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Analysis of Photographic Records of Coal Pyrolysis

Final Report

J.N.D. Dodoo

October 1991

Work Performed Under Contract No.: DE-FG21-90MC27326

For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia

By
University of Maryland Eastern Shore
Department of Natural Sciences
Princess Anne, Maryland

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I am indebted to my graduate student, Mr. Richard Ochran for his painstaking retrieval of data from the film and assisting in every way with the analysis

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ANALYSIS OF PHOTOGRAPHIC RECORDS OF COAL PYROLYSIS

1. Background and Motivation

1.1 Introduction

Bituminous coals upon heating undergo melting and pyrolytic decomposition with significant parts of the coal forming an unstable liquid that can escape from the coal by evaporation. The transient liquid within the pyrolyzing coal causes softening or plastic behavior that can influence the chemistry and physics of the process. Bubbles of volatiles can swell the softened coal mass in turn affecting the combustion behavior of the coal particles. The swelling behavior of individual coal particles has to be taken into account both as the layout as well as for the operation of pyrolysis, coking and performance of coal-fired boilers. Increased heating rates generally increase the amount of swelling although it is also known that in some cases, even highly swelling coals can be transformed into char with no swelling if they are heated slowly enough [1,2].

The swelling characteristics of individual coal particles have been investigated by a number of workers [3,9] employing various heating systems ranging from drop tube and shock tube furnaces, flow rate reactors and electrical heating coils. Different methods have also been employed to determine the swelling factors. The following sections summarize some of the published literature on the subject and outline the direction in which the method of analysis will be further extended in the study of the swelling characteristics of hvA bituminous coal particles that have been pyrolyzed with a laser beam.

1.2 R.H Essenhigh and G.C. Yorke [3]

The authors studied single coal particles in the size range 0.5 to 2 mm connected to fine silicon threads with a high temperature cement. The arrangement was then suspended, cantilever fashion, between two electrical heating coils heated to about 1000°C. One particle was enclosed in a brass box, with observation window that could be flushed out with carbon dioxide. This made it possible to observe the swelling of particles that were being pyrolyzed without burning. Forty particles were studied all of which showed the characteristic behavior of generation and combustion of volatiles with swelling during the combustion phase and subsequent residue burnout.

The particle diameters were measured from photographic records. A plot of the square of diameter against time (the authors actually used frame number in their plot) is shown in Fig.1. The graph shows a sudden sharp rise and fall in the curve at the start of the combustion indicating swelling of the particle. The authors attribute such behavior as indicating that in air, swelling is a two-step process. First there is a large expansion followed by a contraction. In the presence of carbon dioxide only expansion occurs with no subsequent contraction. Swelling factors, defined as the ratio of the diameter at the start of the residue combustion to the initial cold diameter of the particle, were obtained for individual coal particles. The values were in the range between 1.4 and 1.72

1.3 P. Lightman and P.J. Street [4]

Three kinds of pulverized coal particles, Prince of Wales, Cwm and Rawdon, were heated in two different vertical furnaces (1) a drop tube and (2) a shock tube. In the drop tube furnace the coal particles were introduced at a rate of about 1.3 g/min into the top of the tube together with a small quantity of transport air at a rate of 200 ml/min. The wall temperature was maintained at 1200 °C and the flow gas was argon or argon-air mixture. In the shock tube experiment the particles were very rapidly dispersed into a heated gas column. The gas temperature was in the range between 500 °C to 3000 °C and the heating rate was 10^5 °C/s The gases used for treatment were argon,nitrogen and nitrogen-oxygen mixture. The authors studied the treated particles and made the following observations.

Drop tube furnace

The Cwm particles treated in argon showed a number of swollen thin walled cenospheres. The walls were about 1 micron thick and the particles expanded to more than twice their normal diameter. By contrast, the Prince of Wales and the Rawdon particles treated in the same way showed no such changes and little change in size.

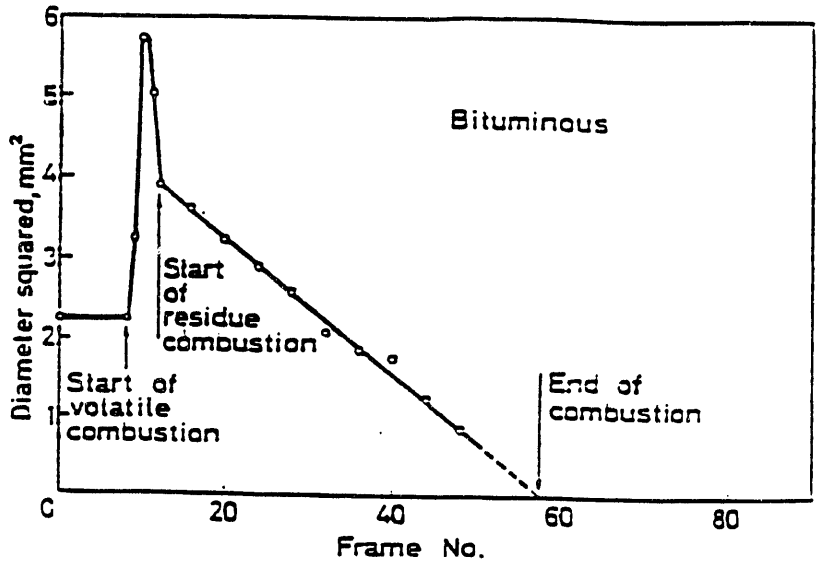
Shock tube furnace

No swelling was observed in any of the three types of coal particles studied in nitrogen and at temperatures between 500 °C and 700 °C.Cenospheres were,however,observed at a gas temperature of 900 °C. Particles treated at temperatures as high as 2600 °C only showed partially developed cenospheres but no swelling.

1.4 P.J. Street, R.P. Weight and P. Lightman [5]

The work of these authors was an extension of the work previously reported by Lightman and Street [4]. The method of treatment was by a vertical drop tube furnace with a maximum operating temperature of 950 °C. The treated coal particles were examined under both optical and scanning electron microscope.
The extent of particle swelling is shown in Fig.2. which is the result of analyzing some 300 particles. Of significance is the fact that swelling at a temperature as low as 300 °C where the swelling ratio is about 1.05. Also shown is the apparent density of the

Fig.1 Variation of diameter squared with time of burning bituminous coal particle (Cowpen)



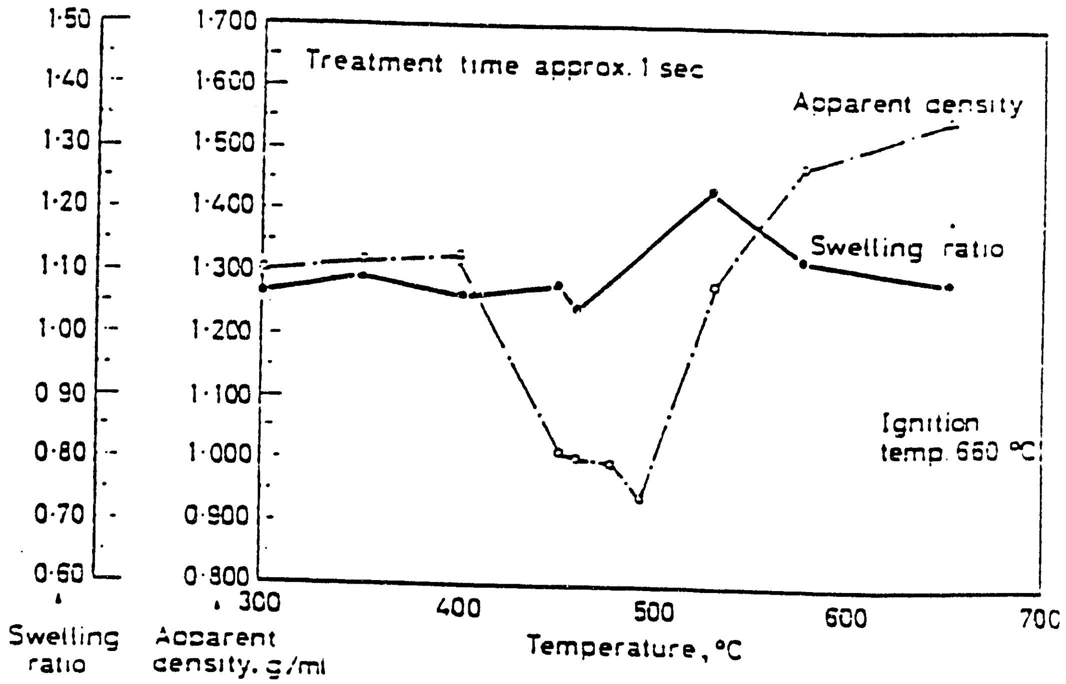


Fig.2 Variation in swelling ratio and apparent density with temperature

particles during treatment. The apparent density was determined by means of the density bottle method using D.C. 702 silicone oil as the displacement fluid.

The authors conclude that the swelling ratio is dependent upon gas composition. Swelling ratios of particles treated in air were less than those of particles treated in nitrogen. The apparent density of the particles showed a uniform decrease in nitrogen. In air below ignition temperature the minimum in the value of the apparent density coincided with the peak of swelling. The subsequent sudden increase in the density figure are attributed to expulsion of volatiles and the formation of surface holes allowing the silicone to penetrate into the particles during the density determination.

1.5 Toshiaki Matsunagi,Yoshiyuki Nishiyama,Hidenori Sawabe and Yasukatsu Tamai [6]

These authors examined the swelling behavior of single coal particles under rapid heating up to 870 K in an atmosphere of nitrogen and oxygen. The particles were treated with ammonia to determine whether such treatment affected the swelling property of Japanese bituminous coal. The particle diameters were in the range 1 to 2 mm and were in a glass vessel with a molybdenum heating plates. The upper surface of the heating plate was coated with a refractory cement before each run to prevent direct contact between particles and the plate.

The events were photographed at a rather slow rate of 5 frames/sec and analyzed by microscopy. The swelling factor as a function of temperature is shown in figure 3 for untreated (with ammonia) coals in a hydrogen environment. The authors conclude that the Japanese coal particle changed its shape in a complicated manner with repeated expansions and contractions. Also the degree of swelling varied considerably for the same species under the same conditions. Other species that were impregnated with a catalyst such as nickel salt were found to have a decreased swelling factor.

1.6 P.F. Melia and C.T. Bowman [7]

Melia and Bowman have developed a model which predicts volatile evolution rates and swelling of single coal particles during devolatilization in inert atmospheres. the authors indicate that the driving force for swelling is the pressure differential between the inside and the outside of the particle due to volatile evolution. The pressure differential is that required to force the volatile mass flux through the existing pores. The volatile mass flux was calculated from a distributed activation energy pyrolysis kinetic model for particle temperature-time history by Anthony and co-workers [8].

The authors assumed that the swelling was due entirely to increased pore volume and the increased diameter of the particle was calculated from the new volume. The results of their computation are shown in figures 4 and 5. The data considered span seven orders of magnitude in heating rate, initial particle diameters

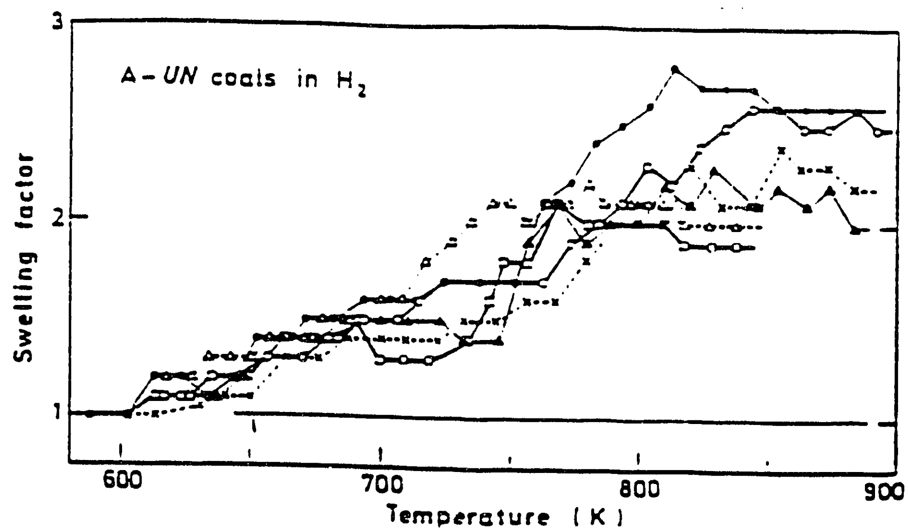


Fig.3 Swelling behaviour of A-UN coals in hydrogen. (Symbols denote different coals)

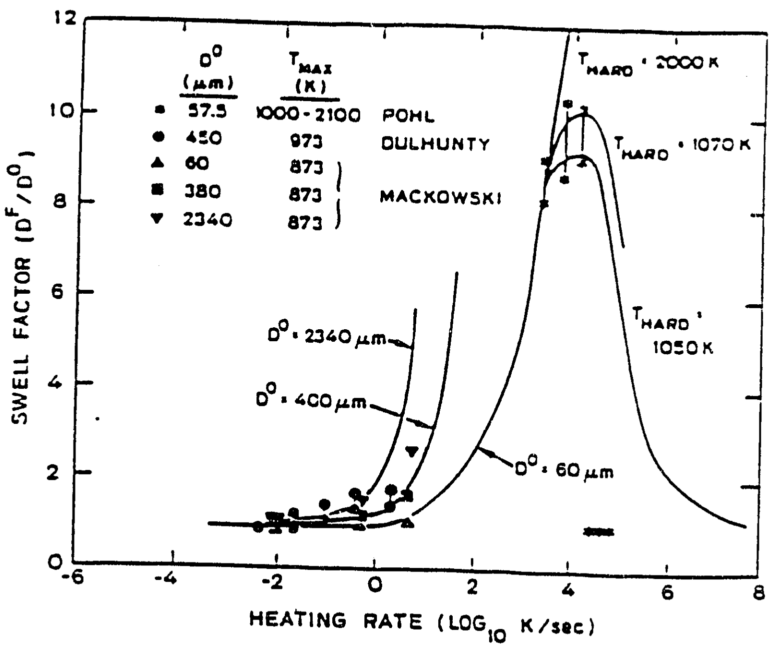


Fig.4 Variation in swell factor with heating rate and initial particle size Model predictions are solid lines.

