2	2	3	1	3	0	2
1	0	2	1	3	1	5	3	1	1
1	1	2	0	0	2	1	2	0	1
0	0	0	3	0	0	1	0	2	2
0	1	0	2	2	2	0	2	1	0
1	1	0	0	0	3	0	0	1	0
2	2	2	3	1	2	0	0	4	0
40100									
0	0	1	0	1	2	3	1	7	4
3	6	14	11	12	16	25	27	35	40
56	57	56	66	59	72	83	60	76	87
91	86	90	84	90	109	99	62	79	60
61	75	50	47	42	30	44	29	24	26
24	21	25	18	16	10	10	10	8	9
3	9	3	8	7	4	5	4	3	4
3	9	1	3	2	1	2	2	4	3
1	3	2	3	1	1	2	2	1	2
2	1	0	0	0	0	2	1	0	3
40200									
1	1	0	2	0	1	1	1	1	2
2	6	2	2	2	5	0	3	2	0
4	1	2	0	2	1	1	2	1	1
1	1	1	3	0	0	2	2	2	1
2	3	3	0	1	0	0	0	1	5
1	1	1	2	0	1				

4003 Array 203 $\Delta t = .1$

1386									
10000									
1386	268	766	301	121	77	48	33	24	12
13	3	12	10	5	8	10	26	15	34
60	72	107	98	97	94	82	66	62	54
33	31	17	20	23	12	7	8	7	3
5	6	5	8	2	5	4	7	9	5
4	6	5	4	4	4	6	3	5	8
7	4	5	8	8	3	2	5	2	10
6	4	6	10	9	5	4	3	4	8
8	7	3	6	1	3	4	5	4	4
5	9	9	4	6	6	5	4	8	6
10100									
2	6	8	8	2	5	7	3	2	9
6	6	7	3	6	1	8	2	5	4
5	6	3	3	2	5	6	3	9	9
2	7	6	6	3	5	4	10	6	10
6	3	7	6	1	3	8	9	6	5
7	4	4	7	7	7	10	4	5	4
5	12	6	5	11	8	6	5	6	4
7	6	7	10	9	8	9	4	11	1
2	2	9	1	4	5	6	2	13	7
11	6	9	3	10	4	7	6	4	11
10200									
3	6	3	2	7	6	4	3	1	6
3	9	12	2	6	7	0	9	4	8
6	9	4	6	7	6	7	2	4	7
5	8	7	4	8	5	4	7	4	10
4	4	9	1	6	3	5	3	3	3
8	7	5	1	3	2				

4004 Array 1 $\Delta t = .005$

1158									
40000									
1158	1419	416	156	70	31	22	15	8	11
2	5	2	1	0	0	0	0	2	0
0	2	2	1	0	0	0	1	1	0
0	2	0	1	1	2	0	0	0	2
0	1	1	2	0	0	0	0	0	1
1	1	0	0	1	0	1	0	0	3
1	2	0	1	0	1	0	2	0	0
1	1	2	0	1	1	3	1	0	0
2	0	0	2	1	1	0	0	1	1
1	1	0	2	0	0	3	1	2	2
40100									
2	4	8	8	12	16	20	29	23	28
45	32	38	43	47	44	41	54	44	54
35	39	37	35	34	22	20	23	20	10
12	8	9	5	4	3	6	4	2	5
1	2	2	1	0	1	0	3	1	1
2	1	3	2	0	1	2	1	1	2
0	1	0	1	1	0	0	1	0	3
0	2	1	0	1	0	0	0	1	0
3	2	1	1	1	0	0	0	0	1
0	0	0	0	1	1	1	0	1	0
40200									
0	1	1	2	2	2	0	0	1	0
0	0	0	0	0	0	0	1	0	0
2	2	0	0	0	0	0	1	2	1
0	1	0	2	0	0	2	0	0	1
1	1	3	1	0	0	1	1	0	0
1	0	0	1	1	3				

4004 Array 203 $\Delta t = .005$

767									
10000									
347	143	41	57	32	33	30	36	31	46
48	39	37	37	27	34	42	42	39	34
32	51	51	69	78	103	125	187	260	326
427	554	690	765	945	1036	1059	1127	1115	1085
1122	989	979	929	878	800	694	574	532	468
422	347	330	276	234	185	178	164	144	92
98	78	77	69	56	61	59	43	60	43
49	41	30	45	22	26	28	30	24	36
25	21	19	27	23	26	24	30	21	16
23	20	17	17	29	19	17	23	23	18
10100									
21	29	20	12	14	17	14	27	18	21
20	17	19	9	17	11	17	11	23	15
10	14	13	19	15	18	14	20	23	22
12	12	19	15	14	13	13	13	15	13
19	13	12	16	14	12	17	14	13	17
13	23	11	16	15	11	9	18	11	16
13	18	13	10	13	13	4	11	15	13
16	10	8	20	16	6	11	15	11	9
6	4	9	11	9	6	11	16	11	13
8	12	14	11	17	18	15	9	9	14
10200									
12	7	9	8	10	9	9	15	15	14
12	12	14	5	14	8	12	10	8	15
10	19	16	9	15	8	11	10	14	17
9	9	11	13	11	7	10	11	15	13
11	11	13	8	9	12	11	15	8	6
13	12	6	12	9	7				

4005 Array 1 $\Delta t = .13$

761									
10000									
2761	46	2	1	5	5	1	1	6	4
4	1	4	7	3	3	5	4	3	5
3	2	0	1	2	3	1	5	2	2
3	3	1	2	6	2	2	1	5	2
3	1	2	7	5	6	4	3	3	2
6	7	3	4	4	5	2	4	1	2
0	4	2	3	2	4	2	3	2	3
3	4	5	7	6	1	4	4	1	4
3	2	5	5	4	6	3	6	0	6
6	3	1	4	4	3	6	7	3	3
40100									
5	1	2	3	6	3	2	3	2	2
1	1	4	3	2	4	4	2	2	1
3	2	3	4	3	5	6	6	1	3
0	2	6	2	5	3	2	3	1	5
1	3	2	5	1	3	5	1	1	3
2	2	1	6	2	4	5	5	6	6
9	12	13	16	16	10	18	29	36	37
34	35	51	55	42	73	52	60	55	61
63	77	77	59	101	87	85	72	94	72
92	83	68	70	92	81	66	74	62	55
40200									
53	59	61	43	56	51	35	44	33	30
34	29	25	33	24	29	20	23	23	13
19	27	13	10	13	10	16	14	9	10
14	6	8	9	5	4	5	17	3	4
9	7	3	4	7	6	11	6	4	5
4	4	8	2	7	5				

4005 Array 203 $\Delta t = .13$

274									
10000									
234	80	33	16	19	21	17	10	16	18
17	12	16	15	16	17	24	31	19	21
22	23	18	34	46	45	75	101	123	188
237	302	367	457	548	544	632	680	662	612
686	594	529	571	478	459	408	349	295	262
226	207	164	144	113	96	82	76	61	57
53	60	30	32	40	32	24	19	17	18
23	19	19	14	12	19	24	15	12	21
20	43	13	20	8	6	10	18	17	16
22	13	13	14	13	13	11	15	16	12
10100									
9	13	9	14	16	15	11	9	15	13
10	13	11	14	12	10	8	15	13	8
15	11	10	14	15	11	7	7	12	15
11	12	15	18	6	8	10	16	8	10
12	17	21	10	12	9	16	7	4	11
8	7	8	9	10	10	13	6	9	14
8	15	12	9	11	9	19	8	4	10
9	6	12	11	16	5	5	8	9	14
12	6	10	10	10	7	12	8	11	13
10	7	6	16	11	6	13	7	15	8
10200									
8	9	6	10	12	12	7	8	7	5
7	15	9	9	10	16	4	6	8	7
8	10	12	10	14	8	10	7	8	4
8	6	9	4	9	5	10	12	12	15
11	5	3	15	9	7	5	4	8	7
4	7	10	11	1	8				

4006 Array 1 $\Delta t = .064$

580									
40000									
2500	19	3	2	0	4	2	4	0	2
2	0	0	0	3	2	5	2	3	1
1	0	2	4	1	2	1	3	1	2
1	1	4	5	1	1	1	4	2	1
2	3	3	2	2	1	0	2	2	1
2	2	2	2	2	2	0	1	1	4
2	1	2	2	2	2	4	1	2	1
3	0	2	2	1	0	1	2	2	4
4	2	1	2	4	1	2	3	5	2
0	1	0	2	1	2	2	2	0	4
40100									
3	2	0	2	1	2	1	1	0	1
2	3	1	0	1	2	3	2	0	0
5	0	1	2	1	3	2	3	0	3
0	1	2	0	3	1	3	1	2	2
1	2	2	0	0	1	5	0	2	0
3	0	3	5	10	3	6	9	1	5
9	6	12	12	18	11	30	22	34	38
42	47	40	60	64	61	74	79	88	87
107	111	115	92	101	109	127	116	108	135
114	119	120	108	121	118	109	103	117	119
40200									
84	74	89	109	82	99	74	82	68	82
68	53	49	34	40	38	32	35	28	31
23	37	19	25	14	18	22	16	12	19
13	9	12	12	3	7	6	10	5	4
7	7	2	6	5	6		6	2	5
2	4	0	4	3	5				

4006 Array 203 $\Delta t = .064$

556									
10000									
586	531	38	13	12	5	8	11	13	6
10	14	8	5	13	9	8	6	15	6
8	12	11	9	17	24	32	46	89	124
166	168	268	206	291	350	343	327	310	299
318	294	283	222	252	177	183	149	122	117
100	87	69	56	36	34	33	33	28	12
13	20	11	16	12	8	13	5	8	6
3	6	6	7	3	10	9	5	8	7
12	10	7	4	4	2	14	8	5	7
9	9	7	12	6	5	3	4	3	8
10100									
4	7	2	10	6	4	10	9	9	8
11	8	7	7	10	10	3	8	7	7
6	5	5	7	7	5	11	6	8	2
3	8	7	5	4	8	6	10	7	6
7	4	3	7	8	9	3	7	8	7
8	3	5	6	7	4	5	3	5	8
7	5	4	5	4	15	9	8	8	8
7	7	5	11	7	8	4	6	6	11
7	7	4	6	5	6	5	7	3	3
5	5	6	10	4	3	8	5	9	7
10200									
7	5	1	3	7	5	9	3	5	10
3	3	10	3	3	4	4	8	5	14
6	7	4	3	4	7	6	1	5	2
8	5	7	4	11	1	7	5	6	6
4	9	4	6	3	2	4	8	6	1
3	5	6	4	7	4				

4007 Array 1 $\Delta t = .034$

314									
40000									
1314	779	11	2	1	2	0	2	2	0
0	2	0	2	3	0	1	0	2	1
0	0	0	2	1	0	0	1	1	1
1	0	1	1	0	1	0	1	0	1
2	1	0	0	0	1	2	0	1	0
1	2	0	0	0	0	1	0	0	1
2	0	0	0	0	2	0	2	1	0
0	0	2	1	0	1	0	0	2	0
0	1	1	3	0	0	1	0	0	0
0	0	0	0	0	0	2	0	2	4
40100									
1	0	2	2	1	2	0	1	0	1
0	0	1	1	1	2	1	0	0	2
1	0	1	0	1	0	2	1	0	2
2	1	1	0	1	1	0	1	0	1
0	0	1	1	0	2	1	2	4	1
1	2	6	3	2	8	8	7	10	24
12	22	19	35	46	48	49	50	70	49
71	72	71	78	80	78	86	92	90	80
95	98	92	95	88	107	95	116	87	97
86	101	81	65	72	74	54	51	43	64
40200									
60	47	39	28	34	39	35	24	22	22
30	19	15	14	11	8	21	12	7	5
9	11	6	2	3	5	3	3	3	7
6	5	5	3	7	1	1	2	0	2
0	4	1	2	3	3	2	0	0	1
1	2	2	0	1	1				

4007 Array 203 $\Delta t = .034$

781									
10000									
781	52	974	780	380	239	140	99	72	38
41	29	36	26	23	20	15	16	16	12
8	12	9	14	10	22	17	27	20	25
30	33	59	80	96	105	118	116	121	124
120	135	118	112	110	88	67	83	65	63
55	36	30	33	20	13	24	21	10	9
12	9	17	6	8	14	15	5	14	7
15	4	11	15	6	10	17	11	10	6
13	9	8	11	14	11	13	10	12	18
9	7	10	5	8	8	7	8	12	7
10100									
12	9	10	7	4	11	10	15	15	8
2	12	7	9	10	7	9	13	7	7
7	7	13	9	2	5	14	6	4	7
10	11	6	15	13	6	9	9	8	10
7	7	7	4	12	9	10	7	7	4
8	18	13	4	3	8	10	10	2	9
6	11	11	9	9	11	8	10	10	6
8	12	10	8	6	10	8	7	8	10
4	7	8	8	3	13	6	6	7	7
10	12	5	9	10	12	15	9	8	7
10200									
10	13	10	14	3	7	9	5	5	8
11	5	5	7	5	7	6	7	8	9
8	13	5	4	10	11	5	10	12	12
11	9	7	8	9	9	7	6	11	8
6	4	8	7	6	9	9	10	14	11
8	11	10	10	9	12				

4008 Array 1 $\Delta t = .0034$

1965									
40000									
1965	2355	897	416	227	122	88	44	35	8
14	7	4	5	8	9	4	6	1	1
4	0	4	1	1	1	4	1	0	2
1	0	1	1	0	1	1	1	1	2
0	0	2	0	0	4	0	2	0	0
2	3	0	2	0	0	0	2	1	3
2	1	2	0	0	0	2	3	0	1
2	4	0	0	0	0	0	1	2	1
2	1	2	1	2	1	1	1	2	0
1	0	0	4	1	1	0	2	1	3
40100									
0	1	1	2	0	1	0	1	1	0
0	0	1	1	1	2	0	0	0	1
0	2	2	1	0	1	1	1	2	1
1	0	0	2	1	0	3	1	2	1
1	0	2	0	0	1	0	0	1	1
2	3	3	2	2	1	0	1	0	2
0	3	1	4	1	7	6	3	7	11
11	8	12	12	14	22	24	27	23	30
38	32	48	39	32	51	53	49	51	55
68	50	43	54	64	59	74	47	59	42
40200									
45	38	42	52	37	37	35	34	39	27
24	22	28	10	20	21	16	15	14	13
13	7	9	3	4	4	5	5	1	1
4	4	3	2	7	4	0	2	2	2
0	7	2	1	4	0	0	3	2	1
0	2	4	2	1	1				

4008 Array 203 $\Delta t = .0034$

10500	1141	841	266	125	56	33	21	19	20
18	14	15	9	13	4	12	8	7	3
10	11	8	13	13	13	22	25	37	51
60	76	77	119	140	191	189	184	184	187
207	222	184	176	163	166	163	125	115	103
82	73	38	38	32	39	30	23	21	10
11	15	12	14	11	14	7	5	8	14
9	7	13	9	9	6	3	11	7	11
5	6	7	12	9	10	12	1	10	9
17	9	6	8	7	6	10	10	4	8
10100									
7	5	6	12	8	5	12	9	9	9
1	4	12	4	5	11	7	9	6	6
3	7	10	7	9	7	12	10	9	4
7	9	6	11	4	12	11	9	8	5
5	4	5	8	8	14	3	8	17	13
10	11	16	4	5	11	9	12	11	8
10	6	6	4	10	3	7	6	10	4
13	6	8	8	11	11	8	10	6	8
7	10	5	15	5	7	8	7	2	9
5	6	6	13	6	7	3	7	10	6
10200									
8	6	10	8	5	9	9	9	5	10
6	8	12	8	11	7	6	7	8	9
11	6	7	4	4	6	9	12	6	10
9	9	8	9	11	7	8	8	5	5
8	6	7	7	5	8	10	8	11	6
10	13	12	3	6	11				

4009 Array 1 $\Delta t = .0067$

1692									
40000									
2692	2162	450	142	55	24	7	9	6	7
3	2	3	3	1	3	3	1	3	3
0	0	1	1	2	2	2	1	0	1
2	0	0	2	2	2	0	1	0	1
1	2	2	2	1	0	2	0	0	2
0	0	1	1	2	1	4	0	0	0
0	0	0	0	1	0	1	0	2	0
1	0	1	0	0	1	2	0	1	3
1	1	1	0	1	0	0	0	0	0
0	1	1	1	0	1	0	2	3	2
40100									
2	2	3	1	2	0	1	1	4	0
3	3	0	0	2	1	2	1	5	1
0	0	2	0	0	0	1	0	1	1
1	0	1	3	1	1	1	1	0	0
1	2	1	0	1	1	0	1	1	1
1	1	1	1	2	1	0	4	2	4
1	2	4	4	8	7	8	6	11	14
19	26	31	27	41	35	41	39	47	46
55	53	70	68	68	84	81	95	93	74
96	83	83	97	89	82	77	95	79	90
40200									
85	73	82	72	53	56	64	53	46	54
41	36	26	36	18	27	22	11	15	14
18	10	10	13	4	8	7	4	5	5
3	8	5	4	3	5	7	4	1	1
3	4	1	1	5	2	0	2	3	5
2	5	3	1	2	5				

4009 Array 203 $\Delta t = .0067$

542									
10000									
542	152	149	120	120	124	126	124	115	93
100	104	104	94	79	108	79	77	92	78
86	67	81	65	64	72	64	61	52	44
52	59	68	53	53	63	51	69	63	58
33	39	57	49	61	74	50	52	44	61
54	51	61	69	105	94	73	73	65	68
89	90	102	117	96	82	79	77	71	95
91	96	75	77	87	72	77	78	80	51
54	59	49	56	53	48	53	52	45	42
55	40	42	39	43	38	39	39	33	34
10100									
43	30	27	34	34	39	36	41	43	36
39	29	21	24	31	31	17	35	21	29
33	35	25	41	25	36	38	34	23	32
19	25	28	27	23	32	20	38	40	24
21	24	27	34	24	27	36	29	34	34
28	24	31	36	26	23	37	16	26	38
22	24	17	34	34	31	29	24	20	27
35	20	38	30	24	24	23	38	29	33
36	36	28	33	31	24	30	30	21	29
27	30	23	32	31	23	24	24	26	38
10200									
24	36	22	36	36	18	22	36	36	31
40	34	36	31	21	26	18	32	34	31
32	36	35	20	23	34	35	28	26	28
27	28	32	30	30	28	26	25	40	25
31	27	32	22	30	34	34	31	19	27
31	16	19	23	23	28				

107									
10000									
107	119	103	107	95	101	92	94	97	98
73	83	78	81	93	71	83	84	79	63
78	68	74	59	54	85	65	67	71	71
62	54	65	51	77	76	46	57	75	70
75	112	110	100	124	105	103	129	166	150
109	105	107	140	109	125	120	140	161	146
171	107	153	155	125	125	122	126	84	87
181	106	71	171	86	82	61	80	74	69
52	52	52	62	51	47	43	50	46	42
41	26	34	23	43	34	41	34	33	35
10100									
25	26	32	28	33	25	32	21	27	37
33	14	10	24	24	19	18	23	19	20
72	30	23	21	27	29	29	34	25	30
35	28	23	25	28	26	18	25	22	34
26	23	24	26	24	20	23	14	14	29
27	22	21	38	24	25	23	23	20	32
24	21	22	26	21	17	25	30	31	21
29	14	24	20	26	28	23	21	21	17
19	16	16	26	31	21	29	30	21	18
19	24	28	15	29	21	28	30	23	25
10200									
15	19	21	31	25	24	23	20	28	24
25	30	20	20	27	25	22	25	19	21
25	20	21	22	26	27	18	22	27	22
30	20	26	18	23	21	27	31	25	23
26	20	18	24	28	14	18	28	14	23
21	31	31	26	17	23

178									
10000									
178	42	56	38	40	38	53	31	37	26
24	37	25	33	34	30	24	20	20	23
20	22	19	19	22	25	23	23	33	75
69	97	69	70	74	96	100	102	78	79
100	76	71	63	73	71	59	53	50	47
54	58	41	51	44	54	47	47	49	38
24	24	27	16	18	28	14	22	18	14
19	15	8	15	8	12	7	9	11	9
6	2	9	10	10	11	8	12	10	5
10	4	11	12	12	14	8	13	12	8
10100									
8	9	4	8	6	9	12	6	9	7
15	7	9	9	9	10	6	3	4	11
6	7	7	8	11	10	6	5	16	9
8	7	3	9	6	14	8	10	14	6
3	5	7	11	3	7	6	8	6	6
9	10	5	11	7	12	10	7	8	9
12	8	7	9	6	10	7	12	11	9
4	4	7	9	6	5	12	5	8	8
6	8	7	8	6	8	9	5	9	7
9	8	7	10	5	7	8	4	10	7
10200									
13	5	7	2	7	5	5	6	9	6
12	3	5	6	7	3	8	6	7	10
7	5	8	11	5	5	9	6	6	8
6	7	5	6	4	5	14	11	7	5
7	8	11	3	7	8	7	5	8	5
10	4	5	6	11	10				

100000									
137	171	40	25	22	16	17	11	20	18
17	16	14	12	25	14	12	11	25	19
23	18	22	38	31	43	43	72	96	130
177	229	287	357	432	490	504	585	605	612
665	621	614	557	527	477	448	377	352	311
280	205	180	156	131	120	87	93	66	46
66	53	54	39	25	22	26	21	23	22
14	17	27	14	13	13	17	18	22	13
13	19	16	14	13	11	20	14	15	13
14	18	14	8	4	15	11	12	17	10
10100									
13	12	16	10	13	12	18	12	16	8
9	11	13	12	13	10	16	13	13	10
10	12	17	11	8	11	13	9	11	12
17	18	11	10	8	10	12	11	11	10
17	8	9	14	17	17	12	4	12	7
13	10	10	9	6	14	9	8	4	10
7	11	3	9	7	17	13	11	10	7
10	5	13	9	14	7	11	12	11	7
8	9	12	10	15	7	10	9	10	9
11	11	10	8	6	24	7	11	15	13
10200									
8	10	9	7	8	11	7	14	10	6
3	11	13	13	9	12	13	5	12	8
9	4	9	11	10	8	6	12	8	11
9	8	4	9	6	4	15	11	10	7
9	3	8	4	5	9	2	5	8	10
5	8	9	8	11	14				

3020 Array 1 $\Delta t = .056$

369									
40000									
2569	136	6	2	1	3	0	2	0	3
1	1	1	1	1	1	0	1	3	4
1	3	2	1	1	8	2	1	2	2
2	1	1	4	0	0	1	3	3	1
2	1	0	3	1	2	0	3	1	0
1	1	2	1	4	1	5	3	1	1
2	3	2	0	2	3	2	1	0	3
1	3	2	1	0	0	2	1	2	2
2	0	2	3	4	3	2	0	4	2
2	2	0	2	5	0	3	1	2	1
40100									
3	2	0	1	3	0	1	1	0	2
2	0	2	3	0	2	1	0	0	0
1	1	2	1	4	2	2	4	1	1
0	2	3	1	0	2	5	4	1	2
2	3	2	4	0	1	2	5	0	1
0	2	5	5	5	2	3	4	8	7
12	16	16	17	28	29	41	38	37	48
68	73	67	78	84	103	111	105	104	123
100	107	127	133	132	143	131	117	134	100
105	102	99	95	97	100	90	85	90	80
40200									
85	76	76	78	77	63	83	80	76	81
50	57	45	46	53	43	43	45	30	43
23	31	19	15	16	12	9	22	17	17
11	12	11	9	12	7	5	9	5	8
11	9	11	6	4	7	7	5	3	6
6	1	0	5	6	2				

3020 Array 203 $\Delta t = .056$

200									
10000									
250	520	36	25	19	16	17	21	20	22
18	19	23	16	23	30	54	68	75	102
146	193	177	210	197	194	174	166	162	130
144	109	106	96	93	100	83	95	82	92
92	95	84	78	74	70	60	83	69	65
76	85	103	96	109	113	132	90	101	87
76	49	51	52	42	51	35	38	28	19
30	21	23	26	12	25	17	17	7	24
11	24	12	13	15	5	16	11	23	16
17	21	16	12	14	8	20	17	10	14
10100									
16	11	12	11	15	13	14	13	10	8
19	13	8	8	12	12	13	7	8	15
9	10	10	16	10	10	15	19	11	13
17	12	17	10	12	10	8	9	15	15
5	12	3	16	4	11	15	16	11	10
14	17	15	16	10	17	8	16	11	12
12	8	13	15	15	11	18	15	13	12
8	9	10	6	11	13	12	8	13	8
8	12	10	5	8	15	16	14	15	9
17	11	10	12	11	10	14	9	3	9
10200									
11	11	14	9	17	11	8	12	13	13
8	9	14	4	10	16	15	9	8	14
9	5	12	9	11	10	10	7	12	12
9	12	9	8	12	9	5	11	9	11
10	13	13	5	15	12	10	14	11	15
6	17	16	8	14	11				

3022 Array 1 $\Delta t = .035$

3633									
40000									
3633	431	8	2	2	1	0	0	2	2
0	2	3	0	1	0	2	0	0	0
1	1	2	3	2	0	0	2	1	0
1	1	2	1	4	2	1	2	1	0
3	0	1	0	1	2	2	3	4	5
3	1	3	3	2	0	1	1	0	1
5	2	1	1	1	3	5	3	2	0
6	2	1	2	3	2	5	1	1	4
4	3	3	1	2	3	4	6	1	4
3	2	3	6	2	5	1	1	6	1
40100									
4	6	8	4	8	8	9	3	5	7
7	9	6	4	7	3	5	4	5	4
8	10	11	5	8	15	8	8	11	8
10	8	5	7	10	9	12	15	11	15
20	14	13	11	18	15	15	20	24	17
26	18	25	18	19	25	25	23	29	23
32	28	21	37	31	33	34	26	41	36
30	39	39	41	45	39	34	32	39	21
29	30	17	31	38	38	48	32	49	44
55	34	36	33	27	44	31	31	20	28
40200									
28	24	27	17	26	14	10	11	11	13
17	8	17	14	20	16	12	15	17	12
10	3	10	9	7	4	5	5	6	7
0	5	3	3	0	3	2	3	2	3
2	5	3	0	2	3	2	1	3	2
1	1	2	2	2	3				

3022 Array 203 $\Delta t = .035$

126									
10000									
480	1504	147	37	34	20	19	21	15	28
16	21	30	17	20	20	20	33	30	55
46	51	79	84	96	100	120	168	173	193
220	272	281	261	259	238	220	220	206	220
198	190	172	196	194	198	154	136	130	124
100	119	93	83	78	66	73	64	46	45
31	46	37	34	24	29	21	22	15	24
27	27	26	24	32	16	21	16	21	20
20	15	17	12	18	21	17	23	25	18
18	18	13	14	24	10	14	10	13	20
10100									
22	24	17	18	18	8	26	22	19	20
17	15	13	16	10	14	17	11	16	20
12	13	25	22	42	15	24	20	15	19
11	20	9	11	26	15	11	14	17	15
10	19	16	13	21	13	20	23	20	19
15	22	12	17	12	10	22	18	15	13
13	14	12	16	16	11	15	12	17	15
17	24	16	13	7	18	19	12	19	23
15	11	12	21	14	16	10	16	14	18
12	15	14	20	21	17	18	14	10	15
10200									
11	15	12	12	15	6	19	15	15	16
18	19	19	17	15	17	9	21	18	16
17	20	21	12	8	12	12	24	16	15
17	23	14	15	20	14	12	21	20	15
21	14	15	12	17	18	12	18	11	17
12	19	11	9	21	17				

3023 Array 1 $\Delta t = .025$

4786									
40000									
4786	1684	42	11	4	2	1	1	2	1
2	3	2	1	1	1	1	1	4	1
0	0	1	0	3	2	2	2	2	3
2	1	3	2	2	1	1	3	1	1
3	3	4	3	5	3	2	0	3	3
3	3	2	3	2	0	2	2	3	3
1	1	1	0	5	3	3	2	4	3
3	5	7	8	5	2	6	6	5	4
4	3	6	5	5	2	0	3	6	2
2	5	9	3	5	1	4	1	3	2
40100									
3	4	4	7	8	2	8	5	3	5
2	6	7	5	4	4	8	9	7	9
6	11	9	11	7	4	4	5	8	10
10	1	9	12	8	10	11	9	11	13
10	10	18	13	16	17	25	14	16	14
17	20	24	24	32	30	36	40	56	31
37	48	37	50	52	49	65	40	60	52
49	36	45	54	45	50	38	32	36	33
36	37	35	43	23	29	24	34	28	36
39	32	45	27	28	26	22	21	28	19
40200									
15	22	18	18	21	24	15	12	14	14
10	16	10	13	9	7	12	11	11	11
12	9	10	10	9	8	10	3	7	5
0	5	5	5	2	2	8	5	5	2
2	6	6	3	6	3	2	5	0	2
3	2	4	2	3	3				

3023 Array 203 $\Delta t = .025$

2000	287	56	46	46	29	30	19	29
10000	31	46	49	43	38	49	60	63
5000	97	417	128	170	124	159	137	166
2000	177	189	189	160	161	173	138	142
10000	51	113	106	106	100	80	78	81
5000	19	57	50	50	49	36	40	35
2000	33	27	35	35	27	24	19	28
10000	19	22	28	28	24	35	34	29
5000	27	22	32	22	28	23	26	27
2000	31	33	21	20	34	29	19	23
10000	29	22	23	26	19	24	22	26
5000	29	28	18	18	27	23	24	24
2000	94	18	30	24	14	24	27	22
10000	19	31	17	27	28	28	20	26
5000	26	22	18	18	16	24	22	18
2000	25	17	22	27	26	22	19	19
10000	25	24	23	23	18	19	28	21
5000	33	34	16	23	45	23	16	18
2000	20	21	20	27	12	25	24	16
10000	18	22	16	18	24	26	19	23
5000	20	19	11	17	16	20	25	25
2000	18	12	25	17	23	27	22	20
10000	14	21	22	19	16	20	16	21
5000	23	29	14	18	20	16	28	21
2000	18	21	15	20	26	15	25	25
10000	21	26	22	33	26	25	21	26
5000	29	17	15	20	20	16	28	21
2000	24	25	22	23	26	15	25	25
10000	28	21	17	17	16	20	28	21
5000	10	26	26	17	23	27	22	20
2000	19	16	16	19	16	20	16	21
10000	19	19	19	18	20	16	28	21
5000	29	17	15	20	26	15	25	25
2000	24	25	22	23	26	15	25	25
10000	28	21	17	17	16	20	28	21
5000	10	26	26	17	23	27	22	20
2000	19	16	16	19	16	20	16	21
10000	19	19	19	18	20	16	28	21
5000	29	17	15	20	26	15	25	25
2000	24	25	22	23	26	15	25	25
10000	28	21	17	17	16	20	28	21
5000	10	26	26	17	23	27	22	20
2000	19	16	16	19	16	20	16	21
10000	19	19	19	18	20	16	28	21
5000	29	17	15	20	26	15	25	25
2000	24	25	22	23	26	15	25	25
10000	28	21	17	17	16	20	28	21
5000	10	26	26	17	23	27	22	20
2000	19	16	16	19	16	20	16	21
10000	19	19	19	18	20	16	28	21
5000	29	17	15	20	26	15	25	25
2000	24	25	22	23	26	15	25	25
10000	28	21	17	17	16	20	28	21
5000	10	26	26	17	23	27	22	20
2000	19	16	16	19	16	20	16	21
10000	19	19	19	18	20	16	28	21
5000	29	17	15	20	26	15	25	25