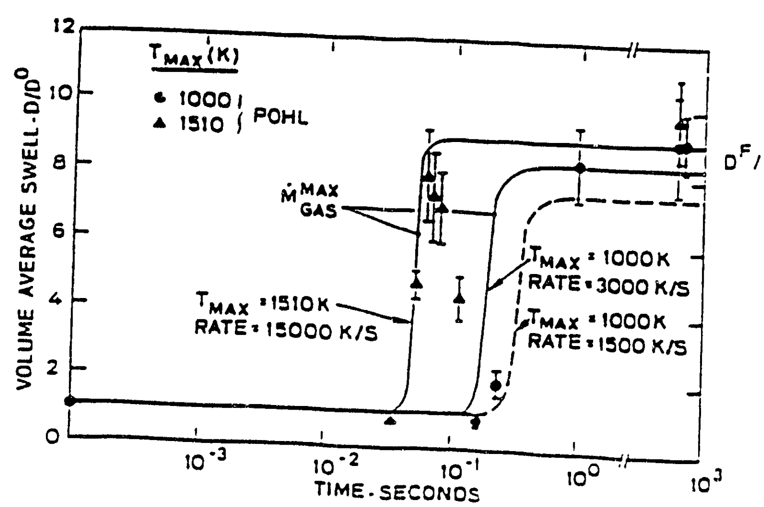


Fig.5 Variation in swell ratio wit time for 57.5 μm diameter bituminous coal particle for several heating rates. Model predictions are represented by broken lines

from 57.5 to 2340 micrometer, and swell factors from 1 to 10.5. The highest swell factors represented volume increases on nearly 1200 times the original particle volume.

1.7 Donald J. Holve, Thomas H. Fletcher and K. Gomi [9]

The authors studied pulverized coal particles in a continuous, small flow rate coal slurry atomizer and laminar flow reactor operated over a wide temperature range and oxidizing conditions for the early stages of combustion. The primary diagnostic employed in the study was a laser-based particle counter-size-velocimeter system to measure the concentration and size distribution of particles prior to and throughout the early combustion region of the flow reactor. the measurements were conducted at both ambient and combustion conditions of 300 K and 1700 K respectively. The authors arrived at the following conclusions.

1. Agglomeration increases the top size of coal/water slurries by a factor of 2-3, and the volume mean diameters by a factor of 4-6 over the equivalent constituent pulverized coal.

2. Particle swelling during the devolatilization phase increases particle diameter by a factor of 50-100 per cent for the dry coal and coal/water slurries investigated. A numerical model calculation predicted that char burnout times increased with increased particle swelling.

3. Chemically beneficiated slurries showed rapid swelling at reaction times of less than 5 ms.

1.8 Rationale for the present work

The U.S. Department of Energy is investigating the combustion characteristics of various coal feedstocks in its new Fuels Evaluation Facility. This facility is designed to test combustion, emissions, slagging, fouling and erosion properties of both dry and pulverized coal and coal-water slurries. Data obtained from each study or groups of studies will became part of a data base for coal combustion. The data base will provide for a better understanding, and enable modeling of the behavior of coal in practical utilization systems. Coal devolatilization has been the subject of extensive study,[11-20]. At the Morgantown Energy Technology Center,(METC), the rapid devolatilization behavior of single hvA bituminous coal particles has been studied by Maloney [19,20], inside an electrodynamic balance apparatus. In this experiment freely suspended single coal particles were irradiated from two sides by counterpropagating pulsed laser beams of equal intensity. The devolatilization processes were time resolved by high-speed cinematography. The response of each coal particle to a given heating pulse was obtained using a high-speed 16 mm movie camera with a framing rate of 5000 frames per second. Timing pulses signaling the initiation of the laser beam were simultaneously recorded on the film to facilitate accurate determination of the period of occurrence of particular events. Among the goals of this METC program is one that seeks to analyze the film records to obtain information such as particle size, characteristic times for volatile evolution, bubbling and particle swelling which can then be used to obtain valuable information on density changes, and temperature sensitivities. This report considers only one of the important characteristics listed above,namely,the swelling characteristics. The work is directed in two very important areas.

1). Design and setup a video-enhanced microscopy system capable of analyzing photomicrographic images.

2). Use the setup in (1) to analyze the photomicrographic data collated in the electrodynamic balance experiment.

The analysis is directed to determining the swelling ratio of hvA bituminous coals as a function of time. The effect of laser intensity is also investigated. The swelling data are compared with those obtained by previous workers [3,9] using different heating methods.

2. Experimental Design and Setup

2.1 Introduction

The apparatus necessary for analyzing video images must have the following essential capabilities. (1) The ability to grab the image-either still or moving image, (2) store the image for indefinite periods and (3) analyze visual information represented by standard or nonstandard signals. The video signals may come from standard video cameras,VCRs,television broadcasts or from nonstandard devices such as microscopes, and even scanning electron microscopes, SEMs. The video signals are sampled electronically by a frame grabber (image acquisition) which can store and display the images. Image acquisition converts an image into an array of the data points, which can be stored digitally, processed and enhanced.The system must also be capable of displaying the processed image on a video monitor. The quality of the image displayed depends on a number of factors. The two most important factors are explained in the following sections.

2.1.1 Resolution

2.1.1a Pixel and Spatial Resolution

The number of picture elements or pixels which make up a digitized frame determines the spatial resolution of the signal and the amount of detail with which shapes in the image are represented. The spatial resolution is expressed as a matrix -the number of pixels (columns) per line by the number of lines (rows) into which the image is divided. Typical values are of the order of 512 pixels x 480 lines.

2.1.1b Brightness Resolution

The accuracy with which a particular digital pixel value represents the brightness or color of the corresponding location in the original video signal,the Brightness resolution is determined by the analog to digital, A/D converter.

2.1.2 Aspect Ratio

This is an important factor in cases where the area of a given region is determined by counting pixels. The aspect ratio is defined as the horizontal dimension of the image to the vertical dimension of the image.

Other considerations that make for an effective image processing system are input and output requirements of the video monitors. The input and outputs of most frame grabbers are compatible with any of a number of video communication standards such as RS-170 or RS-330 NTSC (National Television System Committee) color signals. An RGB (red,green blue) color monitor ensures that the video image can be displayed in color after application of pseudo-coloring. A number of manufactures specialize in the development of modules for image processing. After an extensive review of the various options offered by several vendors the image processing system offered by **DATA TRANSLATION (DT)** was chosen in preference to any others. Using the DT modules a video-enhanced optical microscope image analysis system was constructed.

The setup is shown in the block diagram Figure 6. As illustrated, the video-enhanced microscopy system consisted of a microscope, a video camera, a video image processor and a high resolution monitor. An image of the specimen was picked up by the CCD camera and directed to the arithmetic frame grabber where it was captured and then digitized. The digitized data were then stored in the computer memory to be processed at a later stage using the frame processor. The image processor was vital to the system; and the quality of the video image observed on the output monitor depended on its capabilities. Good optics on the microscope and the high resolution camera were essential for a clear video signal which led to good and reliable results. Figure 7 shows the complete data acquisition system used in analyzing the photomicrographic data. The various components of the apparatus are described below.

2.2 Detailed Description of the Apparatus

2.2.1 DT2861 Frame Grabber

The DT2861 is an arithmetic frame grabber for the PC AT, that can acquire and display video images and stores 16 video frames in real time using onboard memory (4 Mbyte total) The video input is monochrome via an RS-170/ RS-330 NTSC 512 x 480 x 8 bit or CCIR/PAL 512 x 512 x 8 bit, with slow-scan compatibility of 0 - 12 MHz. The board is optimized for processing operations and contains built-in Arithmetic Logic Units (ALUs) that perform 8-bit real-time operations.

2.2.2 DT2858 Image Processor

The DT2858 is a high resolution 512 x 512 x 8 bit Data-In/Data-Out frame processor that performs complex operations like histograms and convolutions of data transferred to it from the arithmetic frame grabber. The data transfer rate is 3.3 MHz and the processor can perform approximately 3.3 million additions and multiplications