3024 Array 1 $\Delta t = .020$

7770	2013	94	18	11	4	4	6	7	9	15	4	6	2	3	2	3	4	4	3	6	13	4	6
40000	2013	2	2	8	4	4	8	8	9	10	10	10	14	8	22	28	24	30	31	17	14	11	13
7770	2013	0	1	1	10	4	4	6	10	16	16	12	14	8	22	28	24	30	31	17	14	11	
6	2013	0	0	1	5	4	4	5	25	27	18	29	26	14	22	28	24	30	31	17	14	11	
4	2013	4	5	4	5	4	4	4	34	34	26	33	25	10	22	28	24	30	31	17	14	11	
2	2013	0	5	4	5	4	4	4	58	43	42	42	23	10	22	28	24	30	31	17	14	11	
4	2013	3	5	1	5	4	4	4	31	24	23	22	13	10	22	28	24	30	31	17	14	11	
40100	2013	4	3	6	3	6	6	6	3	5	3	5	6	8	10	10	8	8	10	10	4	4	
4	2013	8	5	8	5	8	8	8	9	10	10	10	10	10	10	10	10	10	10	10	4	4	
11	2013	10	9	4	9	4	4	4	9	10	10	10	10	10	10	10	10	10	10	10	4	4	
10	2013	7	10	19	10	19	19	19	10	10	10	10	10	10	10	10	10	10	10	10	4	4	
21	2013	26	25	27	25	27	27	27	25	26	26	26	26	26	26	26	26	26	26	26	4	4	
29	2013	37	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	4	4	
32	2013	30	29	30	29	30	30	30	29	30	30	30	30	30	30	30	30	30	30	30	4	4	
32	2013	26	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	4	4	
16	2013	15	18	17	18	17	17	17	15	16	16	16	16	16	16	16	16	16	16	16	4	4	
40200	2013	11	15	17	15	17	17	17	15	16	16	16	16	16	16	16	16	16	16	16	4	4	
11	2013	11	12	9	12	9	9	9	11	11	11	11	11	11	11	11	11	11	11	11	4	4	
8	2013	4	11	4	11	4	4	4	11	11	11	11	11	11	11	11	11	11	11	11	4	4	
2	2013	4	0	6	0	6	6	6	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
4	2013	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	

3024 Array 203 $\Delta t = .020$

[illegible]3025 Array 1 $\Delta t = .016$ [illegible]3025 Array 203 $\Delta t = .016$

238									
10000									
238	876	110	38	28	11	12	5	11	6
8	10	6	4	7	7	7	7	12	6
10	5	11	15	18	22	28	40	54	67
114	170	169	191	228	254	294	309	308	267
270	209	247	185	189	155	120	125	106	76
70	57	53	35	29	32	19	27	16	11
18	13	11	7	12	13	8	5	8	5
9	10	6	7	6	9	9	11	13	7
3	13	7	4	10	6	7	12	6	11
3	8	9	10	2	8	6	6	8	8
10100									
11	5	8	8	9	9	11	7	6	8
8	7	4	8	1	6	2	11	4	3
7	5	2	7	8	7	7	8	9	11
10	6	5	9	9	7	10	5	11	6
7	9	6	6	11	14	10	11	5	5
2	11	7	6	7	6	8	2	3	4
5	7	5	3	7	11	4	4	7	7
7	7	8	5	8	6	5	11	7	7
5	6	8	10	5	8	9	12	8	9
14	11	8	7	4	2	8	13	5	4
10200									
6	7	8	5	7	8	9	9	10	8
12	4	2	6	8	5	9	8	5	10
15	14	9	7	6	7	4	8	5	7
8	7	8	6	3	3	5	8	6	7
3	7	9	6	9	6	8	4	7	8
8	4	4	7	9	5				

3026 Array 1 $\Delta t = .016$

3201									
40000									
3201	662	64	10	5	1	2	3	1	0
4	2	1	1	2	0	1	2	1	2
3	1	0	2	0	0	0	1	0	1
0	1	0	0	0	2	0	3	0	0
0	1	0	2	0	2	1	0	0	0
1	2	2	2	0	2	2	1	1	2
0	1	2	2	1	1	0	0	0	3
2	0	0	2	1	0	1	1	2	1
1	1	0	0	0	0	0	0	0	1
1	0	1	1	0	1	0	0	0	0
40100									
2	0	2	0	1	2	2	0	0	0
0	2	0	0	2	1	0	1	2	1
0	0	2	2	0	1	2	1	0	2
0	0	0	4	1	1	1	1	0	2
3	1	0	0	1	2	2	2	2	0
4	5	3	11	9	7	10	15	20	18
20	26	24	44	35	47	50	54	63	62
85	81	92	85	92	82	80	84	74	81
77	85	83	73	75	72	65	66	60	59
62	60	53	43	54	46	29	36	20	27
40200									
29	22	29	23	24	15	12	12	14	10
4	18	16	8	10	7	7	5	9	5
6	8	2	7	5	2	9	5	5	2
5	4	2	5	2	3	8	5	2	5
2	5	4	2	1	3	1	3	4	1
2	4	3	3	3	1				

3026 Array 203 $\Delta t = .016$

496									
10000									
486	1796	490	130	49	26	31	22	20	23
14	20	19	21	19	10	10	21	25	21
21	23	19	20	23	16	26	25	30	34
48	65	65	73	109	121	146	163	166	183
238	215	221	213	220	184	187	199	167	155
120	156	124	114	113	94	86	95	78	74
57	48	47	41	54	27	38	22	31	22
19	24	15	23	23	11	17	18	13	12
14	13	16	19	19	14	14	14	8	22
17	18	8	13	12	17	16	11	9	8
10100									
15	14	10	15	9	10	13	18	16	7
14	9	14	21	22	12	12	19	20	13
19	17	17	8	13	16	6	23	15	22
14	12	16	10	22	16	14	20	12	18
16	19	16	16	8	21	9	10	19	15
20	16	13	21	12	11	18	15	17	9
15	16	14	12	19	16	21	14	12	17
10	10	15	6	16	16	13	15	15	17
12	16	11	14	6	16	17	12	8	16
18	20	18	8	16	16	8	12	17	18
10200									
18	11	10	11	10	16	10	16	13	11
10	21	16	15	14	11	14	12	8	13
11	14	13	14	12	9	19	16	12	10
13	12	11	15	15	15	12	13	13	11
18	11	12	17	12	10	10	11	15	13
15	13	12	15	13	9				

3027 Array 1 $\Delta t = .011$

3275									
40000									
3275	2253	244	61	26	16	11	5	2	2
3	3	3	3	2	4	5	5	2	5
5	2	2	2	4	1	2	2	5	1
2	4	2	1	2	2	3	3	4	3
1	3	4	1	2	1	1	1	2	1
1	1	3	0	2	1	1	1	1	2
2	2	4	9	2	2	3	4	0	1
1	2	1	1	2	3	1	4	1	1
0	4	3	0	1	0	0	4	4	2
2	8	2	1	1	2	2	2	1	1
40100									
3	2	0	1	0	2	1	4	1	3
3	3	2	3	2	3	2	1	1	4
1	2	2	1	4	1	1	0	2	4
1	1	1	3	1	2	4	2	3	4
1	3	2	0	2	3	2	2	0	4
0	4	4	4	4	4	6	3	3	6
8	7	7	3	5	8	21	10	14	12
9	11	17	16	14	17	24	21	28	13
24	22	23	29	40	39	45	39	52	56
71	40	69	51	52	58	73	59	68	71
40200									
72	72	69	72	64	54	82	76	55	63
69	63	64	64	70	56	48	58	51	48
52	45	41	29	38	33	27	36	27	26
18	19	22	10	10	11	8	11	13	9
5	9	6	4	5	7	7	9	5	4
6	7	6	2	6	6				

3027 Array 203 $\Delta t = .011$

RUN - 3027 ARRAY - 1

3028 Array 1 $\Delta t = .006$

799									
10000									
399	11.8	878	266	101	48	33	26	10	13
16	13	4	11	9	11	9	8	10	9
13	18	21	16	17	23	35	30	36	61
83	107	106	166	199	211	183	208	206	177
182	141	144	117	136	114	90	77	61	50
40	33	27	23	23	17	18	12	15	15
13	18	10	7	6	10	8	15	10	5
3	5	12	18	7	5	11	15	5	7
14	13	11	7	8	15	6	9	10	11
5	9	13	7	15	12	4	8	8	14
10100									
7	13	13	7	6	8	9	12	5	10
11	7	14	12	10	10	8	11	20	8
9	6	11	5	8	11	4	8	8	10
13	10	7	5	9	7	12	10	5	11
5	6	9	6	16	10	12	10	11	5
12	8	7	8	5	6	6	10	6	14
5	10	9	12	9	7	7	6	14	9
12	2	7	12	13	14	10	8	13	8
6	7	3	8	8	6	7	8	8	11
8	8	13	5	11	13	10	12	11	9
10200									
9	11	9	8	7	12	13	8	7	14
5	10	9	9	8	9	11	6	10	7
9	15	14	8	15	4	9	8	4	5
4	12	4	8	12	11	6	10	8	12
10	4	9	2	10	6	11	7	9	9
4	8	9	6	13	10				

3029 Array 1 $\Delta t = .007$

2407									
40000									
2407	2267	138	123	54	20	8	7	4	3
2	1	3	3	1	5	0	3	1	3
2	2	1	0	1	2	0	2	2	1
0	2	0	2	0	1	1	2	0	1
5	2	4	3	0	4	2	0	2	2
1	1	3	2	2	2	0	0	1	3
1	0	1	1	1	3	1	0	1	3
3	0	0	2	0	1	1	0	1	0
2	0	1	3	1	0	3	1	1	0
1	1	1	1	0	0	1	0	1	5
40100									
2	2	1	0	2	1	3	0	0	0
3	1	3	0	2	1	1	1	2	0
1	1	1	3	4	5	1	2	1	1
0	2	2	1	0	2	3	2	0	0
1	2	3	1	0	2	2	2	4	2
1	2	8	5	5	7	7	11	10	11
11	21	21	17	34	38	38	39	49	64
61	53	73	83	76	87	92	88	113	94
106	91	93	104	105	80	91	84	82	86
85	62	60	62	51	62	47	47	34	35
40200									
30	35	24	32	15	21	23	22	15	11
10	8	11	7	10	7	5	10	2	7
4	1	3	5	1	5	5	1	6	4
2	1	0	2	3	1	3	7	0	1
2	2	0	2	0	2	1	1	1	3
0	1	5	1	2	1				

3029 Array 203 $\Delta t = .007$

7000									
10000									
355	996	896	260	111	46	36	27	24	15
17	10	18	12	13	8	11	11	13	10
11	14	15	14	20	23	33	42	51	57
170	128	162	176	202	214	193	189	175	158
149	142	134	117	82	78	70	54	59	40
30	25	13	21	18	12	12	13	17	9
12	7	9	5	3	8	10	12	16	6
7	19	15	6	11	3	7	14	8	7
10	7	10	8	6	6	11	2	10	8
9	9	11	10	9	9	16	2	14	3
10100									
9	6	8	12	7	7	10	9	11	9
8	11	11	6	6	9	5	7	6	8
12	16	13	3	9	7	8	9	14	6
9	9	17	16	6	14	13	11	8	7
7	7	14	10	7	9	9	9	6	3
3	9	6	9	7	11	6	10	5	8
5	12	11	12	15	7	11	10	6	6
9	11	3	8	3	5	9	7	9	9
10	8	7	11	14	5	5	11	13	6
8	10	14	2	12	5	10	5	10	7
10200									
10	10	4	12	7	14	6	5	8	7
8	10	5	9	14	7	7	9	9	12
7	7	14	9	10	13	10	8	10	7
3	3	6	6	5	2	5	10	3	6
5	12	7	13	8	11	8	8	13	8
6	12	7	8	10	3				

3030 Array 1 $\Delta t = .007$

2006									
40000									
2006	2436	450	143	63	26	11	8	4	5
7	4	3	2	1	2	2	3	1	1
4	1	1	4	2	2	2	3	1	1
0	1	2	2	4	0	0	0	1	4
3	0	1	0	1	2	1	1	0	5
4	1	3	0	2	4	2	0	3	2
0	2	1	0	2	0	0	2	0	0
0	1	2	0	0	1	1	2	1	0
1	2	2	3	1	1	1	0	2	2
2	0	1	0	1	0	0	2	2	3
40100									
3	1	0	1	2	1	0	0	3	1
1	1	3	0	2	1	5	3	0	0
0	1	2	0	1	3	2	0	3	0
2	4	0	0	0	1	2	0	2	1
1	3	1	2	4	1	1	3	4	2
8	7	8	17	8	18	25	20	33	45
37	34	39	55	62	69	65	63	66	65
71	76	75	74	79	78	89	71	75	68
69	67	67	70	66	60	64	50	58	50
47	48	37	28	38	28	26	19	13	15
40200									
25	14	16	8	13	9	3	6	7	5
6	9	6	5	4	2	2	3	5	1
3	3	2	7	0	3	4	6	2	2
2	3	3	3	1	1	1	3	4	1
1	1	2	1	0	1	0	2	3	0
2	1	0	1	3	1				

3030 Array 203 $\Delta t = .007$

464									
10000									
464	958	1241	438	210	95	63	33	23	31
22	18	13	14	17	12	12	17	11	20
14	18	22	11	27	32	36	39	69	68
90	107	119	132	170	177	186	166	166	159
148	164	123	123	110	98	80	76	63	45
55	41	42	35	39	26	22	17	18	25
18	12	19	17	12	12	8	14	14	11
9	9	11	19	17	13	13	11	16	11
12	14	13	10	13	13	10	10	9	16
10	15	10	12	14	14	11	14	15	12
10100									
10	14	14	7	7	16	14	18	9	9
10	11	22	17	16	13	11	11	16	11
10	12	13	10	17	16	4	13	13	11
13	11	15	11	17	14	7	22	18	11
10	12	14	17	11	16	14	17	8	14
12	14	10	11	12	12	13	14	10	20
9	19	12	13	11	8	12	8	11	10
6	12	10	15	13	5	8	17	14	12
11	6	12	16	12	7	13	21	11	14
9	5	10	14	10	13	7	12	9	16
10200									
13	10	16	8	12	16	17	11	15	9
12	9	13	10	12	10	11	16	13	18
19	12	16	13	9	15	10	10	11	17
15	11	8	12	11	12	8	12	18	10
12	6	18	13	7	18	15	10	15	16
6	11	4	11	16	19				

3031 Array 1 $\Delta t = .006$

2494									
40000									
2494	3002	696	220	99	50	27	18	6	6
10	9	2	6	5	3	6	6	2	2
3	3	0	1	2	2	2	5	2	3
4	1	2	2	2	0	1	1	1	1
3	1	3	3	2	3	4	2	2	4
0	1	0	4	1	3	2	4	0	1
2	5	1	4	2	0	2	1	2	2
0	0	0	0	1	1	0	1	1	5
0	2	3	2	2	1	0	0	0	6
1	1	0	2	0	2	1	0	2	0
40100									
0	2	1	2	0	1	1	0	2	2
1	1	1	3	3	1	1	1	2	1
2	3	0	1	1	0	1	3	2	2
1	1	1	0	1	2	0	0	4	1
3	1	3	2	0	4	6	5	4	7
5	12	13	22	16	13	22	25	23	26
36	44	35	36	60	47	59	62	64	75
46	58	72	70	53	62	73	75	66	77
68	72	71	63	58	53	73	49	53	48
37	31	37	35	39	37	26	36	27	16
40200									
20	20	14	22	18	15	17	15	18	10
11	13	5	10	9	11	13	5	8	8
6	4	7	3	7	6	6	5	3	6
4	2	4	3	2	5	7	3	3	4
3	0	2	1	5	2	3	4	3	2
3	1	3	3	3	1				

3031 Array 203 $\Delta t = .006$

547									
10000									
547	193	1482	820	420	237	126	94	72	61
25	37	36	21	34	17	20	20	18	18
25	10	21	21	28	30	37	60	70	60
70	83	103	99	102	83	79	95	114	91
84	72	78	61	68	79	52	52	62	61
61	35	39	30	35	30	28	34	24	23
19	16	16	21	10	17	11	25	27	19
10	20	16	18	14	12	11	18	18	13
21	7	18	17	12	17	19	13	15	15
12	14	21	10	14	16	15	13	19	21
10100									
10	17	13	18	13	15	11	12	9	14
14	17	11	15	7	15	14	12	10	19
15	12	17	15	22	18	8	24	23	12
15	19	12	19	20	8	19	21	10	16
16	15	11	8	12	12	18	15	11	24
11	18	15	17	17	13	12	14	19	13
11	6	13	20	10	17	16	12	24	14
14	21	16	15	9	14	12	16	12	13
9	16	17	13	12	17	12	14	12	5
13	20	10	21	19	18	14	10	12	15
10200									
13	13	16	12	17	17	19	25	6	12
14	19	13	18	20	10	7	16	12	12
22	13	17	18	13	11	12	11	10	18
8	12	13	12	14	15	13	12	11	18
13	21	9	13	15	18	23	7	12	9
13	15	16	14	11	11				

3032 Array 1 $\Delta t = .004$

2748									
40000									
2748	3236	1080	504	224	116	81	42	22	19
12	12	6	8	3	4	1	3	2	4
0	6	3	3	3	0	3	1	4	0
5	1	2	1	4	2	4	5	0	1
2	1	2	4	3	2	1	1	0	2
0	2	3	1	0	4	4	0	3	1
1	3	3	2	1	3	0	2	3	4
0	5	3	2	0	2	0	0	6	0
1	2	0	0	1	1	1	3	1	0
2	3	2	1	3	5	5	4	2	3
40100									
3	2	0	2	3	0	2	5	2	4
2	1	0	3	2	6	1	1	2	0
2	1	0	3	3	2	2	5	4	4
1	3	3	6	6	8	10	3	8	7
8	10	10	12	14	12	15	17	16	16
23	23	20	24	34	27	31	32	34	28
26	36	29	35	38	32	39	32	35	30
37	22	40	18	25	25	39	35	37	18
25	28	23	20	24	27	20	18	13	27
16	13	21	16	20	14	13	9	9	12
40200									
15	10	11	11	16	9	5	7	6	5
8	15	11	5	6	5	4	5	4	3
3	10	1	4	6	2	7	4	6	4
3	5	2	5	4	5	3	3	3	2
2	6	1	2	2	4	1	1	1	4
3	2	1	4	2	1				

3032 Array 203 $\Delta t = .004$

877									
10000									
833	2119	168	76	63	58	67	61	61	69
53	73	63	63	79	70	78	61	73	72
80	100	123	125	145	147	153	165	142	164
197	166	207	203	200	214	205	232	254	259
234	200	241	193	193	143	172	142	138	129
113	101	84	87	66	71	60	62	67	62
59	43	62	66	45	53	61	49	47	50
46	55	47	71	47	53	55	54	43	54
53	50	53	58	47	49	51	45	50	59
45	46	39	46	42	36	44	33	48	55
10100									
57	57	42	54	62	40	41	42	41	47
55	45	46	47	41	49	53	51	41	40
40	35	49	65	46	32	54	42	39	58
48	33	34	42	47	40	46	49	39	44
54	38	50	48	49	45	40	42	40	32
43	44	40	34	40	42	56	49	54	57
44	43	36	39	38	50	32	41	52	51
55	55	48	34	45	33	51	44	39	44
34	39	41	33	50	42	57	34	39	40
44	50	43	32	38	43	35	33	43	44
10200									
48	44	31	35	39	43	48	37	43	39
52	40	42	35	40	46	36	32	49	33
26	42	42	42	33	31	43	41	38	31
42	40	43	36	39	42	38	32	30	41
33	28	42	32	44	43	30	32	29	45
43	25	31	40	47	30				

3019 Array 1 $\Delta t = .03$

11954									
40000									
11954	1377	54	19	10	8	6	3	9	3
10	4	5	6	4	9	6	2	5	5
4	5	2	9	3	2	5	9	4	7
6	11	4	10	4	8	8	6	12	11
8	9	8	7	10	7	5	9	6	9
5	7	5	11	6	8	6	6	8	8
7	9	7	11	5	6	8	9	1	2
9	7	5	4	3	4	7	9	13	10
8	4	14	5	7	5	9	6	6	8
7	1	6	6	6	8	7	7	7	3
40100									
6	8	8	7	11	5	6	9	9	6
8	6	8	8	9	9	9	6	14	8
8	12	13	9	12	8	9	18	18	10
18	6	10	10	8	14	21	14	24	18
20	16	22	23	25	26	17	27	35	37
24	32	41	42	32	30	32	27	31	29
33	34	35	33	38	35	26	25	40	31
50	41	48	52	35	43	61	49	34	40
30	36	28	23	27	34	27	22	26	18
28	29	24	20	17	15	19	17	23	10
40200									
15	17	14	10	9	8	14	9	7	8
11	11	12	12	6	8	8	14	13	13
8	9	4	2	7	9	5	5	9	6
6	13	5	3	11	7	9	4	6	7
8	5	7	5	8	8	2	3	6	11
7	6	2	5	3	7				

3019 Array 203 $\Delta t = .03$

RUN - 3019 ARRAY - 203

RUN - 3019 ARRAY - 1

957									
10000									
877	1586	137	126	104	114	118	112	108	96
90	113	120	123	116	118	147	156	189	273
345	361	303	397	381	407	424	503	518	519
475	518	524	561	475	474	517	488	510	533
541	536	515	503	502	505	535	500	438	420
439	411	382	387	325	303	289	290	298	270
239	223	194	214	216	195	174	163	168	143
158	110	134	120	104	110	95	92	120	82
109	97	113	95	105	86	116	95	74	77
99	72	93	87	74	71	77	80	68	90
10100									
90	75	58	77	82	75	69	66	71	72
91	73	71	68	87	80	72	72	77	78
70	73	77	91	69	82	58	80	103	78
67	67	82	65	63	69	62	83	73	56
70	59	60	74	66	50	84	76	75	74
80	75	76	68	61	56	73	67	67	47
47	67	69	73	60	81	74	62	70	61
67	69	67	74	54	59	69	72	59	53
65	75	74	56	65	56	47	64	70	58
61	59	80	54	58	49	83	65	57	62
10200									
54	71	77	79	60	66	43	57	46	57
61	80	63	75	67	52	53	70	71	50
70	52	53	56	57	61	55	65	56	69
55	60	63	68	66	59	53	63	60	74
57	67	55	65	51	59	56	44	78	53
52	59	49	45	51	48				

3018 Array 1 $\Delta t = .055$

12085									
40000									
12085	1110	20	10	10	13	12	12	12	13
8	14	13	9	8	16	11	14	17	12
12	6	9	13	13	9	10	12	10	17
9	11	9	16	9	14	8	20	10	15
8	8	15	10	9	6	9	7	10	15
16	12	7	11	12	11	6	7	12	16
14	17	6	14	20	15	14	16	18	13
16	17	14	16	14	12	15	11	11	9
9	22	14	17	18	16	14	10	16	15
13	14	14	16	17	15	17	22	12	12
40100									
12	12	22	12	17	18	21	12	17	20
18	14	22	15	20	26	21	19	24	24
29	24	23	31	29	34	43	38	32	32
50	40	41	34	58	62	51	47	63	72
62	62	107	86	76	72	72	83	76	89
75	75	86	103	89	113	108	104	107	98
103	107	102	99	103	102	108	102	99	96
93	91	94	87	97	98	94	74	95	85
90	72	106	78	83	83	97	87	78	83
73	72	72	89	79	59	56	51	52	57
40200									
57	60	40	54	58	54	55	46	46	38
49	48	47	40	51	31	33	27	25	28
33	31	33	28	21	35	20	29	20	17
16	14	14	16	24	19	11	20	17	13
12	11	19	11	15	15	16	14	15	13
12	9	15	12	19	14				

3018 Array 203 $\Delta t = .055$

16000									
1672	124	83	63	73	72	56	55	52	
58	50	67	56	53	69	52	60	55	61
58	66	56	57	55	66	68	63	65	73
66	78	95	97	108	115	112	132	134	137
164	164	164	162	162	153	164	180	146	140
140	145	119	144	108	120	110	111	95	92
74	63	58	77	62	63	60	58	66	58
45	49	37	54	40	46	51	53	67	46
41	43	48	56	47	41	49	50	39	47
49	54	50	55	44	56	48	52	47	50
10100									
46	39	37	37	52	50	51	39	44	42
46	52	47	39	38	40	38	45	35	43
44	27	51	42	44	41	50	53	31	34
37	26	39	50	41	45	48	39	51	51
44	26	52	46	41	45	47	32	33	47
38	36	47	33	39	45	47	37	39	26
38	49	59	54	52	52	46	41	39	28
41	43	40	46	26	40	34	39	39	37
45	30	36	33	31	28	43	49	50	39
48	40	38	36	34	39	42	52	45	39
10200									
38	47	48	38	36	33	31	37	41	32
45	32	33	50	37	44	32	40	39	38
37	38	35	37	28	26	38	34	39	38
48	30	38	33	38	40	33	32	39	33
34	44	33	45	40	41	41	31	41	23
45	35	33	30	45	35				

3016 Array 1 $\Delta t = .040$

7857									
40000									
7857	1842	24	21	8	8	8	4	3	9
9	8	8	7	4	8	5	4	9	10
3	5	4	4	3	4	7	8	11	7
6	5	8	7	8	4	7	8	6	7
7	9	11	9	4	5	8	5	6	5
7	6	13	9	8	6	8	10	1	6
3	4	7	2	6	2	7	6	5	5
7	8	9	2	3	6	2	7	10	5
7	6	4	8	5	11	9	3	11	10
9	7	9	9	8	2	7	7	7	5
40100									
5	4	8	2	2	5	7	7	7	8
7	4	8	6	5	9	5	7	5	6
10	10	6	8	2	7	7	11	6	3
2	7	8	10	4	11	1	14	9	8
5	9	9	8	5	3	3	5	10	12
2	5	10	11	9	6	6	7	5	11
9	13	10	4	6	5	3	12	8	13
8	13	7	6	8	15	13	10	8	12
13	11	15	18	17	16	17	25	20	15
26	21	18	19	13	30	28	24	13	21
40200									
28	31	24	31	24	27	34	24	31	23
25	24	23	18	21	28	36	32	14	20
13	15	20	24	20	24	17	13	9	13
8	12	13	13	11	15	5	9	14	6
3	8	6	8	11	10	9	12	9	10
10	8	6	7	5	6				

3016 Array 203 $\Delta t = .040$

3006	905	117	96	89	88	80	98	110
10000	900	112	92	97	114	118	95	109
91	101	129	97	105	118	94	114	88
112	99	86	97	145	146	147	173	196
102	125	117	130	145	185	185	175	181
202	204	204	225	188	202	185	175	97
165	146	143	151	124	124	99	99	77
93	99	85	86	79	89	89	79	81
87	83	90	74	75	74	81	83	77
76	73	68	74	75	79	51	75	68
86	61	75	77	73	67	67	75	76
10100								
81	64	75	85	65	71	60	76	71
65	75	64	71	56	76	70	71	63
68	70	61	71	58	66	71	80	87
70	69	60	68	63	52	64	69	64
52	70	75	64	72	70	54	63	53
57	71	67	60	44	67	54	67	66
65	61	63	57	64	64	64	49	51
60	62	62	44	66	67	63	60	60
40	57	55	54	62	52	53	66	54
60	49	51	69	42	56	42	69	48
10200								
44	50	47	47	45	55	60	56	53
41	57	55	58	53	44	59	51	54
50	52	58	48	50	39	54	41	47
48	43	46	50	48	34	63	46	37
74	48	52	47	56	47	32	49	
47	40	47	46	50				

3006 Array 1 $\Delta t = .070$

3006	905	16	18	19	17	29	13	19
40000	900	16	18	19	17	29	13	14
91	101	16	18	19	17	29	13	14
112	99	16	18	19	17	29	13	14
102	125	16	18	19	17	29	13	14
202	204	16	18	19	17	29	13	14
165	146	16	18	19	17	29	13	14
93	99	16	18	19	17	29	13	14
87	83	16	18	19	17	29	13	14
76	73	16	18	19	17	29	13	14
86	61	16	18	19	17	29	13	14
10100								
81	64	16	18	19	17	29	13	14
65	75	16	18	19	17	29	13	14
68	70	16	18	19	17	29	13	14
70	69	16	18	19	17	29	13	14
52	70	16	18	19	17	29	13	14
57	71	16	18	19	17	29	13	14
65	61	16	18	19	17	29	13	14
60	62	16	18	19	17	29	13	14
40	57	16	18	19	17	29	13	14
60	49	16	18	19	17	29	13	14
10200								
44	50	16	18	19	17	29	13	14
41	57	16	18	19	17	29	13	14
50	52	16	18	19	17	29	13	14
48	43	16	18	19	17	29	13	14
74	48	16	18	19	17	29	13	14
47	40	16	18	19	17	29	13	14

3006 Array 203 $\Delta t = .070$

RUN - 3006 ARRAY - 203

RUN - 3006 ARRAY - 1

460									
10000									
460	118	101	112	98	103	90	103	95	89
100	94	99	108	94	108	98	92	102	83
99	98	89	92	103	89	93	85	82	91
77	72	64	71	73	95	70	84	87	85
82	81	83	79	84	65	82	87	82	81
87	63	89	82	88	109	91	97	98	92
105	122	109	126	137	135	132	135	140	159
164	163	143	185	158	177	164	174	172	196
184	176	181	191	200	222	196	218	216	222
246	252	259	249	259	246	246	246	232	242
10100									
283	292	282	267	267	241	234	237	223	213
195	204	178	185	175	171	174	147	144	145
108	134	102	109	112	111	87	94	83	110
89	75	74	77	65	94	84	63	75	60
60	81	81	54	65	69	67	69	53	55
56	61	60	60	51	69	55	47	54	59
58	63	50	59	56	46	41	47	64	52
50	57	45	56	58	35	46	42	56	49
40	54	48	37	51	47	40	35	61	44
43	42	62	42	53	33	41	52	50	43
10200									
38	42	55	56	46	47	51	46	46	43
36	42	39	51	54	44	45	32	44	48
55	44	40	40	39	40	44	43	47	56
42	45	48	22	37	45	39	52	38	34
36	49	54	29	56	43	42	49	29	41
49	29	53	33	40	46

344									
10000									
340	181	64	58	54	60	58	52	61	55
47	56	54	62	52	55	50	60	67	89
97	134	144	229	304	424	563	729	985	1146
1449	1543	1752	1792	1848	1955	1794	1666	1501	1374
1257	1082	925	742	667	571	496	394	354	284
233	227	166	165	142	119	107	84	81	77
69	57	55	47	56	56	48	46	50	33
49	47	29	40	44	32	36	52	40	46
39	34	35	40	25	32	23	40	29	32
27	25	21	30	39	28	32	31	22	44
10100									
18	34	25	25	24	24	29	29	23	30
31	34	22	24	23	25	26	21	26	33
30	30	24	17	27	24	23	22	26	24
25	24	19	24	24	30	25	25	25	15
28	13	16	28	20	22	29	18	22	23
20	17	24	28	21	35	21	16	15	24
19	15	20	19	15	22	14	21	26	17
17	25	21	14	20	15	18	15	32	15
24	19	19	20	16	20	20	21	17	15
18	15	26	16	19	20	22	20	16	15
10200									
14	16	24	16	13	21	19	14	16	15
13	13	21	13	16	19	20	14	19	9
23	17	13	14	18	27	14	19	15	11
20	23	20	22	15	18	11	11	17	18
18	15	10	11	17	18	10	16	20	13
16	13	15	15	11	16				