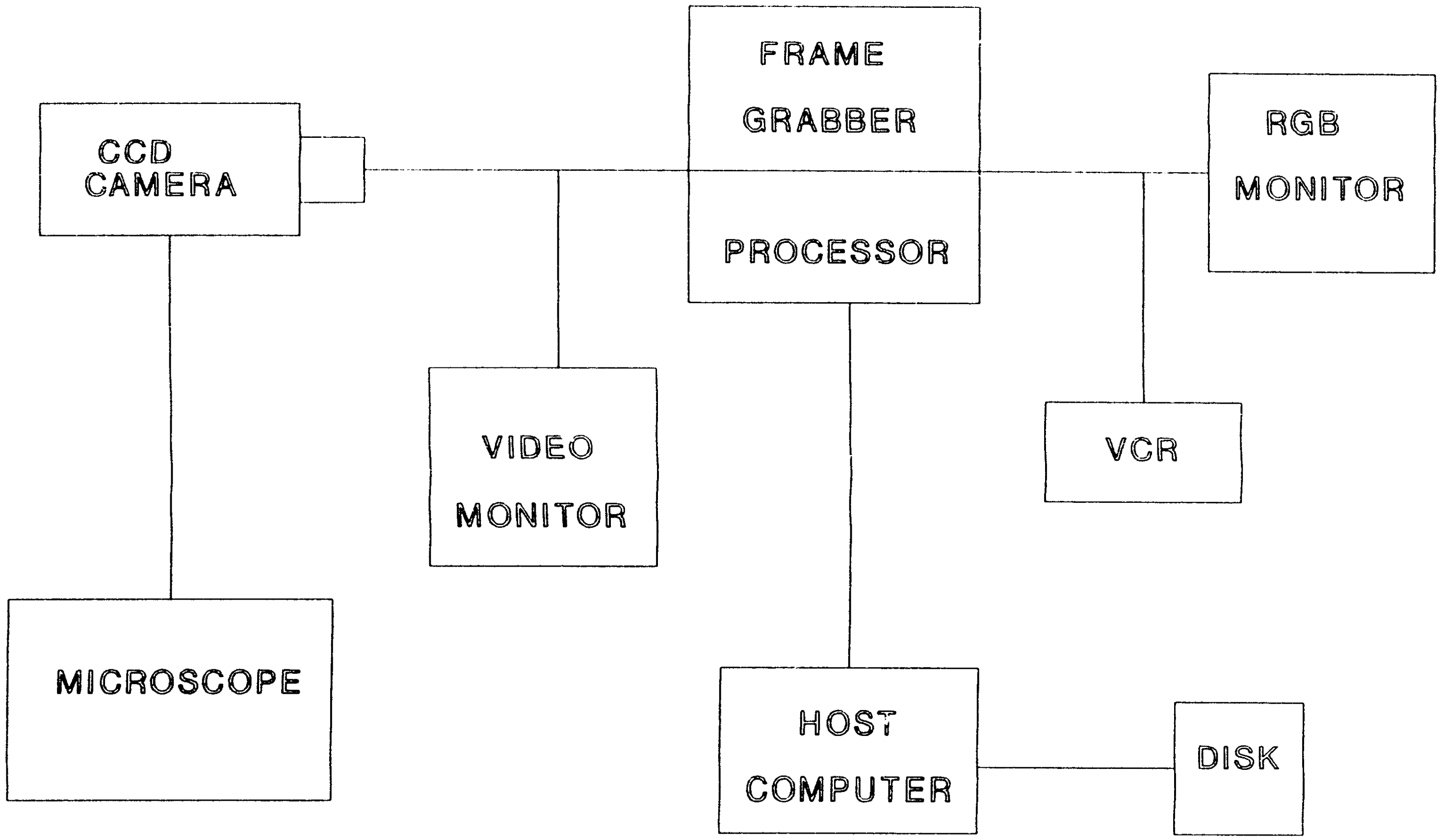


Fig.6 Block diagram of the video-enhanced microscopy system

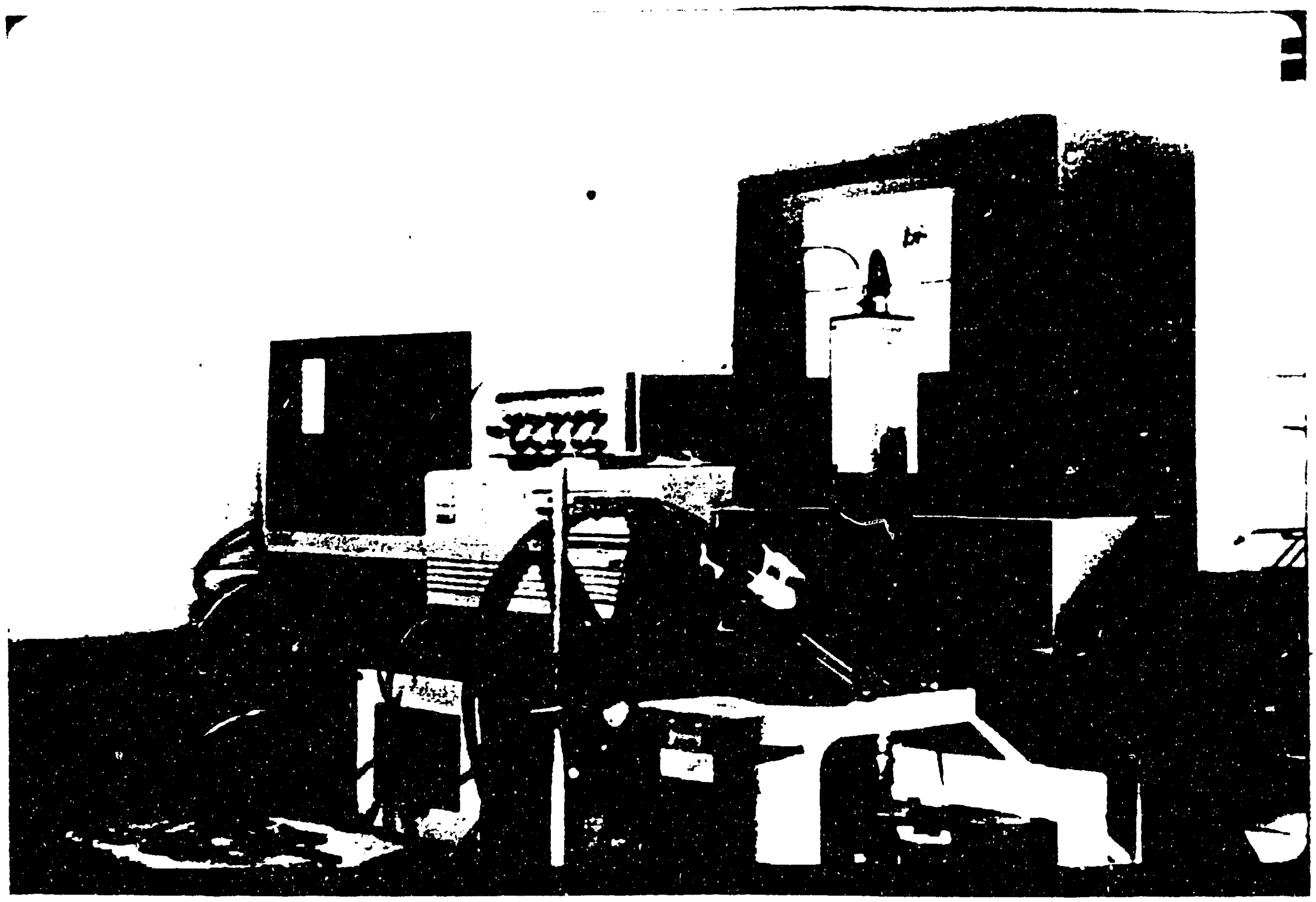


Fig.7 A photograph of the video-enhanced microscopy analysis system

or 1.3 million divisions per second. The convolution consists of high pass, low pass or Laplacian filters. There is also capability for horizontal and vertical edge enhancement filtering to provide for a better delineation of the image.

2.2.3 EP197 Coaxial Cable Assembly

A flat ribbon coaxial cable assembly that connects the DT2861 to the video system.

2.2.4 C3057 CCD Video Camera

The C3057 cathode coupled diode (CCD) camera is a CCIR system with a 510 x 492 resolution. The horizontal scanning frequency is 15.7 kHz (60 Hz vertical). Synchronization was possible from either internal or external source. The camera is powered by a companion ac adaptor, 12-V d.c power supply A3472. A C-mount adapter was required to mount the camera on the microscope whose objective also served as the lens for the camera and therefore precluded the need for a separate camera lens.

2.2.5 RGB Video Monitor

An RGB (red,green,blue) video monitor with a video input RS-170/RS-330 512 x 480 x 8 NTSC was required for visual display of the image projected by the video camera. The monitor was selected to respond to the analog output signal characteristics of the DT2861

2.2.6 A3194-00 Connecting Cable

A coaxial cable for connecting the power supply to the video camera.

2.2.7 12 Mhz 386 VGA Zenith Computer

An AT compatible personal computer (pc),with the following specifications was needed to complete the setup: 1 Mb RAM, 40 Mb hard disk drive, 1.2 Mb floppy. The frame grabber and the frame processor boards plugged directly into the pc and were controlled by the computer software. The 40 Mb hard disk was subsequently upgraded to 65 Mb. This provided ample storage capability for the processed data. For backup the data were stored on floppy diskettes.

2.2.8 Bausch & Lomb Microscope

A Bausch and Lomb microscope with a trinocular head mount coupled with the CCD camera provided the necessary analog signal that was subsequently digitized and processed by the array processor. The optics on the microscope were good and provided very clear images at all times.

2.2.9 Video Cassette Recorder (VCR)

A home video cassette recorder was included to provided a continuous image input to the image grabber.

3 Method of Analysis

3.1 Acquisition of image from film

As indicated in section 1.2, the devolatilization processes were recorded on a 16 mm film at a framing rate of 5000 frames per second or 0.2 ms per frame. Initially, the film images were rerecorded onto a video cassette. Using a film projector the 16 mm film images were projected onto a screen. The projected images were then videotaped with a camcorder to provide video cassette inputs directly to the image grabber. The VCR output while it provided a continuous image was found, however, to be unsuitable for quantitative analysis. Changes in particle state from one instant to the next were almost impossible to discern. For this reason analysis from the video player input was abandoned in favor of the microscope input where the 16 mm film was set on a microscope stage for a frame-by-frame measurement.

A typical event contained between 100 to 150 frames of images. Each event commenced with the initiation of the laser heating pulse the presence of which was indicated by a series of timing streaks that lasted for about 25 frames. All prior frames represented the stationary particle in the chamber before the laser pulse was fired. Thus frame #1 represents the first laser timing streak. To define the initial particle diameter the analysis of each particle began ten frames prior to the laser timing streaks. All the values measured between frame -10 to frame 0 were added and averaged. The average value was then taken to be the initial particle diameter and served as the basis for comparison for all subsequent measurements for that event. In order to correctly identify the frame number for the first laser timing streak the frame count for any given sequence was started from the very first frame in which an image appeared. For example, for particle #1 the first laser timing streak is observed in frame number 85. This frame is thus frame number #1 for and the changes due to the devolatilization of the particle are considered to begin from that frame. The frame immediately before the first timing streak frame was always taken to be frame #0. Applying the above method the first frame from which data were used to commence the calculations for this particular event was frame number 75. The average value for the initial diameter was obtained by averaging all the data between frame 75 and 84.

Successive sections of the film were secured onto the microscope slide with a adhesive tape and placed on the microscope stage. For a lateral movement of the stage five consecutive frames could be placed in turn in the view field of the objective. The microscope image was directed by the CCD camera to the image grabber for capture and storage in the host computer memory. A second output terminal on the camera provided an outlet for observing the image on a video monitor. Once the section of film under the microscope had been recorded it was removed and advanced to place another set of frames on the slide as before. A "take-up" spool was setup on the opposite side of the film spool so that the free end of the film could be wound on this spool. This arrangement also made it easy to rewind the film onto the original spool once the measurement was completed.

3.1.1 Grabbing the data

The first stage of the data acquisition consisted of grabbing the desired frame. For this either a single frame mode or a continuous mode of operation of the frame grabber could be employed. In a single mode operation the image is "frozen" at the instant the triggering pulse is applied. Depending upon the synchronization the image may be captured in its entirety or in part. When only a part of the image is frozen the operation is of course, repeated until a full image is obtained. In the continuous mode operation the image is observed continuously on the monitor and the decision to freeze is taken by the operator. For a video player input the continuous mode is the only practical choice. With a microscope image, however, both the single frame mode and the continuous mode may be used. The operation was menu driven and could be repeated any number of times until a satisfactory capture had been made.

Once a full image was captured it was labeled appropriately and the data stored on a disk. A typical label would be P5F44. This is taken to mean frame #44 of particle number 5. Subsequent frames for any given particle were recorded at reasonably spaced intervals; close enough to ensure that the physical changes due to the devolatilization processes were properly documented.

3.1.2 Saving the buffer data

Each frame buffer of the DT2861 requires 256 kbytes of memory to store the buffer data. Storing the entire buffer data would have exhausted the host computer storage in no time. To avoid this, a window function was created to permit a definition of the position and size of the active area. The active area is the region within which the image resides. The active area only could then be stored providing considerable saving in storage. Figure 8 shows a typical frame acquired by the frame grabber. This buffer data required 250 kbytes of memory. In figure 9, the same image is shown in a window. The active area represented by the window took up only 34 kbytes of storage. All the data acquired by the frame grabber were prepared in this manner before storing in the computer storage to be analyzed at a later stage. Backup copies were also prepared on diskettes.

3.2 Analyzing the data

To analyze a particular image the windowed buffer data was loaded from the host computer into an output buffer in the DT image processor and displayed on the RGB monitor. The following procedure was then applied.

3.2.1 Filtering

Every signal processing procedure generates inherent noise signal known as "quantization noise". In extreme cases signal-to-noise ratios can be fairly low (< 30 %) If this noise signal is not removed prior to analysis the resulting data would be in serious error. Filtering or Spatial filtering is a process whereby quantization noise is removed leaving a clear image. Spatial filtering is typically used for edge enhancement. Since the analysis included tracing the shape of the particle filtering the image to remove any noise signals was essential for accurate analyses of the photographic data.

3.2.2 Contrast

Contrasts of varying degrees were applied to change the brightness in the image using pixel distribution operations. The degree of contrast applied was dictated by the relative brightness of the image compared with its background.

3.2.3 Area measurement

The area of the image was measured (in pixels) by first tracing the edge of the image. The pixel values within the current active region of the specified frame buffer were summed up to provide the total area of the image. The perimeter of the image was also computed in the same operation. The values were stored in a Lotus data base for computational analysis.

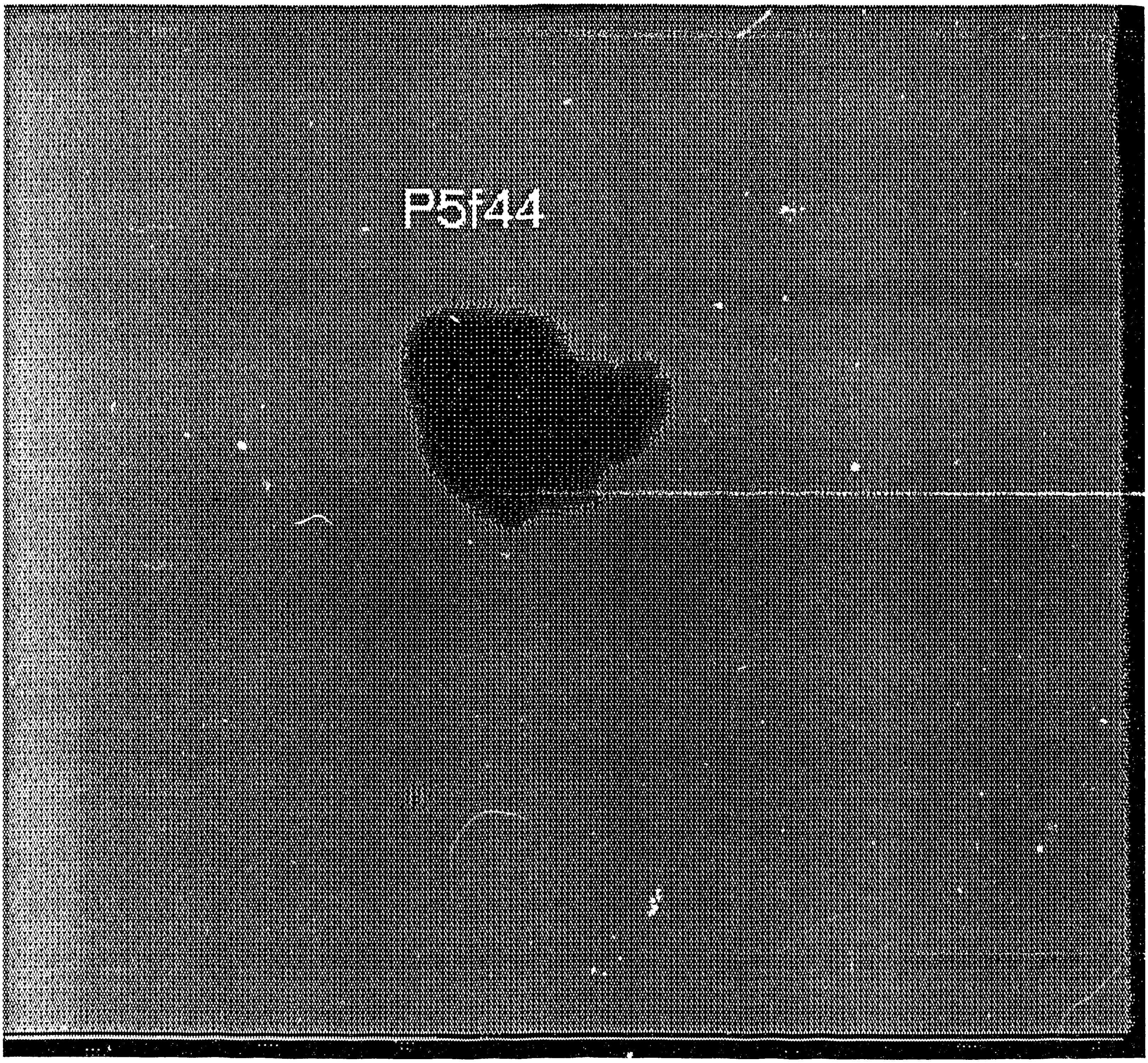


Fig. 8 A typical image immediately upon capture.
The full buffer required 256 kbyte of storage.

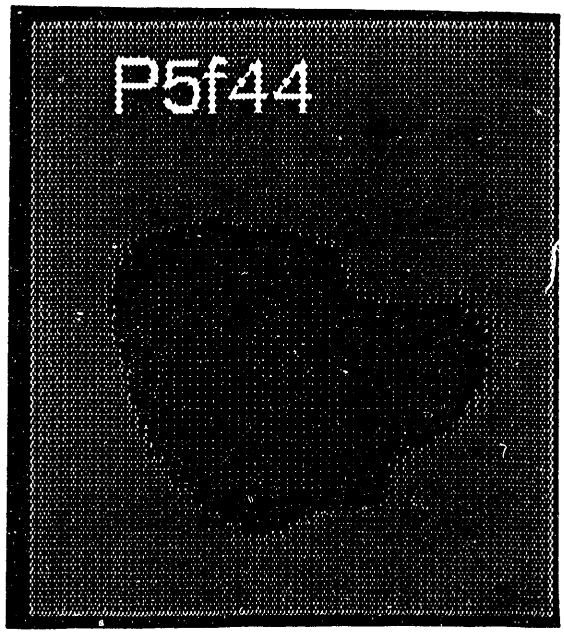


Fig. 9 An image placed in a window requires less storage space. The image in Fig.8 shown here in a window used up only 34 kbyte storage

4 Conversion of pixel data into metric units.

4.1 System calibration

A 0.1 mm stage micrometer with ten subdivisions was used to calibrate the setup. Applying the same overall magnification the micrometer scale was projected via the CCD camera onto the RGB monitor. Two full circles of diameter 100 μm and 50 μm were constructed inside the scale. The circles were prepared for analysis as would any other image. That is, filtering and contrast were applied to both and the area in pixels were measured. The two circles were grabbed and stored on disk as described in section 3.1.1

4.2 Conversion factor

To compute the diameter of the particles in metric units a conversion factor was determined using a geometric figure of known dimensions. Thus the circles described in section 4.1 presented the ideal figure for comparing the areas of the images from the photographic records. For this reason the projected areas from the images were converted to equivalent circle areas. The conversion factor was determined as follows. Let the particle of diameter D (μm) project a circle of area A (pixels). The calibrating circle of diameter d (μm) projects area a (pixels). Comparing areas D is easily shown to be

$$D = d\sqrt{\frac{A}{a}} \quad \mu m \qquad (1)$$

The area of the circle like those of the images depended upon the overall magnification. When that was changed a new calibration value was computed for the new overall magnification.

4.3 Swelling ratio

As indicated in section 3.1, a zero frame was defined as the frame just before the arrival of the laser pulse. This also made it possible to correlate all the data from the rest of the measurements. The initial particle diameter assigned to frame 0 was the average of three values starting from ten frames before the arrival of the laser pulse. Diameter changes as a direct result of the devolatilization process were calculated from the area data using equation (1) above. A correction factor was applied to account for the unknown magnification during the initial photography and subsequent copying. Based on a knowledge of the original dust diameters, the initial diameter of one particle was compared with the measured value at t = 0. A ratio of the calculated initial diameter to the known diameter provided the correction factor of 0.5089 which was applied throughout the analysis. The swelling ratio was obtained as

$$r_{sw} = \frac{Diameter}{Initial\ Diameter} \qquad (2)$$

The complete analyses for all the particles studied are listed in Appendix A. The analyzed data for particles #1 is shown in Table 1. The numbers in column 2 represent the actual frames, "record frames", from which the photographic images were recorded for analyses. Changes in the area and perimeter of the particle (in pixel units), are shown in columns 3 and 4 respectively. The laser timing pulse begins from frame 85. The time count for the devolatilization process, (t = 0), thus begins from frame 84, "event frame". The initial particle diameter is calculated by averaging the values from record frame 75 up to and including record frame 84. The average value is shown in column 1. By applying equation (1) to the pixel data in column 3 the particle diameters are computed (in μm), in column 5. A correction factor is applied to account for system calibration. to obtain the final particle diameters shown in column 6. The swelling ratios calculated according to equation (2) are in column 7. The last column contains the event periods used in plotting the data. Since record frame 84 corresponds to the event at t = 0, the subsequent event periods are obtained by subtracting 84 from the corresponding record frame number.

5. Results

5.1 Swelling characteristics

The swelling characteristics of hvA bituminous coal particles irradiated with pulsed laser beams are now discussed with the aid of the diagrams in figures 10, 11 and 12. Frame (a) in each diagram represents the particle in its initial state just before being struck with the laser beam; (see section 3.1). Frames (b) through (d) represent various stages of the particle during the devolatilization process. In Figure 10, the particle begins to heat up approximately 1.2 ms after the heating pulse impinges on it. It begins to swell as evidenced in frame (c). At about 7.8 ms (frame d), the swelling continues and appears to be strongest along the major axis of the particle. A somewhat similar behavior is observed in the particle in figure 11. The particle assumes an oval shape during heat-up. The swelling of the particle shown in figure 12 appears to be uniform throughout the particle. Approximately 5.6 ms after application of the laser pulse the particle has swollen to almost twice its original size.

Part#	Record frm #	Area pxl	Permtr pxl	Dia. um	Crtd um	Ratio	Event frm # x.2 ms
1	1	7962	384				
	5	7753	343				
	9	7703	357				
	13	7790	367				
	14	9120	430				
	17	7598	349				
	20	6902	332				
	23	7650	368				
	26	6942	337				
	29	9124	465				
	33	7575	345				
	37	7497	369				
	41	7862	352				
	45	7923	352				
	49	7721	346				
	53	7817	363				
	57	7894	370				
	61	8400	402				
	65	8162	357				
	69	8049	367				
*	75	7993	380				
	76	7954	361				
	79	7953	351				
	80	7902	354				
7899	84	7691	352	226.4720	125.5945	1.0000	0
#	85	7555	344	221.4914	122.8324	0.9780	1
	89	7748	352	224.3026	124.3914	0.9904	5
	93	7995	308	227.8499	126.3586	1.0061	9
	97	8214	353	230.9494	128.0775	1.0198	13
	101	8159	380	230.1749	127.6480	1.0164	17
	104	9769	497	251.8631	139.6756	1.1121	20
	119	8959	395	241.1956	133.7597	1.0650	35
	124	77[illegible]5	354	223.8389	124.1343	0.9884	40
	128	7076	353	214.3549	118.8747	0.9465	44
	133	7436	342	219.7401	121.8611	0.9703	49
	141	11813	412	276.9617	153.5945	1.2229	57
	145	9495	383	248.3059	137.7029	1.0964	61
	149	10156	402	256.8035	142.4154	1.1339	65
	154	11179	424	269.4270	149.4160	1.1897	70
	159	11723	428	275.9046	153.0083	1.2183	75
	164	11941	455	278.4581	154.4244	1.2295	80
	169	12021	459	279.3894	154.9408	1.2337	85
	174	12192	473	281.3695	156.0390	1.2424	90
	179	12560	498	285.5843	158.3764	1.2610	95
	194	12361	501	283.3129	157.1167	1.2510	110
	199	12001	482	279.1568	154.8119	1.2326	115
	204	12811	543	288.4238	159.9511	1.2736	120
	209	12274	498	282.3141	156.5628	1.2466	125

Table 1. Analyzed data for particle 1. The record frames are shown in column 2. The times when the expected changes in the particle

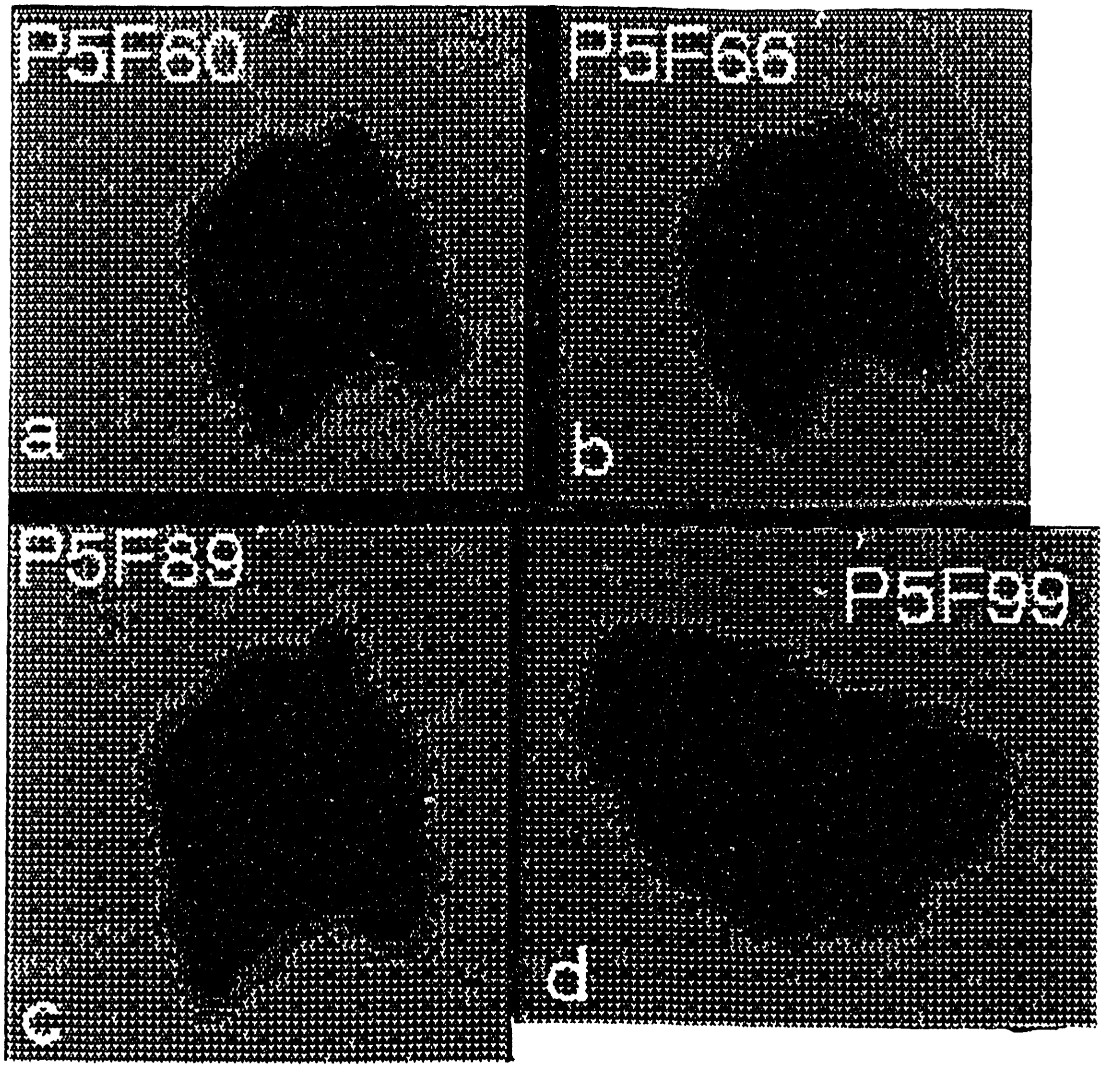


Fig. 10 Selected frames showing different stages of the particle during the devolatilization process