4510 Array 1 $\Delta t = .13$

3718									
40000									
3718	72	7	7	5	7	7	4	6	4
3	3	2	4	10	6	3	10	8	2
5	7	8	2	8	6	3	9	4	8
1	2	8	5	4	5	3	8	6	6
5	6	7	3	6	7	7	4	6	6
4	4	13	7	5	2	2	4	3	5
3	4	4	3	4	7	7	6	8	4
4	6	8	5	5	6	0	6	7	5
5	4	4	5	3	10	6	8	3	6
1	9	5	8	8	8	7	8	5	4
40100									
11	4	10	7	4	3	6	4	5	6
1	7	10	13	19	22	31	28	42	50
65	69	84	106	108	115	125	153	141	177
180	164	178	180	170	190	217	166	194	166
171	175	162	175	137	169	139	125	118	104
106	91	91	92	77	53	80	72	58	48
44	51	44	42	32	27	22	21	40	31
17	24	20	25	10	15	23	17	12	12
12	14	11	11	7	10	7	5	7	5
7	4	9	6	7	8	9	7	7	4
40200									
8	7	5	6	7	3	5	7	4	5
9	3	10	10	6	3	8	10	6	3
9	7	4	6	6	6	8	1	9	10
2	5	4	11	5	10	12	10	1	7
2	10	8	7	3	5	6	3	4	8
8	8	3	5	9	7				

4510 Array 203 $\Delta t = .13$

RUN - 4510 ARRAY - 1

248	565	30	32	28	25	31	26	16	22
29	25	21	21	25	35	43	45	64	77
92	141	203	287	342	504	639	816	918	951
1005	1081	962	964	804	757	625	569	464	359
280	263	206	175	139	117	91	86	68	58
50	55	39	42	38	33	37	33	33	30
23	28	29	23	30	14	23	11	16	16
26	24	20	17	16	21	20	20	18	21
19	18	11	17	20	12	17	16	22	21
21	13	15	20	22	20	18	11	20	10
10100									
17	23	22	7	14	15	15	19	19	21
20	14	26	15	24	21	19	9	9	16
18	13	23	19	27	20	23	12	18	11
17	12	23	15	17	15	21	12	17	14
13	22	13	11	17	14	16	16	15	21
15	16	15	13	13	17	12	12	20	19
17	24	9	20	13	18	16	7	11	14
13	10	15	10	6	13	11	20	19	15
23	12	13	15	19	12	17	11	14	11
15	19	7	9	13	10	13	9	16	14
10200									
15	16	15	12	8	15	14	12	10	15
12	12	13	13	10	13	12	9	11	10
13	9	14	11	19	10	9	17	9	8
8	12	14	14	10	13	7	18	9	10
8	15	16	11	8	17	17	12	7	16
19	20	8	14	11	13				

4511 Array 1 $\Delta t = .065$

3101									
40000									
3101	319	7	5	1	3	3	6	3	5
1	3	6	1	2	2	2	4	1	4
4	4	0	3	5	2	2	4	2	3
2	2	4	8	4	1	6	2	3	4
0	3	4	3	2	5	2	1	3	2
3	5	3	4	1	5	3	5	2	5
3	4	2	5	2	7	1	2	2	3
1	4	3	5	5	0	4	4	3	1
1	2	3	4	3	3	4	2	3	7
2	0	5	2	2	3	5	6	2	5
40100									
3	7	9	15	20	27	49	59	68	62
90	107	120	139	158	179	187	205	200	198
212	226	216	226	224	191	208	198	198	169
157	158	131	146	125	120	107	106	94	71
76	74	70	37	44	58	30	32	32	28
16	32	22	21	22	22	15	17	18	12
16	15	11	11	2	7	2	7	3	6
10	8	5	10	5	7	6	3	3	6
5	3	6	6	3	5	3	7	4	6
4	3	4	6	2	4	3	3	6	2
40200									
5	3	2	2	1	5	7	3	1	3
3	1	4	6	3	4	3	5	5	5
2	2	2	5	5	0	2	7	8	1
2	3	2	3	3	2	4	1	5	2
3	7	4	3	4	2	2	3	3	2
3	3	4	5	1	3				

4511 Array 203 $\Delta t = .065$

10000	94	609	41	14	16	8	8	5	4	6
	12	12	14	11	10	14	8	15	9	12
	8	7	17	16	29	27	49	50	83	103
	135	149	206	237	283	332	392	438	450	462
	454	428	428	363	361	343	297	261	216	226
	185	138	118	111	73	85	58	58	50	39
	41	42	22	20	25	19	14	10	18	8
	10	11	12	11	5	6	12	11	4	9
	14	12	16	8	6	7	7	3	15	6
	6	6	12	10	12	8	9	10	12	9
10100	5	7	2	9	6	6	9	10	14	11
	9	10	8	7	7	4	11	10	10	8
	6	7	7	4	5	2	7	15	6	6
	5	5	7	5	8	2	10	8	7	9
	7	2	9	9	5	12	11	7	6	7
	4	8	10	8	5	6	3	3	7	6
	5	3	6	6	10	3	6	9	6	6
	3	9	6	8	7	7	3	5	7	2
	8	4	6	3	12	4	9	8	3	5
	4	8	6	8	5	8	6	8	5	4
10200	8	11	13	5	6	2	4	7	1	7
	7	8	6	9	6	11	8	6	8	5
	3	8	6	7	7	9	3	7	5	3
	4	6	9	4	6	7	4	11	7	4
	6	3	4	8	6	10	2	7	9	4
	7	7	3	9	3	7				

4512 Array 1 $\Delta t = .030$

1782										
40000										
1782	828	6	3	1	2	1	1	0	0	
1	1	3	1	1	1	0	1	0	0	
1	4	2	0	0	1	2	0	0	1	
2	2	0	0	1	1	0	1	1	0	
0	0	1	2	0	1	0	2	0	0	
0	0	1	0	2	1	1	1	1	1	
0	0	1	3	1	1	1	0	2	1	
1	0	0	2	2	0	0	1	1	1	
1	2	0	0	1	1	1	0	1	1	
1	2	2	2	1	1	2	2	1	1	
40100										
1	2	1	2	0	3	5	1	1	1	
2	0	1	2	1	2	0	1	1	1	
2	1	2	0	3	0	1	2	2	3	
5	1	6	6	11	10	14	24	35	21	
34	59	53	57	53	83	82	97	98	101	
90	124	98	120	120	116	96	115	94	129	
102	107	107	105	101	103	106	95	94	83	
75	74	67	60	47	50	56	59	45	49	
35	38	32	32	33	28	17	20	22	19	
24	24	10	7	8	9	10	8	8	10	
40200										
3	2	3	6	6	4	8	4	3	6	
7	2	0	0	1	2	3	6	5	1	
7	8	2	4	2	0	2	2	0	2	
4	3	3	1	4	2	2	2	1	0	
1	0	1	3	2	1	3	0	2	4	
2	1	1	1	1	0					

4512 Array 203 $\Delta t = .030$

RUN - 4512 ARRAY - 203

RUN - 4512 ARRAY - 1

476									
10000									
476	1562	902	217	91	67	21	26	13	22
12	12	10	19	14	8	12	8	18	17
14	21	18	29	30	44	51	55	69	111
118	152	188	200	249	306	314	299	318	265
286	303	241	236	176	169	165	139	110	92
76	51	54	45	43	25	23	30	22	22
18	13	18	14	20	17	16	10	9	13
15	10	12	12	12	14	11	20	10	13
9	16	12	20	15	8	19	8	4	10
13	19	17	12	15	12	16	8	7	13
10100									
8	9	8	8	9	11	7	7	8	12
12	8	15	9	10	10	8	8	6	11
11	9	14	6	10	9	11	9	15	13
19	9	5	10	12	9	9	13	11	11
17	21	9	12	11	17	12	12	14	6
18	5	5	7	8	11	10	5	12	19
12	8	14	12	9	14	8	8	10	18
10	5	12	13	7	9	15	7	9	8
6	9	12	11	13	12	10	14	7	10
13	11	11	10	17	10	16	9	12	8
10200									
10	11	12	10	11	12	7	10	13	8
15	21	13	16	10	10	13	20	14	10
15	16	6	9	7	11	9	13	12	18
17	9	10	15	8	9	16	9	9	9
15	10	12	9	12	9	9	13	9	6
7	11	7	5	17	10				

4513 Array 1 $\Delta t = .0078$

3680									
40000									
3680	3223	479	148	46	14	7	3	5	5
8	3	2	0	1	4	5	1	2	1
2	0	0	1	0	5	1	0	2	5
1	3	4	3	0	1	1	1	2	1
2	1	2	0	2	0	1	1	2	1
0	1	0	3	0	3	2	1	2	2
2	1	5	4	2	2	2	3	2	3
1	1	1	0	2	3	2	3	2	0
2	0	4	3	3	1	0	1	0	0
0	0	2	3	1	1	0	3	2	0
40100									
1	1	2	1	1	1	2	2	0	2
4	2	3	2	2	0	4	2	5	1
0	3	3	2	4	1	5	5	7	4
11	26	11	25	26	42	44	41	52	67
61	85	68	97	96	107	82	108	109	110
115	108	112	111	118	97	105	115	97	86
92	80	76	72	61	73	48	48	56	56
37	39	33	31	28	28	27	23	27	15
20	19	15	14	7	8	5	10	6	8
5	5	5	5	3	3	4	4	5	4
40200									
3	5	6	1	1	2	1	4	3	3
2	1	1	2	1	7	3	1	0	3
2	0	1	2	0	1	3	2	2	0
0	2	2	1	3	0	1	3	0	0
4	1	1	1	1	2	1	1	0	0
0	0	1	0	1	1				

4513 Array 203 $\Delta t = .0078$

259									
10000									
259	939	115	27	17	14	10	9	11	9
3	13	11	8	5	8	8	7	6	15
13	16	14	24	30	31	43	60	82	103
128	165	183	223	247	266	311	298	291	285
254	245	220	166	172	131	118	101	93	65
52	58	42	35	34	29	23	15	17	13
17	9	6	8	10	7	10	8	6	4
6	9	5	7	4	9	8	7	7	6
6	7	3	14	3	5	5	8	9	6
7	9	8	8	6	4	9	4	9	5
10100									
6	5	2	6	9	4	4	5	5	7
3	5	5	7	4	2	7	7	8	8
5	5	10	7	8	10	9	5	6	6
3	7	7	3	2	8	3	5	9	8
5	5	9	8	7	6	3	7	6	3
4	9	7	6	6	5	5	8	6	9
9	5	4	3	4	4	5	5	1	6
5	5	4	7	4	7	1	8	8	8
10	7	4	7	7	5	8	3	8	11
5	5	8	6	3	6	13	5	4	5
10200									
4	6	7	3	7	6	5	6	5	5
5	12	5	6	7	4	6	4	7	11
2	5	11	9	3	3	10	4	4	3
6	7	5	5	3	7	2	7	2	5
6	7	8	2	9	4	6	3	3	6
3	2	2	9	3	4				

4514 Array 1 $\Delta t = .014$

3030									
40000									
3030	686	58	9	7	1	3	2	1	1
1	0	1	2	2	1	2	1	0	1
0	1	0	2	1	3	0	1	1	1
1	0	0	1	0	1	1	1	0	2
0	0	2	1	1	0	0	3	0	0
3	0	0	2	0	0	1	0	0	1
1	0	0	1	1	2	0	1	1	2
0	0	0	0	1	0	0	0	1	1
1	0	0	1	1	0	1	1	0	0
1	1	0	0	1	0	1	2	1	1
40100									
1	0	3	1	3	0	3	3	0	1
0	1	2	0	0	1	0	0	3	1
0	1	3	0	5	1	8	4	10	12
15	30	21	36	30	62	56	64	64	71
90	81	67	85	114	85	90	103	79	119
88	100	105	85	95	95	92	80	95	74
56	70	56	68	50	53	39	39	30	32
36	24	34	20	25	13	17	18	14	8
9	8	18	15	14	6	8	7	8	7
4	6	6	4	3	4	1	2	1	3
40200									
5	1	2	2	2	0	2	3	0	0
0	2	1	1	3	3	0	3	0	3
1	0	0	1	1	0	0	1	1	5
1	2	0	0	4	1	0	0	1	0
1	1	6	0	1	0	0	0	1	1
8	6	0	0	1	0				

4514 Array 203 $\Delta t = .014$

RUN - 4514 ARRAY - 1

10000									
182	51	56	43	44	33	39	47	32	38
33	25	29	49	32	35	47	43	49	44
51	57	56	58	76	71	70	99	96	121
127	174	171	160	204	254	102	377	491	543
516	527	415	160	386	319	317	267	231	239
196	182	174	227	167	168	163	120	102	117
105	97	69	94	86	86	61	59	49	55
48	37	31	53	25	39	26	31	22	29
31	20	27	24	27	23	23	35	20	21
25	24	20	20	25	21	22	24	34	14
10100									
20	20	19	25	22	13	16	28	17	24
19	22	21	20	21	18	16	20	13	13
15	17	17	19	17	14	14	19	15	18
16	14	24	22	26	17	15	22	13	19
19	8	15	20	13	17	27	23	8	18
17	21	19	23	17	22	13	4	18	16
26	18	10	24	21	19	14	15	19	17
17	15	12	23	17	12	12	17	17	16
9	19	15	8	24	11	11	10	14	15
15	16	18	13	20	21	18	19	14	11
10200									
11	10	11	17	17	15	12	16	14	11
18	16	15	9	19	13	10	14	14	17
13	16	18	10	9	11	13	9	7	10
10	13	11	17	16	14	18	11	14	10
11	13	16	14	9	14	12	13	17	12
14	11	12	19	11	8				

3514 Array 1 $\Delta t = .130$

2587									
40000									
2587	12	2	5	5	8	4	2	7	7
4	4	3	7	5	6	8	6	8	4
1	9	5	3	5	3	6	6	3	4
2	5	8	2	1	4	2	1	7	4
3	4	6	5	4	5	7	6	9	1
3	5	2	2	2	4	4	4	6	8
3	6	5	7	6	5	1	5	3	8
6	5	8	4	4	3	7	2	7	0
5	5	6	2	7	4	5	6	7	4
7	3	7	2	10	8	3	3	7	4
40100									
3	3	8	4	6	9	8	5	8	7
11	10	9	11	10	14	12	13	16	16
15	12	13	18	18	17	17	22	22	20
39	31	43	27	35	39	37	49	37	36
38	47	32	35	28	43	46	41	37	36
36	41	39	31	29	33	24	38	24	24
29	23	16	25	18	16	15	11	10	8
12	9	9	13	9	4	4	5	11	2
4	2	4	6	8	2	5	3	6	6
5	7	10	1	3	10	6	4	7	4
40200									
5	4	7	5	3	0	5	8	4	4
5	6	4	7	6	2	3	3	8	2
7	4	2	4	4	12	2	3	4	4
4	7	7	3	3	2	4	0	3	1
9	7	7	7	3	8	2	1	3	2
2	3	5	6	5	5				

3514 Array 203 $\Delta t = .130$

TIME (SEC)

141									
10000									
341	154	68	72	60	78	72	66	83	89
89	91	119	146	188	205	310	362	354	366
353	348	345	311	217	242	276	262	231	229
289	279	262	287	223	257	239	188	200	202
100	207	187	179	109	177	175	165	158	143
115	125	119	136	154	130	151	179	149	137
103	126	86	79	59	56	55	53	56	49
42	43	39	33	49	50	34	31	32	49
33	43	33	32	40	34	40	29	42	37
30	21	32	28	30	30	28	42	36	36
10100									
32	32	26	37	26	30	25	30	24	26
25	25	26	15	35	31	20	24	29	37
39	36	29	42	30	29	28	34	33	31
28	31	31	31	33	26	33	32	27	29
19	36	28	29	33	34	22	30	28	24
19	35	29	29	24	34	27	23	23	30
34	27	23	14	21	22	22	24	22	16
26	22	15	31	24	31	29	19	23	29
29	29	18	29	22	30	16	16	23	23
25	21	27	16	22	25	14	16	15	21
10200									
30	24	24	27	17	25	11	20	19	31
25	18	18	21	20	20	14	20	23	8
14	17	20	30	14	30	22	16	17	16
14	17	15	16	16	21	19	20	20	14
17	28	25	24	16	19	18	17	16	16
16	27	17	13	17	18				