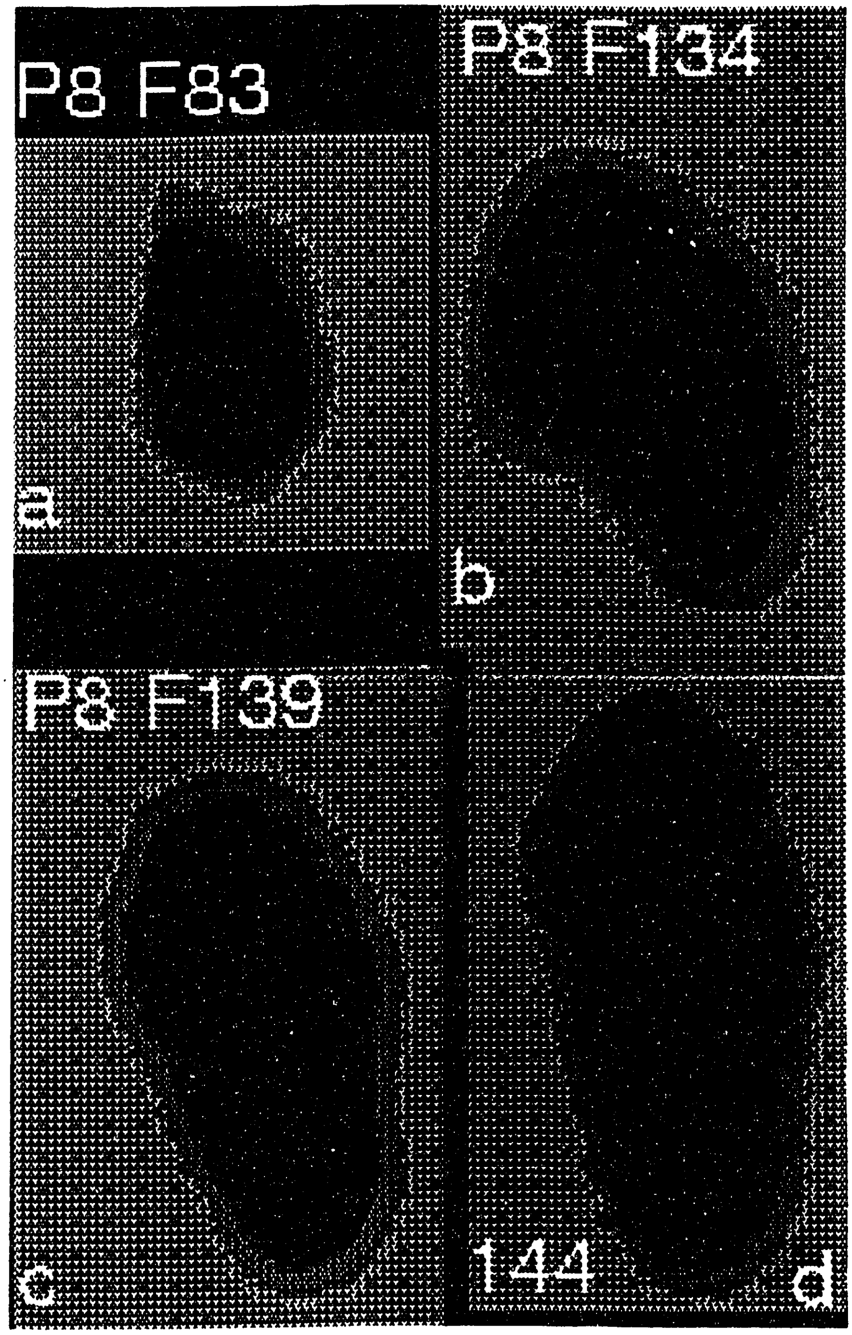


Fig. 11 Selected frames showing different stages of the particle during the devolatilization process

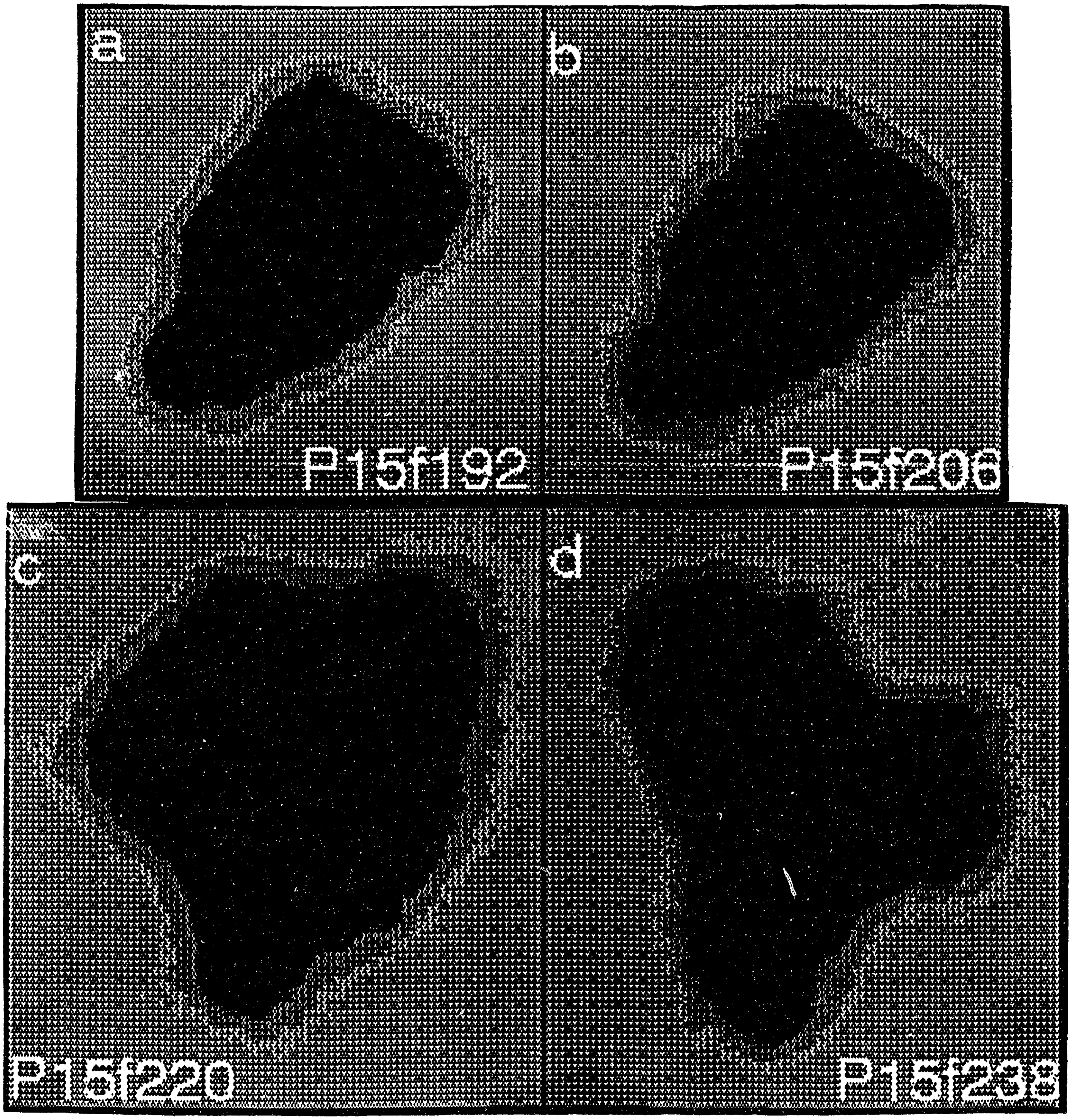


Fig. 12 Selected frames showing a particle undergoing both swelling and rotation during the devolatilization process

The particles in figures 10 and 11 show less tendency for rotation. 7.8 ms after heating begins the position of the particle (Fig. 10d) has not changed significantly. This is also the case with the particle in figure 11. After 3 ms of heating the position of the particle remains essentially the same. Particle swelling and rotation is exhibited by particle 15 as shown in figure 12. In (a) the particle is shown shortly before the heating pulse was applied. (The laser timing streaks actually begin from record frame 202. See Appendix A, particle 15 data). The lower end of the particle marked "X" in (a) and (b) now points upward in (c). In (d) the particle shows further evidence of rotation as the point now locates itself in an easterly direction.

5.2 Swelling ratio

Table 2 shows records of the particles as they appear on the photographic film. There were a total of 21 particles stored on two separate reels. The reels were arbitrarily labeled Film 1 and Film 2. There were nine events on Film 1 and 12 on Film 2. For the purpose of identification the events were numbered 1 through 21 beginning from the first record on Film 1. In Table 3 the particles are grouped in two ways. The first group puts together particles irradiated with the same heating flux regardless of their initial diameters. The second group consists of particles having the same initial diameter but irradiated at different heating levels. The swelling ratios were plotted as a function of time (frame number) for each individual particle. As far as possible the graphs are presented in the order as shown in Table 2 and reference will be made to particle numbers in the following discussions.

Figure 13 Particles 1-2

The differences in the initial diameters listed are rather small and for all practical purposes these particles may be considered the same size. While they were each heated at a different laser intensity, the swelling ratios behave somewhat similarly. All the particles experienced both swelling and contraction during the heating period. The swelling ratio increased for each particle with values rising to between 1.25 and 1.35.

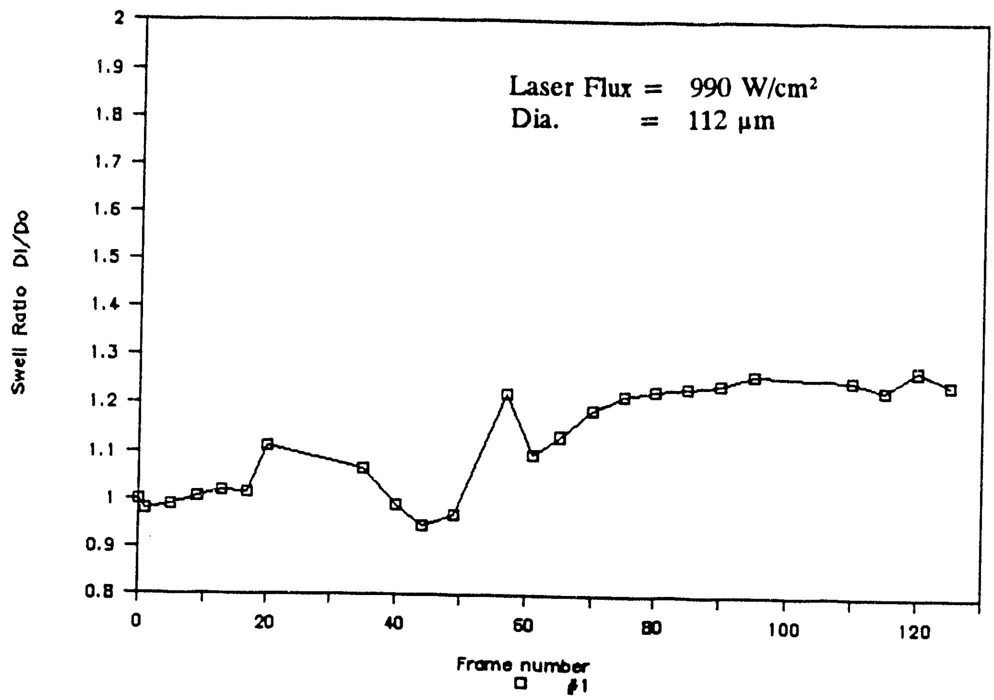
Ref. #	Diameter µm	Pulse duration ms	Laser flux W cm^{-2}
Film #1			
1 1221	115	10	990
2 1218	113	10	1020
3 1220	120	10	1000
4 1225	116	10	750
5 1226	113	10	750
6 1228	112	10	750
7 1229	118	10	735
8 1217	112	10	1040
9 1223	118	10	1000
Film #2			
10 1222	115	10	1000
11 1248	134	10	4200
12 1249	120	10	4200
13 1250	87	10	4200
14 C110	85	10	1050
15 C111	95	10	1040
16 C112	115	10	1100
17 C113	110	10	1040
18 C114	120	8	1050
19 C115	110	6	1050
20 C116	120	4	1040
21 C117	115	3	1040

Table 2. Twenty one events taken from a large film bank showing the particle diameters and the applied laser intensities

Laser Flux W/cm²	Particles (see Table 2)
735	7
750	4, 5, 6
990	1
1000	3, 9, 10
1020	2
1040	8, 15, 17, 20, 21
1050	14, 18, 19
1100	16
4200	11, 12, 13
Particle Diameter μm	**Particles (see Table 2)**
85	14
87	13
95	15
110	17, 19
112	6, 8
113	2, 5
115	1, 10, 16, 21
116	4
118	7, 9
120	3, 12, 18, 20
134	11

Table 3. The events are shown sorted according to Laser pulse intensity (top part) and initial particle diameter, (lower part).

Swelling Characteristics



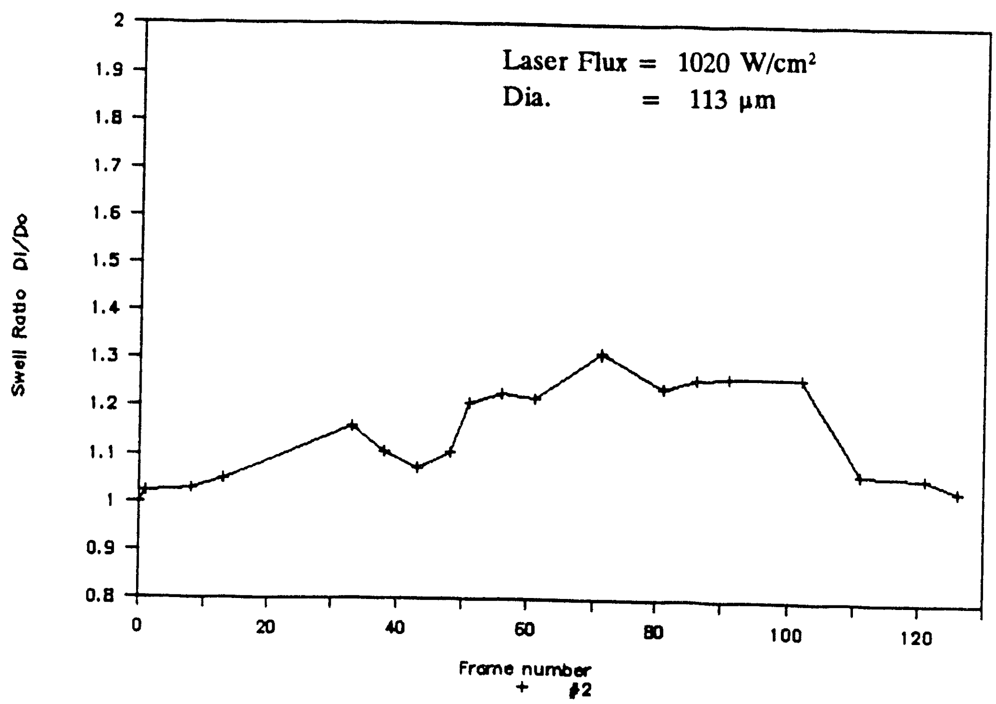


Fig. 13 Variation of swell ratio with time for hvA bituminous coal particle

Figure 14

Here again the differences in the diameters are small and the swelling ratios are about equal. Particle 3 both swells and contracts throughout the heating process. The very slow decrease in the swell ratio of particle 4 after reaching a peak at 1.35 suggests particle rotation rather than contraction. This is was confirmed when the events were viewed in video mode.

Figure 15 and 16

Particles 5 and 6 were both subjected to the same heating flux at 750 W/cm^2. Particle 6 experiences very rapid swelling followed by an equally rapid contraction. The maximum ratio attained is 1.3. Particle 5, on the other hand, swells steadily to reach a value of 1.3 before beginning to contract. There was significant swelling and contraction in particle 7 initially after which the particle continued to swell. This particle had the highest swelling ratio reaching a maximum of 1.8. The swelling behavior of particle 8 is similar to that of particle 7. The rapid swelling and contraction is completed much sooner, however, and the particle continues to swell to a value of 1.6.

Figure 17

Particles 9 and 10 exhibit somewhat identical behavior. Both particles swell and contract in a wavelike manner; and the peak swelling ratio is about the same. The heating flux for both particles was 1000 W/cm^2.

Figures 18 and 19

Particles, 11, 12 and 13 with initial diameters of 134, 120 and 87 μm respectively, were each independently subjected to a very intense flux of 4200 W/cm^2. All three particles were observed to ignite immediately upon being hit by the heating pulse. The particles rotated through the flame at very high speeds resulting in each being ejected from the center of the chamber and out of view. The differences in the sizes of the particles appear to have had little influence in their behavior. In each case the event was completed exactly 3.2 ms after ignition. The graphs reflect this behavior. No swelling occurred during the heatup. Particle 14, heated at 1050 W/cm^2 remained unaffected for several milliseconds after being struck with the beam. Once the swelling began it increased steadily to about 1.7 before the event was completed.