3515 Array 1 $\Delta t = .130$

4427									
40000									
4427	48	4	6	3	13	8	6	5	4
11	4	5	8	8	9	6	8	11	6
5	14	8	9	9	12	12	7	7	7
3	8	7	15	5	6	4	6	10	1
11	12	11	11	8	12	14	6	11	5
4	10	8	5	9	9	7	6	8	10
8	8	8	7	10	11	16	18	20	18
15	25	20	14	14	23	11	26	16	24
13	17	14	19	18	19	16	13	24	18
14	13	18	13	25	32	43	62	61	70
10100									
52	42	34	36	34	34	23	26	29	18
22	23	22	12	16	10	20	15	23	22
31	34	20	19	13	21	23	17	14	19
17	9	16	10	11	20	18	10	9	4
7	8	8	9	8	9	12	15	6	3
12	8	9	2	7	6	4	11	10	5
4	4	7	6	12	5	6	5	6	9
5	5	11	6	7	3	15	9	6	11
8	9	10	7	4	8	7	8	4	6
5	4	3	7	11	4	10	7	6	4
40200									
7	6	15	6	1	8	4	7	6	7
4	6	10	4	11	3	5	5	1	11
5	1	8	7	5	8	1	7	5	8
4	10	7	7	3	5	7	4	5	9
8	6	10	8	6	1	1	8	10	3
3	8	5	10	3	8				

3515 Array 203 $\Delta t = .130$

1200									
10000									
1200	435	94	116	87	93	78	96	80	96
87	82	95	99	97	116	107	142	134	139
174	213	269	357	440	578	717	829	845	951
928	994	932	980	940	964	980	932	910	906
912	1020	1036	1048	1035	1069	1034	1016	1078	1070
1059	1154	1164	1109	1082	1049	893	815	704	667
557	462	444	380	325	331	297	240	206	176
176	135	136	128	103	106	101	105	110	98
86	78	78	86	96	75	82	91	68	67
87	86	70	79	68	79	75	78	93	77
10100									
67	72	64	75	79	76	81	59	70	67
71	81	77	70	66	63	63	75	71	66
67	71	70	67	64	74	67	60	64	58
63	74	67	51	81	61	62	70	79	64
59	65	81	73	72	66	69	67	60	64
65	76	67	66	66	71	75	79	79	86
74	74	74	78	73	85	75	79	73	85
86	74	80	73	74	91	69	61	66	60
60	70	60	62	53	63	61	60	61	55
52	67	53	59	53	56	52	49	64	65
10200									
65	53	54	58	64	54	54	51	62	52
60	49	49	61	55	59	59	54	54	62
45	57	56	49	53	58	54	63	62	79
62	50	59	51	60	46	60	51	45	48
56	56	58	59	51	53	53	55	56	58
52	52	49	52	54	57				

3517 Array 1 $\Delta t = .080$

7534									
40000									
7534	179	8	10	10	10	14	9	7	9
9	12	11	8	8	7	12	9	11	12
9	6	6	11	7	10	3	8	8	5
4	11	7	9	6	9	8	9	9	5
10	11	6	8	8	4	11	3	3	4
3	7	12	8	7	12	13	9	6	11
11	13	14	4	15	12	9	14	7	8
5	9	8	5	10	7	10	3	4	10
10	8	5	13	8	7	8	11	11	8
9	13	13	8	13	11	7	9	8	16
40100									
10	10	8	8	7	14	5	17	8	10
7	9	8	7	13	5	4	6	6	9
7	8	13	17	16	19	9	19	28	24
32	29	46	31	33	36	51	50	75	66
63	74	81	109	117	133	139	160	147	161
171	210	228	218	246	238	227	242	254	257
255	254	259	258	249	235	223	230	251	208
192	168	153	163	130	143	146	132	131	140
116	115	104	99	94	69	85	73	72	61
52	37	60	43	44	24	33	25	31	32
40200									
24	21	23	18	27	22	16	9	13	8
20	21	15	15	18	9	8	15	9	8
12	9	13	9	10	5	9	8	5	7
7	6	12	6	7	4	9	11	11	11
8	8	9	9	5	6	6	7	7	11
10	8	8	5	6	8				

3517 Array 203 $\Delta t = .080$

RUN - 3517 ARRAY - 203

RUN - 3517 ARRAY - 1

736									
10000									
336	827	54	46	25	31	36	27	42	42
39	29	48	36	58	74	90	85	134	142
171	150	172	154	155	157	135	121	129	130
107	113	110	98	77	71	57	62	65	51
54	47	41	43	31	40	37	39	32	34
27	34	32	27	29	26	34	27	30	25
18	19	32	21	28	33	40	33	20	28
29	19	32	34	32	26	29	29	29	24
30	21	26	29	25	22	18	21	23	35
28	29	31	30	26	15	29	20	39	26
10100									
22	32	23	29	26	35	17	16	18	35
17	29	27	24	21	16	27	26	28	19
38	33	27	23	19	22	27	27	20	26
36	24	26	23	28	19	25	24	27	29
23	20	22	28	29	24	21	20	21	22
27	24	28	30	31	22	21	27	22	32
22	26	26	28	26	14	22	21	31	22
25	24	19	28	21	27	24	21	26	26
36	27	21	21	25	24	19	19	20	22
22	26	19	26	35	23	19	35	24	24
10200									
23	14	19	20	21	18	21	20	27	26
26	20	22	19	12	13	23	22	23	17
21	25	33	23	16	31	19	17	14	20
20	18	18	23	20	21	18	22	16	22
25	34	17	25	13	28	24	25	26	21
21	19	26	16	27	17				

3518 Array 1 $\Delta t = .040$

5754									
40000									
5754	511	13	9	5	1	4	5	6	4
6	3	6	7	5	5	4	5	6	4
3	3	6	6	6	2	4	7	7	5
2	2	5	5	6	4	2	4	4	3
5	1	5	4	4	5	2	5	5	2
6	3	4	1	2	7	5	3	4	4
4	7	5	2	5	3	3	5	5	2
2	6	3	7	1	4	5	6	10	1
4	1	1	3	4	2	7	10	0	5
4	9	9	6	5	2	6	1	6	2
40100									
6	6	5	5	7	5	6	5	7	8
2	6	9	4	10	13	9	8	10	11
14	13	18	12	18	14	25	26	19	24
17	26	39	32	27	18	46	31	33	38
34	41	43	47	35	56	44	62	50	68
50	63	63	54	57	51	43	37	43	45
44	56	42	57	38	35	43	38	23	27
30	21	21	19	23	20	18	25	15	15
11	20	10	17	14	8	9	10	12	15
4	8	5	7	4	6	4	9	6	5
40200									
3	6	5	10	4	9	8	8	9	5
3	5	6	4	7	7	6	9	3	4
4	3	7	3	9	5	2	4	8	3
5	2	2	5	5	5	5	2	2	3
2	1	5	4	4	4	3	6	4	10
2	9	4	3	2	7				

3518 Array 203 $\Delta t = .040$

172									
10000									
172	276	22	19	11	12	16	10	17	12
19	13	13	16	15	23	22	40	57	53
98	120	173	191	237	265	252	262	249	191
187	170	175	113	100	91	62	53	47	39
39	20	10	21	23	18	9	15	11	15
19	11	14	19	14	10	11	11	12	12
19	13	17	7	9	13	13	13	8	15
11	11	8	14	16	9	14	14	14	14
13	6	7	15	14	14	12	14	16	14
16	14	14	9	11	12	10	18	15	8
10100									
14	12	15	22	9	15	10	12	13	11
13	9	21	11	11	7	16	16	17	18
11	10	9	9	10	13	11	13	11	10
9	15	11	12	17	9	15	7	11	5
10	14	7	6	8	13	12	9	8	11
10	18	4	11	13	10	14	11	11	12
12	13	13	9	9	7	8	9	8	8
11	12	11	10	8	13	10	5	15	9
7	12	9	13	6	15	7	14	12	10
11	9	13	6	11	6	10	8	10	6
10200									
11	11	4	5	6	9	17	12	5	11
8	11	12	6	11	12	12	9	10	9
12	8	6	5	10	6	7	12	5	16
9	8	11	16	16	11	6	12	13	4
7	12	9	8	9	9	9	5	7	7
8	11	11	4	4	9				

3520 Array 1 $\Delta t = .034$

3073									
40000									
3073	101	5	5	1	3	1	3	1	2
2	3	3	1	6	0	1	2	0	0
1	3	3	1	2	1	0	0	1	2
2	1	3	0	2	2	1	6	2	2
2	2	0	2	1	2	0	1	3	2
4	1	2	4	4	0	4	1	0	2
1	1	1	1	3	3	1	1	0	1
0	0	2	3	4	3	2	3	0	2
0	2	5	2	1	2	1	3	3	2
5	2	2	3	2	0	3	3	6	3
40100									
1	0	3	2	2	2	2	1	1	1
2	3	1	1	4	4	4	2	1	4
1	0	1	6	1	0	2	1	1	1
1	1	1	3	2	0	3	4	3	3
2	5	1	5	3	3	5	4	6	2
9	5	9	10	8	11	16	23	29	19
20	29	31	39	39	39	47	46	46	63
54	63	77	61	61	49	74	62	65	61
63	45	55	63	63	57	48	54	50	53
49	44	47	40	37	43	32	37	33	34
40200									
31	20	29	19	32	22	22	28	13	15
19	26	12	17	14	13	9	10	9	7
2	7	7	10	12	4	7	4	5	3
7	6	3	6	4	1	5	5	4	6
3	3	3	4	3	2	3	1	1	1
2	1	4	0	5	2				

3520 Array 203 $\Delta t = .034$

3438									
10000									
219	210	50	23	25	15	20	4	13	16
16	15	8	12	17	23	18	19	32	31
49	54	56	103	98	130	159	155	187	152
191	193	183	170	157	145	127	102	89	77
82	79	47	59	51	49	49	44	40	31
37	26	24	28	19	14	19	17	9	15
14	20	10	20	11	13	11	14	10	11
12	10	12	10	10	11	16	14	10	4
11	15	12	6	11	8	8	8	16	7
10	13	12	12	14	15	13	9	7	8
10100									
18	7	11	10	12	8	10	6	16	15
7	14	8	5	13	12	10	8	9	8
12	9	16	15	12	7	14	9	12	12
14	7	11	13	13	10	16	12	14	7
12	13	21	9	12	9	7	9	14	10
15	6	14	15	9	11	13	16	6	12
7	5	8	7	11	10	10	13	7	9
14	6	9	13	11	12	7	5	5	11
7	14	10	14	5	9	12	6	10	16
15	13	14	13	6	8	9	12	5	8
10200									
13	12	10	10	11	4	8	17	14	15
11	5	12	7	10	0	7	10	6	7
17	13	7	11	13	10	9	12	7	6
5	8	12	11	7	13	7	12	13	11
11	10	11	5	8	12	9	8	11	10
11	9	6	8	10	9				

3521 Array 1 $\Delta t = .025$

3438									
40000									
2438	393	16	1	6	4	2	1	1	1
2	1	1	3	2	2	3	2	0	1
3	2	3	1	1	2	0	0	0	0
2	3	0	2	1	1	0	1	2	4
0	0	1	1	0	0	0	0	2	1
4	0	1	2	0	2	0	0	1	1
1	0	3	4	4	2	1	0	1	2
1	4	1	0	2	1	0	2	1	2
2	7	3	3	2	1	1	0	0	2
2	1	1	1	1	4	2	4	3	1
40100									
4	2	2	0	2	0	0	0	2	2
0	1	1	4	1	2	2	1	0	1
3	1	0	1	0	1	0	0	3	1
1	4	5	4	7	10	5	7	4	10
9	11	13	16	20	21	19	23	15	22
27	19	33	25	30	38	32	39	46	44
42	48	28	42	39	40	19	42	53	43
39	47	54	41	42	51	49	38	61	55
58	46	56	55	49	65	47	44	51	41
63	49	44	45	42	36	30	33	33	33
40200									
25	29	24	33	21	36	22	17	23	21
19	23	31	24	15	18	5	14	17	10
12	12	4	14	6	12	2	14	10	10
8	11	8	8	7	4	10	3	4	6
6	5	2	3	4	6	5	3	4	3
1	3	2	3	1	1				

3521 Array 203 $\Delta t = .025$

101									
10000									
115	89	54	15	13	19	10	13	10	16
8	8	19	10	23	43	49	59	54	89
77	85	84	77	72	81	72	80	86	62
66	64	73	10	46	45	43	59	39	32
37	39	25	32	35	33	31	22	30	16
28	24	19	19	24	17	23	10	17	14
20	11	14	20	15	10	8	11	12	14
6	12	13	10	15	10	12	2	10	11
15	8	17	6	41	7	9	11	11	10
8	17	11	8	10	10	13	5	12	6
10106									
9	10	3	11	5	4	7	10	2	9
7	10	9	12	15	9	15	4	2	14
10	10	8	4	8	11	12	5	16	10
7	12	6	6	9	9	12	13	8	8
7	11	7	13	7	7	16	7	6	10
5	14	9	7	10	6	8	7	8	9
9	10	3	6	7	8	6	7	10	5
6	9	7	11	12	9	12	7	7	10
5	8	11	14	7	6	13	4	5	11
4	11	2	13	5	5	8	5	7	8
10208									
10	4	10	6	2	4	8	6	8	6
7	9	5	6	8	6	8	7	4	11
5	9	8	5	10	9	10	6	4	17
5	8	8	6	9	7	7	9	8	9
9	14	6	9	5	3	6	7	7	6
6	8	10	4	9	5				

3522 Array 1 $\Delta t = .020$

3571									
10000									
3671	159	18	10	0	0	1	4	2	2
1	2	1	0	0	2	1	1	3	1
2	2	4	1	1	1	4	0	1	0
1	2	2	0	1	2	1	0	0	1
1	0	1	1	1	3	0	0	2	1
1	0	2	3	2	0	2	2	0	1
0	1	1	3	0	0	0	1	0	0
3	2	1	4	1	0	2	2	1	1
0	0	3	1	0	1	1	1	3	2
0	3	1	4	4	6	6	5	6	6
40100									
15	7	15	6	16	10	15	8	14	18
12	14	16	8	14	15	16	16	19	15
22	17	22	18	19	20	12	20	16	19
19	12	17	22	22	19	23	14	19	12
14	13	15	9	10	14	13	14	13	18
9	13	12	8	14	15	18	19	14	21
12	6	13	15	15	17	7	13	10	17
16	9	21	22	13	15	14	8	9	12
11	11	11	12	9	10	21	13	20	9
14	10	9	13	14	16	14	18	8	8
40200									
7	12	10	14	3	7	3	7	7	5
8	3	8	4	7	5	6	4	5	0
3	5	2	5	4	1	3	2	1	2
3	1	1	1	0	2	2	6	1	3
3	2	0	0	2	0	0	0	2	0
2	5	0	2	2	0				

3522 Array 203 $\Delta t = .020$

[illegible]

10000									
188	1167	116	38	22	13	11	11	10	13
14	12	12	19	26	26	25	21	12	20
23	13	22	17	17	15	19	23	13	23
16	26	19	16	23	16	20	16	11	14
13	10	11	5	9	12	6	10	9	10
12	5	6	8	6	11	8	7	6	6
9	6	12	10	5	11	7	16	12	5
8	12	6	5	7	14	8	9	8	6
8	5	8	5	9	6	10	7	13	10
7	10	7	6	8	8	9	12	10	7
10100									
5	11	8	12	10	10	3	5	8	8
9	7	3	10	6	7	5	5	7	9
11	9	6	11	3	9	3	4	7	11
3	5	6	5	10	4	3	5	9	7
3	7	5	8	10	10	3	8	7	12
10	5	1	5	9	8	6	7	9	6
14	9	9	7	5	11	7	4	10	10
8	10	6	4	12	3	3	10	4	8
8	1	6	5	8	10	7	10	3	6
7	6	7	12	12	10	5	8	15	7
10200									
9	7	4	5	9	5	7	10	11	6
7	8	6	4	3	13	9	2	10	8
6	8	5	5	2	6	3	1	11	8
5	2	6	6	6	9	4	7	8	13
3	10	8	6	9	4	6	8	11	10
5	5	5	3	8	10				

3524 Array 1 $\Delta t = .017$

2828									
40000									
2828	761	55	13	5	1	1	2	3	5
2	1	1	0	0	1	0	1	0	1
0	3	0	2	0	1	1	1	0	3
4	1	0	0	1	1	1	0	2	0
0	0	0	0	0	2	2	0	1	2
3	2	3	4	0	4	3	4	4	7
2	2	6	2	5	5	8	5	6	5
8	10	1	3	3	6	4	3	4	1
2	2	2	1	2	1	3	2	3	5
3	0	1	3	7	5	4	5	7	3
40100									
6	6	6	5	9	2	4	6	6	3
3	2	0	4	2	2	3	1	7	2
3	2	4	10	3	7	5	7	5	2
3	1	2	3	3	4	3	2	0	5
6	4	5	3	3	1	3	0	2	0
0	1	4	1	3	1	0	1	3	0
3	1	1	2	1	1	1	1	1	2
0	1	2	2	0	0	2	0	0	4
0	2	2	0	1	2	0	2	0	2
1	0	3	0	1	1	1	1	2	1
40200									
2	1	0	1	1	2	1	1	1	1
1	0	1	2	0	2	1	1	1	2
3	1	2	3	1	2	2	1	1	2
1	0	1	2	1	2	0	2	1	1
0	2	1	1	0	0	2	3	1	0
1	1	1	0	0	3				

3524 Array 203 $\Delta t = .017$

2202	10000	817	259	84	40	25	23	24	18
40000	234	16	16	12	13	9	6	13	9
2202	14	19	7	17	16	27	24	29	41
40000	41	57	62	50	93	98	105	125	124
2202	119	93	129	89	74	75	85	68	72
40000	63	49	38	44	44	26	25	27	18
2202	21	19	16	19	17	14	7	9	11
40000	11	10	16	12	11	11	11	12	6
2202	8	6	9	4	11	7	11	15	18
40000	12	11	5	8	8	11	13	8	7
2202	10000	11	11	4	15	9	8	8	12
40000	12	9	13	8	13	9	7	7	13
2202	10	11	13	13	11	11	15	10	12
40000	12	10	14	14	12	9	8	8	7
2202	8	1	6	17	7	7	8	5	11
40000	9	5	6	7	5	6	9	5	8
2202	13	9	7	5	11	10	11	12	13
40000	12	5	8	13	4	6	12	9	7
2202	16	7	13	8	5	9	12	11	9
40000	5	13	11	9	9	5	5	14	8
2202	10200	7	17	5	5	11	8	10	10
40000	6	7	14	11	8	11	12	5	8
2202	9	9	8	8	9	5	9	15	13
40000	3	6	8	11	5	10	11	9	6
2202	14	8	10	11	5	9	11	9	6
40000	6	8	9	12	5	9	8	5	10
2202	11	7	6	17	10				

3525 Array 1 At = .007

2202	2325	397	101	51	21	15	13	7	5
40000	3	1	2	5	2	0	5	5	4
2202	1	1	3	1	3	0	1	4	4
40000	2	3	1	2	0	1	2	1	2
2202	1	1	1	2	3	1	0	2	2
40000	1	2	2	1	3	1	1	2	2
2202	1	2	0	1	2	3	3	2	2
40000	0	0	0	1	3	5	1	4	0
2202	3	1	1	2	1	1	0	1	1
40000	0	1	2	0	3	0	3	5	1
2202	1	1	2	1	3	5	0	0	2
40000	0	1	1	1	2	0	0	2	0
2202	3	1	1	2	2	0	0	7	13
40000	1	5	3	0	6	5	11	16	28
2202	16	6	22	21	24	14	35	45	40
40000	38	38	49	31	47	34	38	38	51
2202	40	43	45	49	42	46	31	40	34
40000	37	46	42	40	36	35	40	40	
2202	36	16	30	27	27	34	29	20	33
40000	30	24	24	17	21	22	13	20	15
2202	26	13	12	16	14	8	13	6	7
40000	12	4	7	12	2	5	6	4	1
2202	9	4	2	8	3	5	3	3	
40000	3	11	2	8	6				
2202	3	4	5	8					

3525 Array 203 At = .007

298									
160000									
298	1416	541	145	68	34	30	18	18	17
14	7	18	9	14	14	12	13	17	16
15	23	24	23	32	43	83	75	73	97
123	116	107	107	116	105	113	92	83	67
62	58	45	57	31	34	29	37	18	26
20	17	21	25	10	13	13	17	18	20
14	11	15	14	14	6	9	11	15	11
11	9	10	8	12	12	11	13	9	18
13	12	16	12	13	9	15	12	12	13
14	7	12	6	16	12	7	9	13	12
10100									
11	19	15	13	14	10	10	11	10	11
13	11	9	10	9	11	8	14	8	20
14	13	15	8	3	17	15	16	11	7
9	10	9	12	10	5	10	16	9	7
7	8	13	12	10	13	7	15	13	9
12	16	8	12	11	7	11	4	10	9
11	11	9	10	11	11	10	7	11	10
9	12	13	11	15	15	10	15	9	11
10	8	13	7	9	11	14	12	14	9
12	13	6	12	7	6	10	10	14	7
10200									
17	23	14	14	11	10	17	16	6	19
13	8	11	10	8	9	13	11	11	11
9	7	12	5	18	8	17	13	13	8
8	10	13	13	10	6	9	8	16	7
9	8	8	10	6	6	15	12	12	8
9	13	17	8	7	9				

3526 Array 1 $\Delta t = .008$

3173									
40000									
3173	1585	268	59	25	13	8	6	7	3
3	4	2	0	4	3	1	3	1	3
5	1	3	1	3	7	3	1	5	1
3	2	0	0	2	1	1	0	2	0
2	3	1	2	1	1	3	1	2	1
4	1	2	4	1	2	2	1	3	1
1	1	3	2	2	1	0	0	1	2
3	0	0	4	0	4	1	3	2	5
0	0	3	2	0	0	1	1	1	3
2	2	5	1	0	0	5	2	2	1
40100									
2	0	1	1	1	0	1	2	1	1
2	2	1	0	1	1	2	4	3	1
2	2	3	1	2	6	3	7	7	7
7	16	9	19	19	19	21	24	28	28
29	47	31	36	42	41	42	44	46	39
44	38	45	52	43	40	43	20	29	42
27	35	36	38	38	47	23	33	18	20
13	14	24	26	15	21	12	13	17	14
18	13	13	11	12	9	9	6	3	10
11	8	5	5	8	2	4	5	5	6
40200									
7	3	4	6	5	4	5	3	1	2
3	4	3	4	0	2	8	3	4	4
1	6	3	5	3	2	1	1	2	6
2	1	1	2	1	1	2	1	1	1
4	4	2	2	4	1	1	3	0	2
1	2	1	2	1	1				

3526 Array 203 $\Delta t = .008$

10000									
388	1722	1007	278	127	73	39	36	20	21
26	20	6	12	10	16	21	21	20	21
21	42	44	50	43	61	81	78	71	79
84	105	78	68	78	56	65	53	60	51
50	44	34	44	38	38	30	27	26	26
21	29	25	20	18	7	14	17	19	18
22	18	16	18	16	16	18	16	20	13
13	13	12	14	17	15	13	14	15	12
12	18	14	20	13	19	9	21	13	23
14	12	17	10	16	14	8	11	13	14
10100									
11	18	20	10	11	14	8	21	8	11
16	5	14	15	9	10	11	13	12	10
15	8	7	10	11	14	14	6	10	8
9	12	19	11	7	17	19	12	15	11
12	15	10	9	10	19	11	13	16	11
15	17	15	10	15	11	13	14	12	7
14	12	4	14	10	9	8	21	8	9
14	11	11	9	11	10	6	7	17	15
10	7	10	14	8	9	12	14	12	6
13	7	13	14	8	4	9	16	14	13
10200									
11	9	9	4	9	12	5	12	13	9
12	8	9	17	12	8	8	9	8	11
13	11	11	10	12	17	9	15	11	13
12	12	15	12	12	8	10	3	1	17
15	10	15	9	13	8	11	11	5	9
12	14	7	12	12	11				

3527 Array 1 $\Delta t = .007$

2174									
40000									
2174	3237	562	113	56	25	15	11	5	10
3	6	3	4	1	6	4	5	0	4
2	2	3	4	1	1	2	1	3	2
0	1	2	1	2	0	0	1	1	5
2	3	2	2	1	1	2	4	1	2
1	3	1	4	6	5	2	2	1	4
1	1	3	5	1	2	1	2	1	2
5	2	1	5	1	1	2	0	2	5
0	2	2	3	1	2	4	0	3	0
1	2	1	1	1	5	0	2	1	3
10100									
3	2	2	4	2	3	1	2	2	2
0	2	0	1	2	0	2	5	3	8
4	9	7	3	10	10	5	7	10	8
20	16	20	22	19	18	20	23	24	31
27	23	21	34	33	39	36	34	25	38
26	21	34	24	38	27	19	29	25	24
39	26	30	15	20	25	24	16	23	21
13	21	17	10	13	22	17	15	12	13
11	12	8	12	13	14	12	12	7	7
9	7	11	6	11	3	4	9	12	12
40200									
4	8	7	9	10	3	3	5	2	4
5	5	5	5	5	6	4	7	4	6
5	3	5	3	5	6	2	2	0	3
2	5	4	3	3	5	1	5	5	5
3	0	2	0	3	4	2	5	4	3
1	1	4	2	3	2				

3527 Array 203 $\Delta t = .007$

679									
10000									
679	2218	1519	463	210	99	51	47	27	33
32	29	22	31	22	30	31	29	39	60
64	88	90	122	124	129	121	150	130	135
146	170	124	127	80	104	78	92	54	59
91	62	52	44	51	38	40	41	41	40
38	43	45	27	25	24	34	16	29	31
29	37	30	21	23	28	23	29	23	29
25	28	26	28	24	17	29	23	18	18
20	22	25	25	16	20	31	26	21	18
19	12	18	27	29	19	27	20	25	20
10100									
22	21	25	20	23	20	16	21	24	30
17	18	14	20	22	21	20	20	23	25
24	9	21	19	26	16	21	13	17	30
16	23	27	21	21	27	17	22	19	20
23	23	22	15	15	34	23	19	14	26
24	14	25	14	29	23	17	20	17	16
22	20	21	19	22	16	23	27	14	17
16	18	21	23	17	14	16	18	18	20
23	20	15	19	18	15	15	24	22	18
21	20	17	14	25	27	15	21	16	18
10200									
21	15	16	21	17	24	24	17	16	17
16	19	22	23	13	20	25	18	15	18
14	24	20	14	18	19	19	17	21	19
26	18	22	15	19	16	10	16	23	16
17	20	21	21	10	21	19	21	16	13
17	23	18	13	20	15				

3528 Array 1 $\Delta t = .0073$

4186									
40000									
4186	4790	811	240	67	42	16	12	9	5
5	3	4	8	8	5	6	3	7	5
4	4	1	8	3	4	3	4	4	3
5	9	3	5	4	5	2	2	3	4
6	1	1	6	7	4	5	0	3	3
5	8	3	6	4	5	6	2	6	8
1	4	3	1	1	2	2	1	2	3
5	2	2	1	6	4	3	1	2	2
1	1	1	2	3	4	6	2	3	6
8	1	3	0	5	3	5	4	3	1
40100									
2	4	4	9	0	8	5	4	9	7
7	4	9	11	6	11	11	7	14	11
17	19	23	19	25	22	32	22	29	33
40	38	41	39	43	40	46	39	41	47
47	51	41	45	60	51	47	42	54	51
32	42	39	35	36	37	26	27	37	31
24	34	32	32	36	27	27	33	20	22
20	31	25	19	22	28	17	16	25	17
17	15	19	12	16	15	16	17	17	11
12	8	7	11	5	8	12	7	5	11
40200									
10	5	7	7	8	10	8	12	8	8
5	6	9	8	4	4	9	6	2	5
4	10	1	5	5	4	5	2	6	3
3	7	3	2	5	3	7	4	3	6
3	3	6	3	3	5	1	5	8	3
6	4	5	5	6	3				

3528 Array 203 $\Delta t = .0073$

RUN - 3528 ARRAY - 1

253									
10000									
253	1286	449	163	67	32	28	18	19	16
9	14	12	17	7	7	11	6	10	16
11	16	15	23	32	29	32	67	76	98
142	166	195	201	182	271	227	281	195	199
177	164	154	114	116	82	72	55	56	45
46	32	26	21	27	15	18	19	7	11
14	13	14	6	7	9	12	7	5	9
7	11	9	7	10	4	12	8	13	6
14	7	13	8	10	12	7	6	8	11
11	7	12	11	6	8	9	7	6	9
10100									
7	10	14	6	5	12	11	6	8	10
14	11	10	11	10	8	5	11	7	12
6	7	10	5	6	8	7	3	11	6
5	6	6	10	5	9	9	8	8	9
8	9	6	6	6	11	6	9	11	9
7	9	5	7	10	12	5	12	9	13
9	9	9	6	7	10	7	5	14	10
7	11	8	7	8	4	4	8	7	12
5	6	5	4	5	9	8	5	13	9
5	3	2	9	11	6	8	8	7	5
10200									
10	8	6	10	11	4	12	7	16	3
11	6	14	4	10	9	11	5	11	10
11	6	14	8	5	8	9	11	8	14
12	11	7	8	8	6	11	9	10	9
10	9	11	10	13	9	6	7	8	13
6	9	5	15	3	8				

3529 Array 1 $\Delta t = .008$

2817									
40000									
2817	1401	250	75	19	17	7	1	4	1
1	3	1	0	1	1	1	2	1	0
2	3	3	0	2	1	3	0	1	2
2	2	1	1	3	2	2	0	0	0
1	0	3	2	1	0	0	0	2	0
0	4	0	1	1	3	1	0	3	0
2	0	1	0	2	2	1	2	2	1
1	1	2	0	0	1	4	0	1	2
0	1	0	0	2	3	3	1	4	0
1	1	2	0	1	3	0	0	1	3
40100									
0	0	0	2	2	3	0	0	0	3
3	0	1	2	1	3	1	1	2	2
3	5	5	4	7	15	21	17	27	39
34	41	34	57	68	64	59	62	75	78
70	80	70	77	66	75	85	72	79	65
71	49	57	48	63	46	43	40	42	39
30	26	31	27	21	22	20	18	17	14
13	13	18	15	12	13	12	5	6	4
5	6	4	5	1	5	3	3	7	6
4	1	2	3	3	1	3	2	2	1
40200									
4	3	3	5	2	4	0	0	1	2
4	2	1	2	0	1	2	0	1	1
1	2	1	1	2	1	0	3	1	1
5	0	0	1	1	1	3	0	1	0
1	3	2	0	1	2	1	1	2	2
2	1	0	1	0	1				