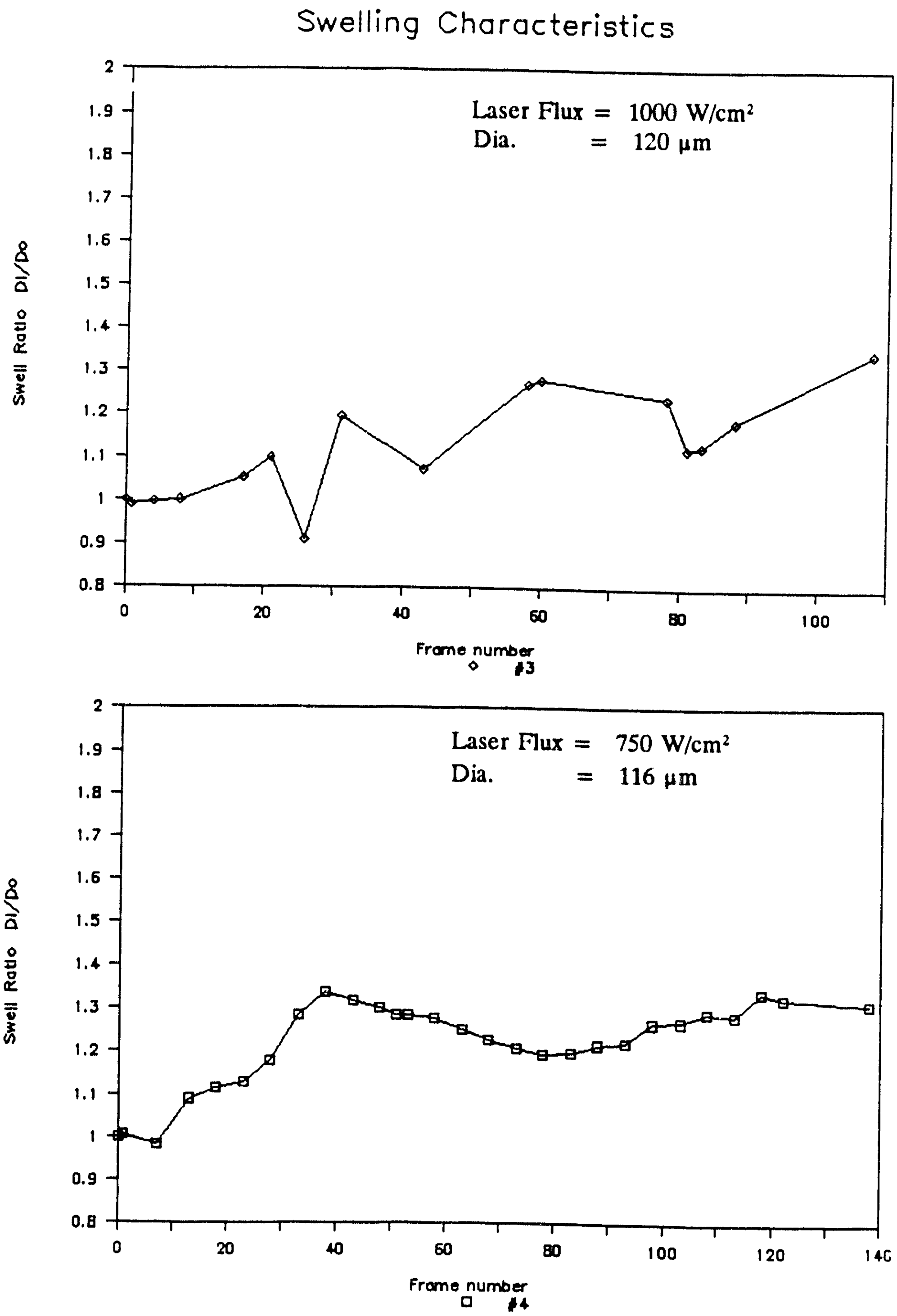


Fig. 14 Variation of swell ratio with time for hvA bituminous coal particie

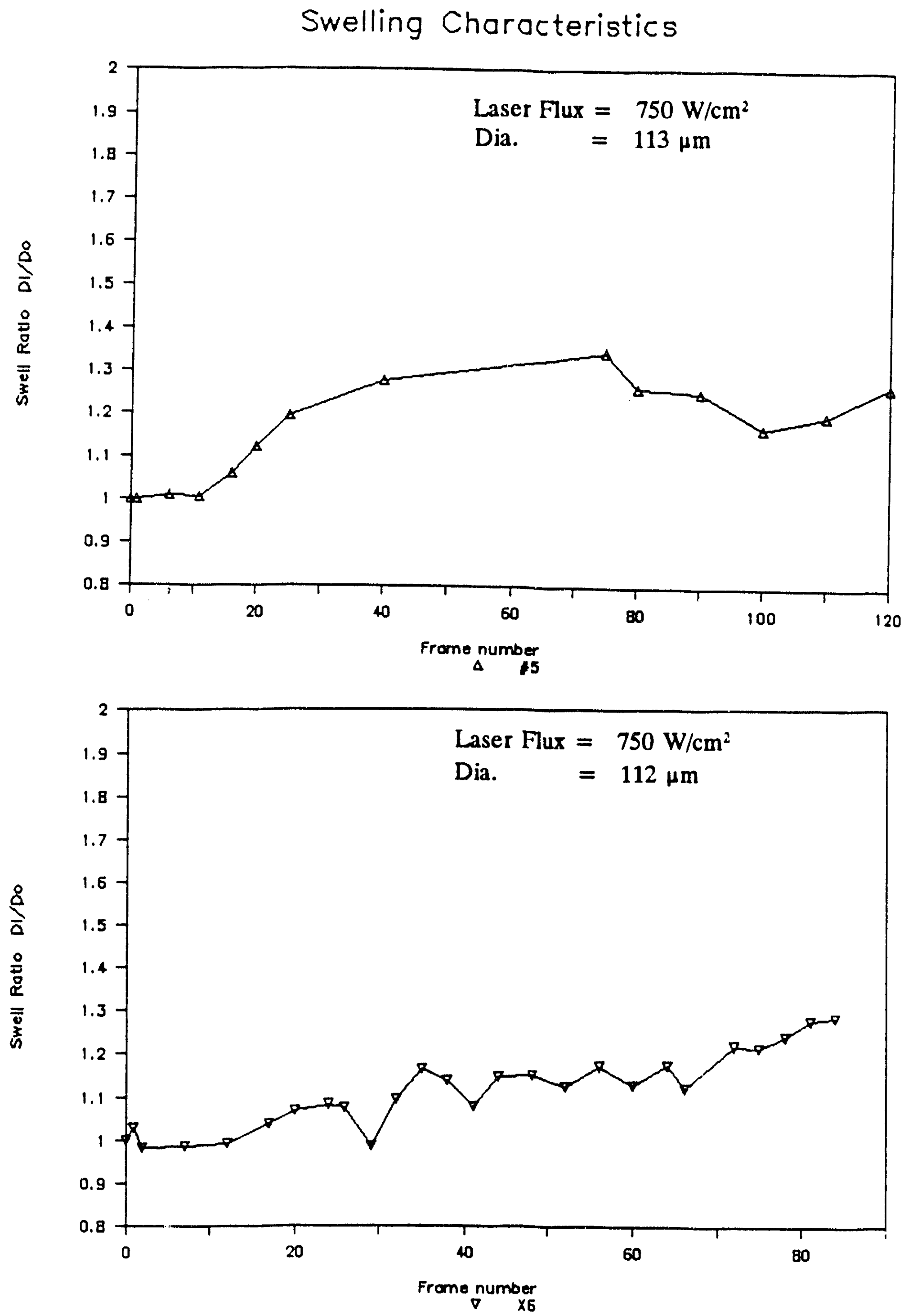


Fig. 15 Variation of swell ratio with time for hvA bituminous coal particle

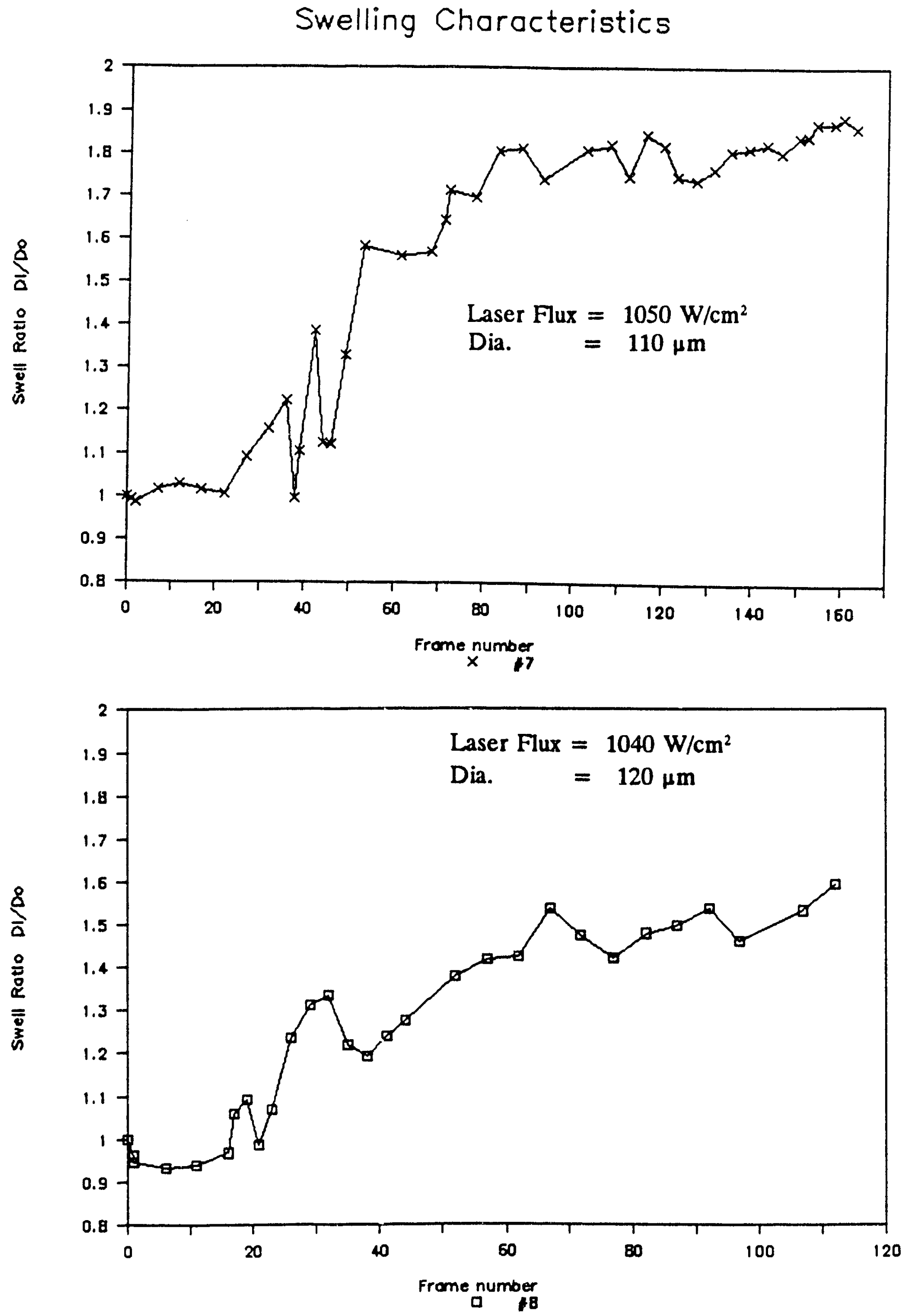


Fig. 16 Variation of swell ratio with time for hvA bituminous coal particle

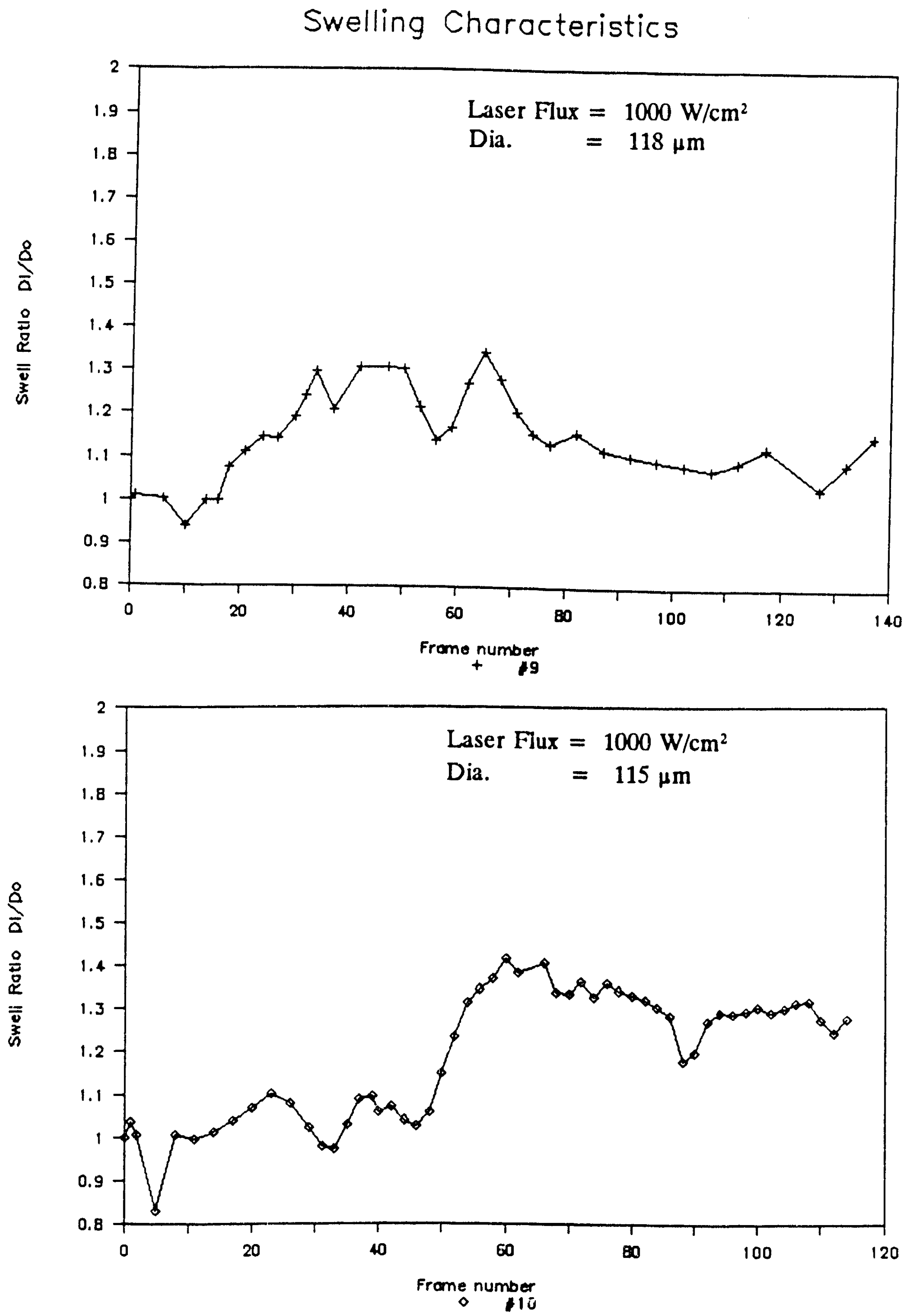


Fig. 17 Variation of swell ratio with time for hvA bituminous coal particle

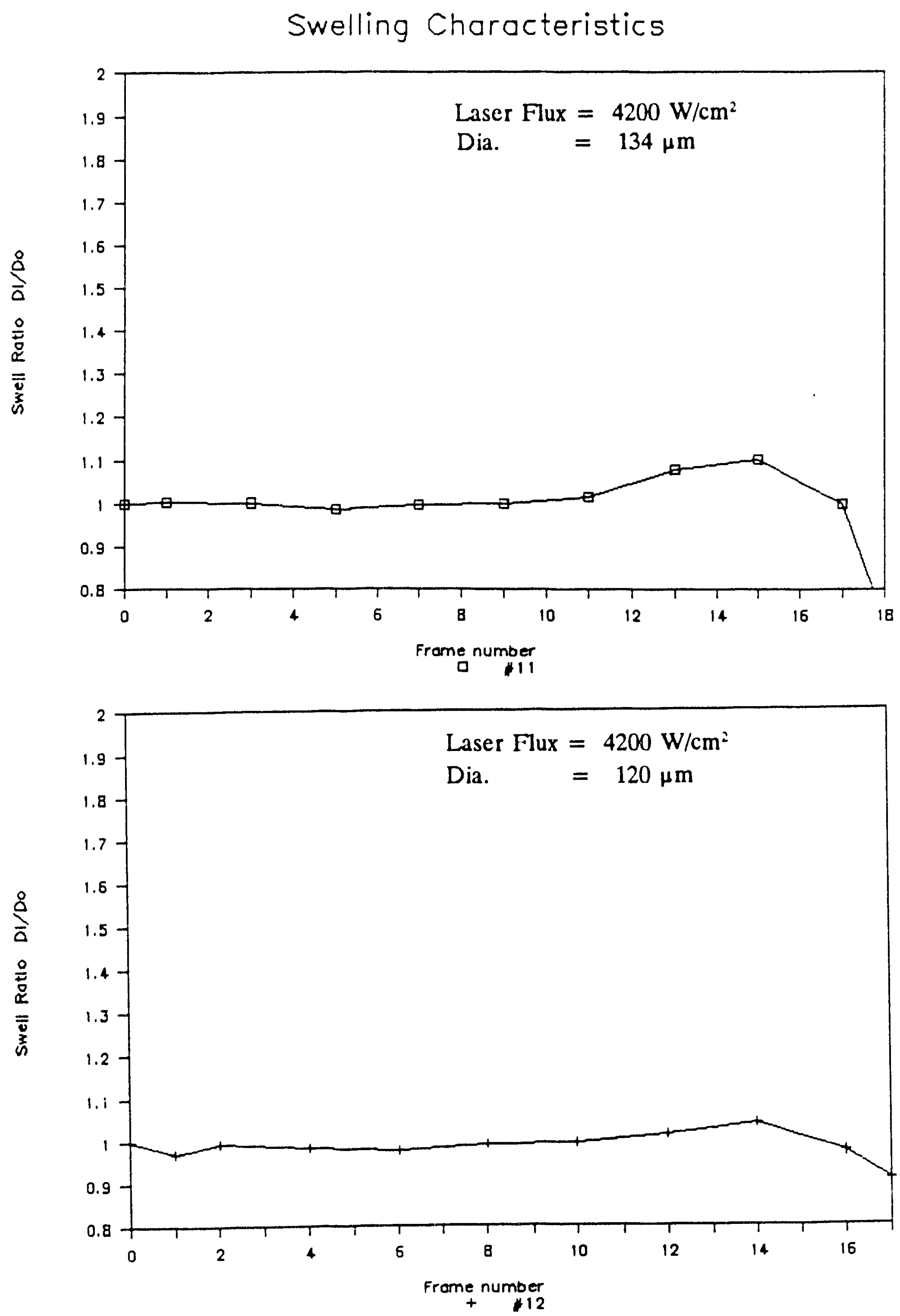


Fig. 18 Variation of swell ratio with time for hvA bituminous coal particle

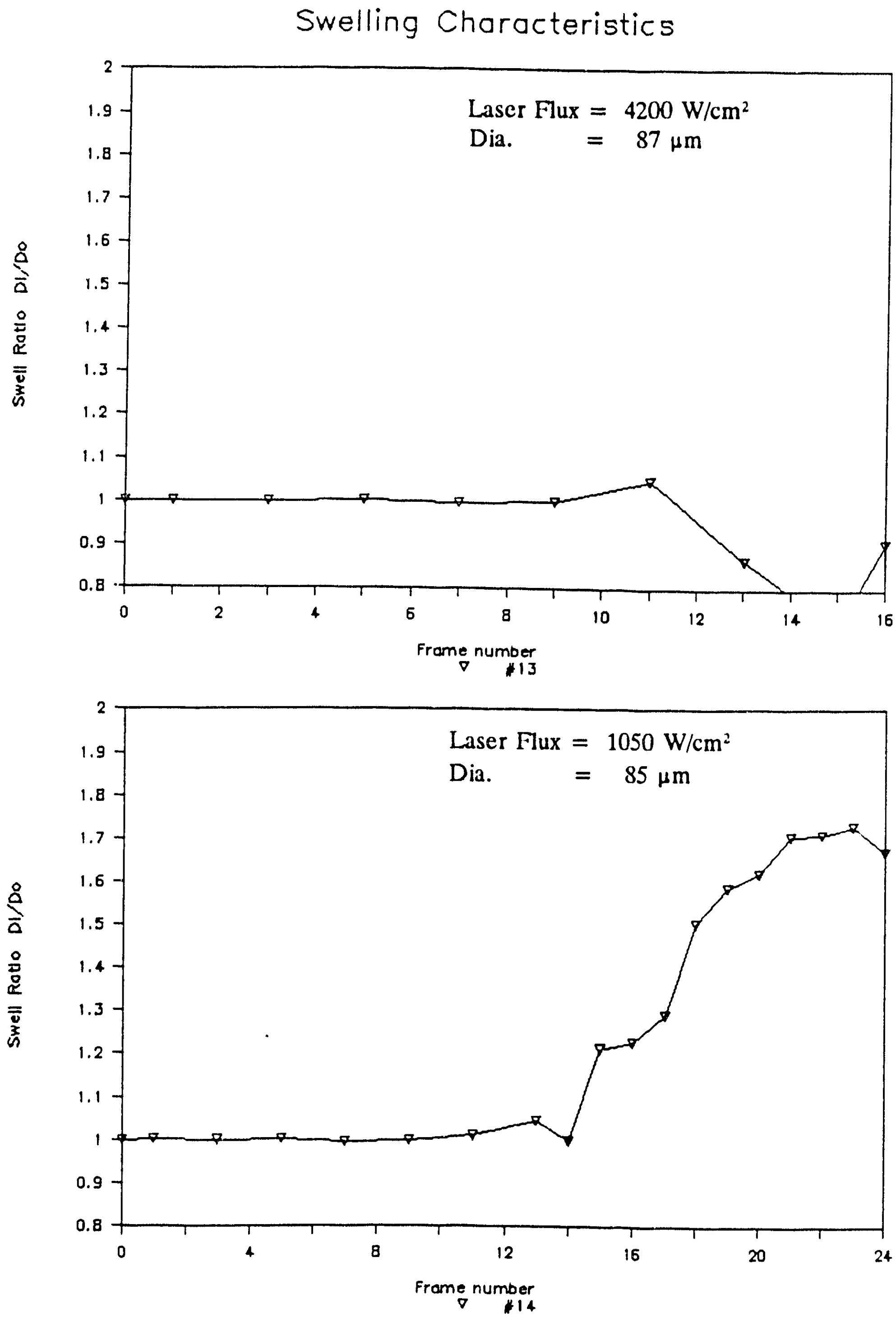


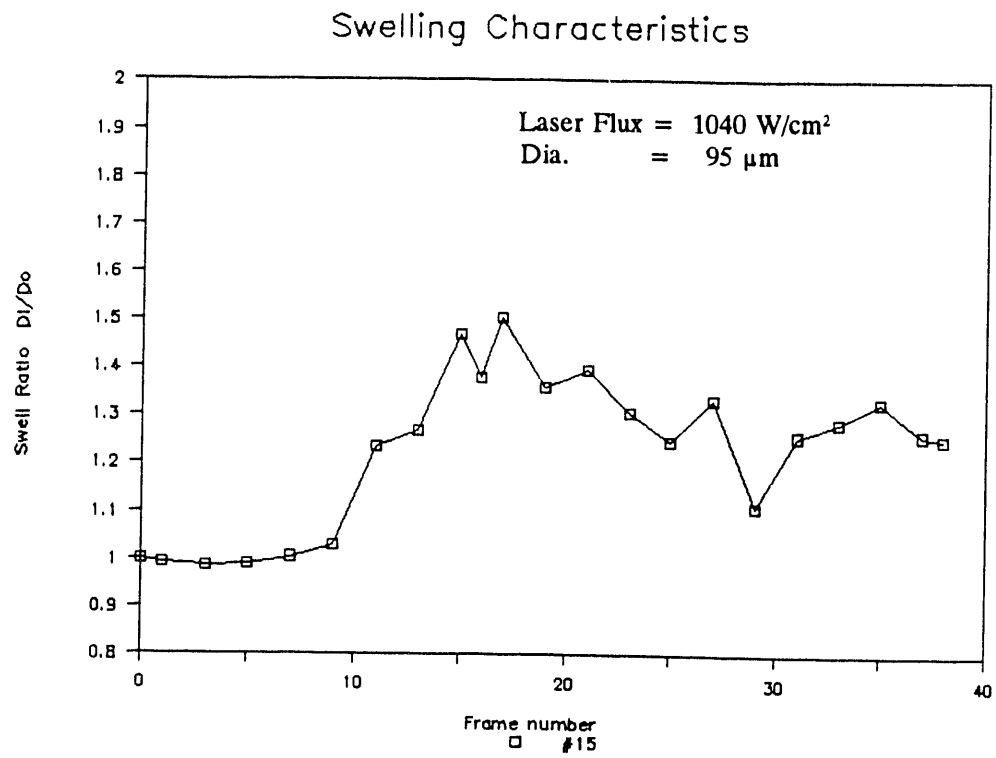
Fig. 19 Variation of swell ratio with time for hvA bituminous coal particle

Figure 20 and 21

Particle 15 appears unaffected for about 2 ms after being struck with 1040 W/cm^2 pulse. (A frame corresponds to 0.2 ms). After this time, however, it swells rapidly followed by a series of contraction. The peak swelling ratio reached in the process is 1.5. Particle 16 did not change significantly when heated with a flux of 1100 W/cm^2. Particle 17 underwent rapid swelling upon being hit by the laser heating pulse. The impact of the beam caused the particle to go into a spin followed by