3529 Array 203 $\Delta t = .008$

297									
10000									
297	827	985	302	135	59	44	34	35	24
14	22	21	13	15	14	12	9	8	10
13	13	12	17	11	17	18	25	16	13
20	29	38	51	48	69	91	96	116	117
136	164	169	175	171	174	194	179	178	168
181	167	153	130	133	110	96	80	72	71
69	52	31	55	32	23	22	23	29	16
17	16	21	17	12	14	12	12	20	14
13	9	9	12	11	12	15	12	11	4
11	6	15	17	12	16	10	15	11	13
10100									
11	16	16	7	13	11	13	4	9	14
17	15	19	17	14	16	12	6	7	11
9	15	8	16	16	12	12	17	15	16
15	9	8	15	7	13	9	10	10	13
11	12	12	18	12	15	8	11	13	7
7	16	16	12	13	5	16	10	13	15
5	9	26	13	8	12	18	9	13	8
7	10	9	10	12	14	10	9	10	7
8	16	11	10	13	18	12	7	10	17
12	9	10	11	16	5	9	7	16	11
10200									
12	10	7	12	9	12	10	15	8	16
12	9	7	14	11	16	8	16	8	11
12	10	14	4	11	12	10	15	13	13
10	9	17	8	8	12	8	7	10	8
11	13	9	11	6	10	13	10	7	8
10	16	16	16	9	17				

3530 Array 1 $\Delta t = .006$

1933									
40000									
1933	2541	529	157	57	32	17	11	8	11
5	3	3	7	3	1	0	2	2	1
1	0	1	3	0	2	0	4	1	1
1	5	3	3	2	0	0	1	0	1
2	1	0	3	3	4	0	1	4	1
2	1	2	3	5	1	2	2	2	2
2	7	3	5	1	2	1	2	4	1
2	0	3	1	1	1	1	3	2	1
2	0	1	2	1	1	3	3	3	1
2	0	0	4	1	0	0	1	1	2
40100									
2	1	0	3	1	1	2	1	4	1
3	0	3	2	4	0	2	2	5	0
2	4	2	2	0	4	3	0	1	0
1	0	0	1	2	0	3	1	0	1
3	1	1	2	1	0	1	0	1	0
1	7	2	5	5	7	2	10	6	11
11	9	20	18	12	29	26	33	36	48
40	57	39	57	58	56	65	62	64	67
64	64	57	57	62	70	64	55	62	39
49	50	52	47	54	54	37	47	31	33
40200									
31	31	50	28	45	23	25	25	18	23
16	24	25	18	19	17	18	18	11	9
8	14	12	6	9	8	7	5	7	6
4	9	2	7	3	10	4	4	5	3
0	6	4	1	5	3	4	2	6	3
5	5	1	5	3	2				

3530 Array 203 $\Delta t = .006$

744									
10000									
216	532	1163	376	190	77	52	32	28	18
21	15	17	18	16	14	24	14	18	16
10	9	14	9	16	18	11	17	12	26
27	28	28	42	46	72	87	94	113	115
126	158	157	167	177	159	175	162	141	145
151	128	129	122	106	85	90	77	83	58
52	49	33	43	42	39	30	30	22	29
26	14	16	17	17	14	16	13	17	16
16	17	4	16	18	9	8	7	12	9
16	14	13	17	11	10	9	10	9	4
10100									
9	13	16	12	16	12	11	16	10	6
8	15	10	8	14	12	14	12	10	10
15	16	15	16	12	17	9	9	8	16
12	16	15	5	8	10	11	7	14	12
10	12	15	16	11	15	17	13	9	6
21	6	12	13	12	12	10	10	11	13
16	12	16	15	13	14	10	5	13	10
8	15	7	8	11	8	13	15	8	12
6	6	15	12	13	14	9	16	10	10
12	12	9	8	14	13	12	14	15	15
10200									
15	9	12	12	15	12	9	11	10	13
12	13	15	13	11	11	16	8	10	12
10	8	16	14	12	14	13	9	11	15
8	13	17	6	13	11	6	5	14	9
13	19	8	15	14	14	11	6	0	6
8	19	17	7	9	9				

3531 Array 1 $\Delta t = .0060$

1274									
40000									
1274	2958	663	200	80	27	20	10	13	5
6	4	2	4	3	2	2	2	2	1
4	0	3	2	3	2	0	3	1	2
2	1	0	0	1	1	3	2	1	1
2	0	3	1	0	6	1	2	0	2
1	4	1	2	0	2	4	3	2	0
2	0	1	3	2	0	1	2	1	2
3	1	1	2	0	2	0	2	1	2
0	1	2	1	2	3	0	0	6	4
1	1	0	2	1	0	0	1	1	2
40100									
2	0	1	1	2	2	1	2	3	1
7	1	1	0	2	2	0	1	3	0
1	3	0	3	4	3	2	1	1	0
1	4	1	1	1	2	1	0	2	3
3	1	2	1	1	1	2	2	2	1
2	1	2	6	5	15	10	10	11	15
14	24	21	23	28	20	35	41	56	37
57	53	41	58	57	61	46	60	48	65
46	59	65	59	42	38	56	46	59	47
43	56	42	49	36	43	38	50	33	32
40200									
34	33	35	28	35	39	23	28	31	22
15	15	20	15	18	16	9	8	9	12
8	8	5	9	10	6	6	2	2	7
4	8	4	5	7	7	6	0	2	2
3	7	4	2	2	6	2	9	5	0
1	1	7	2	2	0				

3531 Array 203 $\Delta t = .0060$

RUN - 3531 ARRAY - 203

RUN - 3531 ARRAY - 1

272									
10000									
272	967	56	30	31	32	30	28	28	25
17	37	20	29	36	41	38	63	61	125
172	197	260	346	379	448	443	468	456	431
393	363	328	283	226	218	155	152	122	105
98	56	29	65	62	54	36	40	31	26
17	32	27	27	29	15	29	35	34	22
32	22	27	30	28	17	18	24	22	30
21	21	20	17	15	31	15	21	25	17
17	17	12	28	26	20	26	17	16	19
25	20	22	26	26	19	21	24	26	20
10100									
28	27	23	22	26	17	20	25	22	17
23	22	20	26	18	12	16	27	21	23
21	20	16	13	21	17	18	28	24	31
18	17	21	22	15	22	29	18	26	12
27	11	28	16	20	21	14	21	32	11
26	24	20	20	20	15	11	19	14	10
18	15	19	20	28	18	22	19	17	23
21	22	16	22	12	22	24	22	14	18
26	14	17	29	11	21	12	30	23	17
27	22	12	19	13	14	15	21	23	20
10200									
13	24	15	20	14	18	9	17	15	15
14	19	21	20	23	17	17	21	10	21
20	12	14	22	17	17	15	17	12	20
17	17	12	25	11	18	15	13	21	20
20	10	18	23	18	19	17	15	19	17
17	23	19	20	18	11				

3533 Array 1 $\Delta t = .034$

4602									
40000									
4602	478	10	4	2	2	4	3	4	8
4	2	4	5	2	2	4	2	2	4
2	2	2	4	3	3	5	6	6	4
1	1	5	1	3	3	2	5	2	2
4	4	3	1	2	0	4	3	5	2
2	2	4	2	2	3	3	5	3	4
1	3	3	5	5	1	4	4	2	1
1	7	2	3	2	4	7	7	1	5
2	1	3	1	1	1	7	2	3	4
4	5	2	5	3	2	3	3	7	5
40100									
6	1	3	4	5	1	5	4	2	2
4	2	2	2	3	2	5	3	6	1
4	7	4	3	1	3	4	3	1	5
4	1	2	8	3	2	1	3	3	1
7	2	6	1	1	5	4	6	11	4
4	5	5	5	3	10	13	5	6	13
12	21	18	29	31	38	44	38	49	58
68	60	68	70	72	73	97	79	72	98
85	100	98	92	90	99	95	90	77	106
102	119	75	87	75	77	61	65	74	73
40200									
72	68	81	60	44	56	41	47	42	37
41	34	52	44	45	36	35	42	41	24
27	29	32	19	25	19	13	21	8	17
15	15	7	22	11	9	8	9	9	14
8	11	3	4	5	5	9	1	6	4
7	12	3	4	2	3				

3533 Array 203 $\Delta t = .034$

440									
10000									
440	1384	93	54	34	40	35	29	27	26
29	30	37	31	53	42	70	76	98	139
165	210	284	328	316	348	349	347	312	292
275	263	232	197	221	186	155	137	123	109
111	76	81	61	35	37	32	34	33	37
41	25	36	37	29	35	44	31	27	24
33	26	30	22	29	26	27	32	32	35
24	23	32	27	33	29	30	28	23	25
25	25	34	32	37	22	29	24	29	19
26	32	25	21	18	25	33	24	21	33
10100									
27	20	37	33	28	24	24	24	22	28
24	29	18	20	24	19	32	20	22	19
30	21	29	22	29	19	17	21	34	26
28	29	27	36	19	24	22	27	16	16
13	27	23	22	21	36	22	30	32	19
18	14	29	34	22	23	17	19	25	23
20	21	20	23	16	22	25	29	32	10
19	30	27	24	21	17	22	23	31	18
18	22	20	28	21	26	18	30	29	23
21	19	19	24	30	14	28	15	22	15
10200									
18	30	19	26	29	15	20	30	20	18
16	13	20	17	24	31	17	22	29	25
19	27	22	24	19	15	23	20	24	27
20	22	15	24	22	22	26	19	21	35
26	20	26	22	18	27	26	26	19	21
18	18	24	17	23	11				

3534 Array 1 $\Delta t = .030$

5347									
40000									
5347	1682	28	10	7	5	5	3	6	5
3	3	5	3	2	3	5	3	4	8
9	3	3	8	3	3	2	2	4	3
2	6	7	4	6	0	3	4	4	2
2	3	5	4	1	1	0	6	4	1
0	1	2	5	4	5	10	3	5	1
5	2	3	4	3	3	3	4	3	5
4	2	3	5	5	4	5	4	8	6
3	2	3	1	5	5	5	3	4	5
2	5	3	4	7	3	3	4	1	5
40100									
8	4	1	2	3	1	2	4	3	1
4	3	3	3	3	3	7	2	7	7
5	6	5	11	14	10	6	16	16	10
17	18	24	26	30	33	33	31	41	34
45	40	48	51	47	58	61	60	70	66
72	85	28	82	67	76	69	91	76	93
93	86	92	98	94	93	81	97	101	108
106	103	103	100	107	117	54	82	92	87
79	80	69	74	78	70	61	57	39	52
51	48	49	41	51	44	46	40	45	31
40200									
24	31	25	22	26	25	18	25	17	20
16	10	7	11	12	9	13	9	6	10
8	6	12	6	5	9	2	3	5	4
5	6	6	8	6	2	6	2	1	5
3	5	5	3	2	5	3	4	6	3
7	5	7	6	1	6				

3534 Array 203 $\Delta t = .030$

304									
10000									
304	1672	291	68	38	20	15	13	15	18
13	6	14	14	15	10	13	16	32	30
37	43	56	66	87	79	78	100	66	64
60	56	64	70	65	75	48	61	77	56
53	72	58	60	53	48	44	47	50	39
40	34	28	39	38	36	30	33	26	29
21	22	20	24	23	18	18	16	18	10
12	13	9	14	12	21	12	14	12	13
8	8	9	6	12	12	10	7	8	7
19	8	11	10	7	16	7	10	10	15
10100									
10	8	16	8	8	8	10	15	14	7
10	14	14	8	12	22	11	8	10	12
13	11	12	9	10	9	11	16	9	8
9	5	9	2	11	13	16	10	11	7
5	8	11	8	9	11	9	11	11	13
7	17	10	8	14	7	9	7	9	11
14	11	10	6	16	13	8	9	10	7
12	5	14	9	10	10	7	15	6	11
15	12	7	12	4	10	14	9	17	8
13	14	13	11	12	10	13	8	11	10
10200									
10	7	10	10	9	13	16	10	6	9
5	12	11	4	8	10	11	11	11	10
7	5	8	5	6	14	6	9	7	8
14	8	9	12	10	10	12	8	8	12
10	11	7	14	10	12	7	11	10	8
10	9	12	10	5	6				

3535 Array 1 $\Delta t = .015$

2859									
40000									
2859	2271	121	15	5	9	1	1	2	6
1	0	3	0	0	1	1	0	1	0
3	1	0	0	2	2	1	2	2	3
3	3	1	0	3	0	3	0	4	2
1	1	1	3	3	0	3	1	1	1
1	6	2	4	1	2	3	0	1	0
0	4	0	1	1	4	4	3	1	3
1	3	1	1	2	3	2	0	5	3
1	1	0	0	1	4	1	0	2	1
0	2	1	0	1	1	2	0	2	3
40100									
0	1	6	5	1	0	0	0	1	1
1	1	0	1	1	2	1	3	6	2
2	0	2	1	2	0	3	1	4	3
2	2	4	3	4	6	1	3	4	12
8	9	13	13	14	20	16	26	10	16
13	18	8	15	19	31	25	17	14	25
37	23	19	26	24	21	23	30	25	23
17	34	27	31	28	32	39	23	19	30
28	23	33	24	27	31	26	24	22	30
27	26	25	22	32	30	34	27	23	24
40200									
19	16	26	24	20	15	25	20	20	14
18	16	24	10	28	21	13	24	15	13
16	13	15	21	16	10	7	15	15	15
18	14	17	14	5	6	9	11	13	13
8	13	13	14	12	10	3	8	8	8
6	8	8	8	6	5				

3535 Array 202 $\Delta t = .015$

384									
10000									
384	1680	372	116	47	39	30	29	28	13
20	14	18	17	27	22	13	25	20	26
32	49	45	48	65	67	58	78	92	86
91	93	78	76	61	73	67	56	59	55
40	37	52	43	38	49	39	41	41	34
25	27	21	21	24	27	17	31	25	26
29	32	16	24	16	17	18	22	25	27
18	22	20	13	17	15	20	18	17	19
27	21	23	23	20	23	24	10	18	18
19	28	17	18	19	11	27	19	21	26
10100									
26	22	14	18	18	25	16	23	22	20
21	25	24	18	18	14	24	19	28	19
20	21	19	23	19	23	19	11	28	19
17	24	16	30	20	18	23	22	21	18
18	12	22	10	18	20	17	19	21	13
20	14	14	26	21	26	27	20	22	19
27	25	16	19	25	18	23	7	25	18
22	21	13	16	20	20	20	25	10	20
8	15	21	19	11	18	11	13	19	21
18	21	22	14	27	17	18	14	26	10
10200									
16	14	19	20	23	16	10	17	18	15
25	21	14	10	30	6	30	21	11	10
20	23	15	14	17	18	20	22	21	19
19	15	16	21	18	11	16	16	19	27
14	24	17	8	22	20	13	18	16	21
16	20	17	25	16	18				

3536 Array 1 $\Delta t = .012$

4328									
40000									
4328	1896	154	46	18	6	8	3	2	1
3	2	2	2	3	0	7	4	1	4
5	3	0	1	3	5	6	1	5	5
2	2	3	5	4	6	2	2	1	3
4	5	3	4	3	4	2	2	1	0
3	3	6	2	4	1	2	1	2	1
3	2	0	2	2	2	4	3	4	2
3	3	1	1	5	1	4	3	6	1
1	3	4	2	4	2	6	4	2	5
5	5	3	5	4	5	9	4	5	4
40100									
9	6	7	4	7	7	8	7	5	8
9	7	3	6	8	10	8	8	8	11
4	5	8	6	7	2	6	12	10	15
6	11	14	10	17	17	14	17	18	22
21	21	24	14	16	16	19	26	18	14
25	19	27	23	17	25	31	23	17	21
18	17	12	17	11	16	12	19	17	20
18	7	15	10	10	9	12	18	12	12
7	12	9	16	10	13	15	7	14	14
12	12	14	9	11	9	18	10	18	12
40200									
12	12	13	9	11	2	10	10	8	6
12	5	7	5	5	4	7	5	5	4
5	4	7	16	7	3	6	4	8	6
7	4	5	1	5	4	7	4	4	3
4	5	6	6	0	1	2	2	2	0
6	2	6	3	2	1				

3536 Array 203 $\Delta t = .012$

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