rotation which caused the particle to be swept from the field of view. The rotation effect is not observed in the graph since no data are available for the period the particle was out of view. It did reappear, however, several milliseconds later. This accounts for the break in the data. The subsequent data from the event suggest that the particle could have broken up while out of view. Particle 18 shows much the same behavior as particle 3. Is initial diameter is 120 μm and the heating flux level differs only by 50 W/cm^2.

Figures 22 and 23

The particles in this group are much closer in size and the heating pulse strength is about the same. The swelling ratio increases rapidly for particle 19 and 20; though particle 20 could only reach a swell ratio of 1.2. The highest swelling ratio of 1.5 was reached by particle 19. Particle 21 experienced considerable contraction after an initial swell up 1.3.



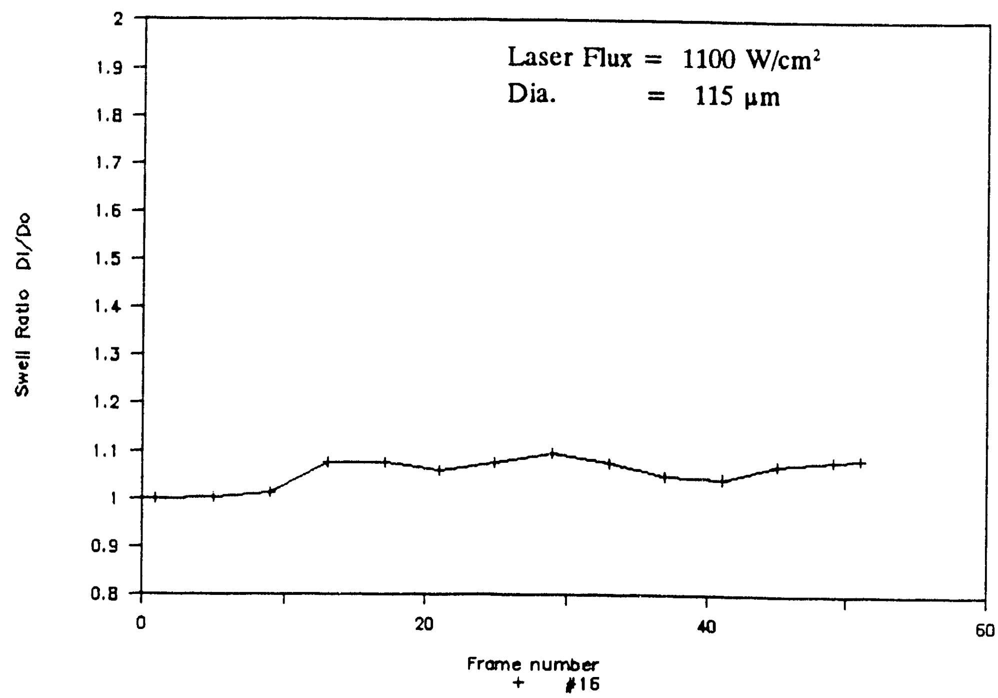


Fig. 20 Variation of swell ratio with time for hvA bituminous coal particle

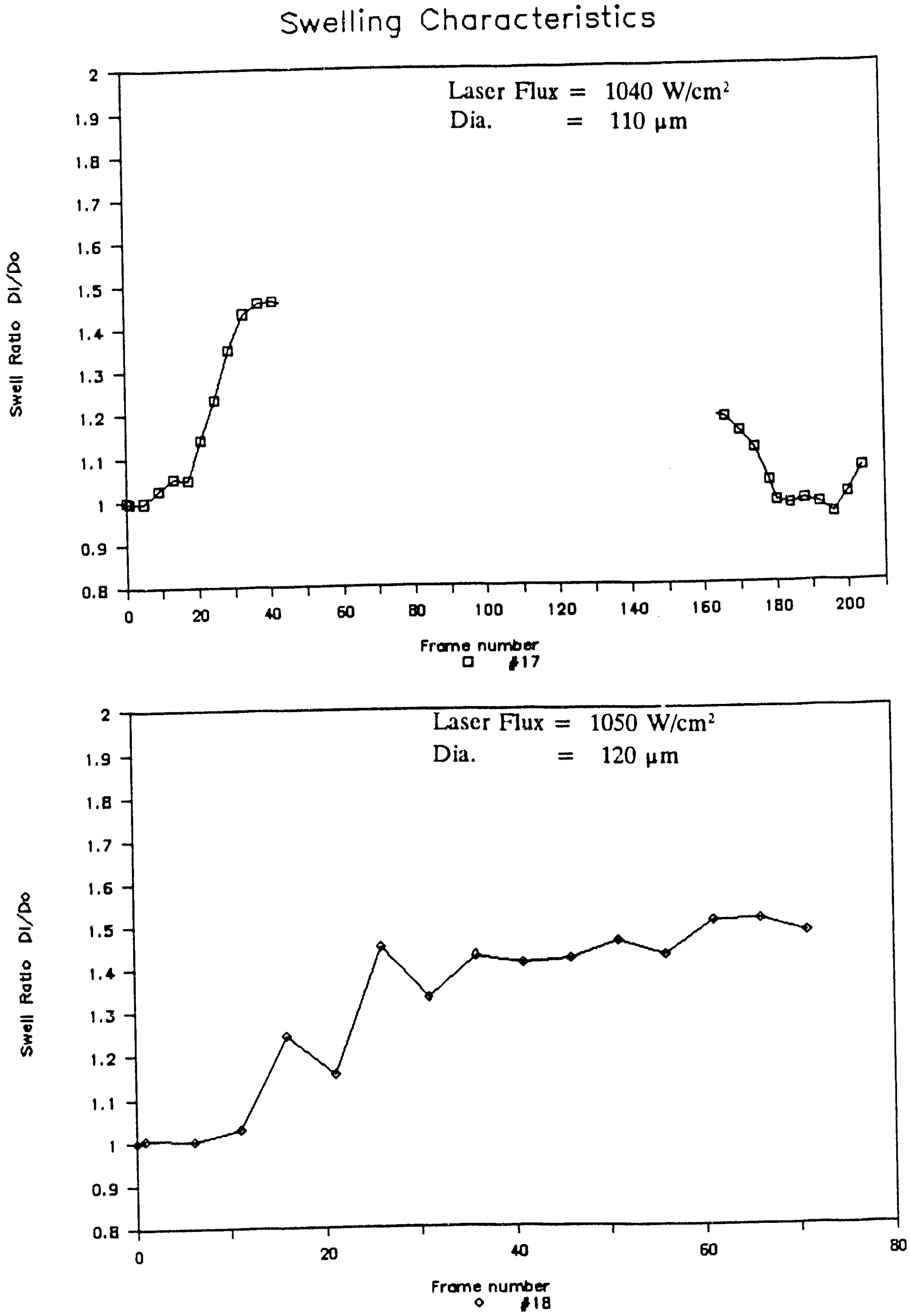


Fig. 21 Variation of swell ratio with time for hvA bituminous coal particle

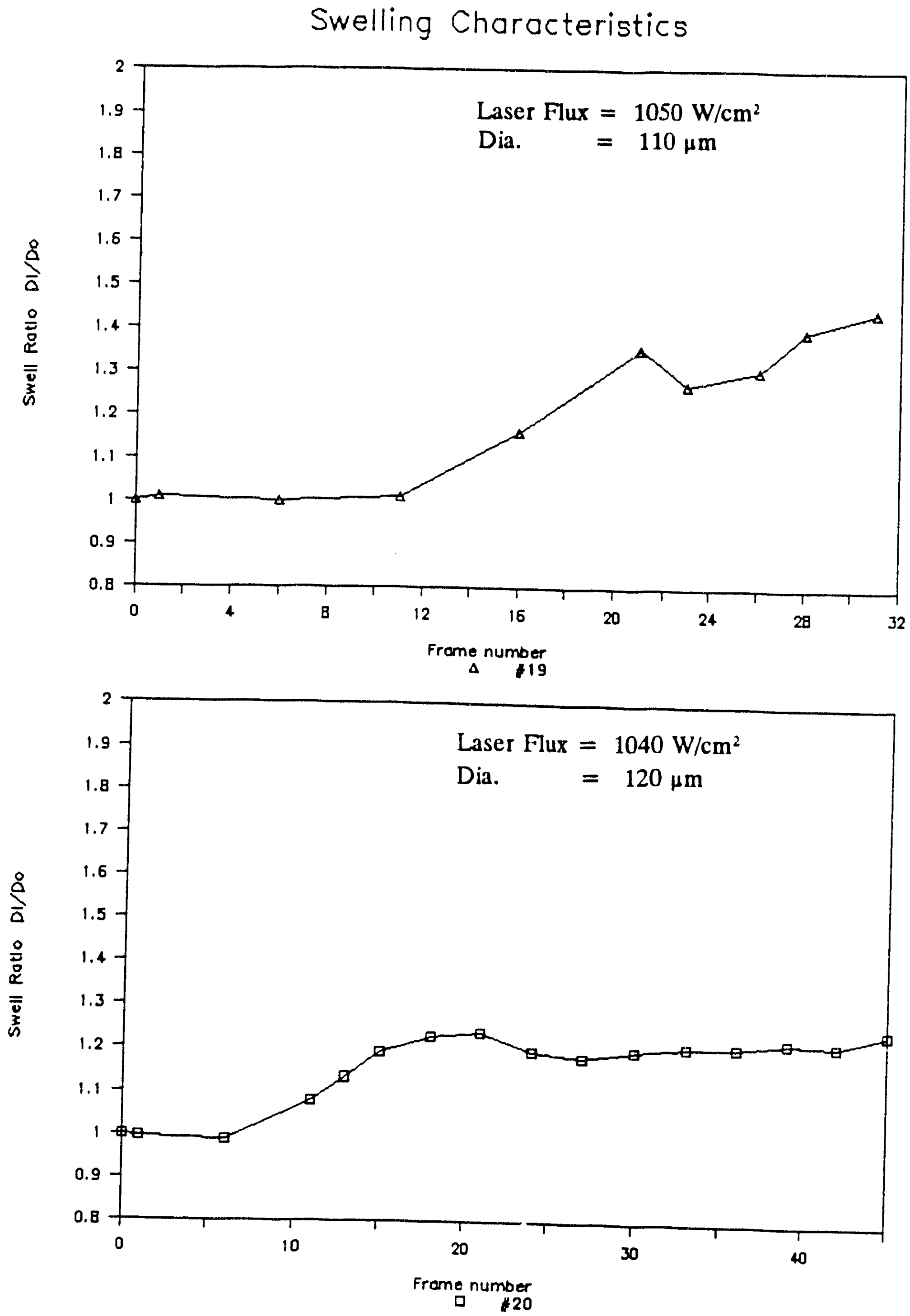


Fig. 22 Variation of swell ratio with time for hvA bituminous coal particle

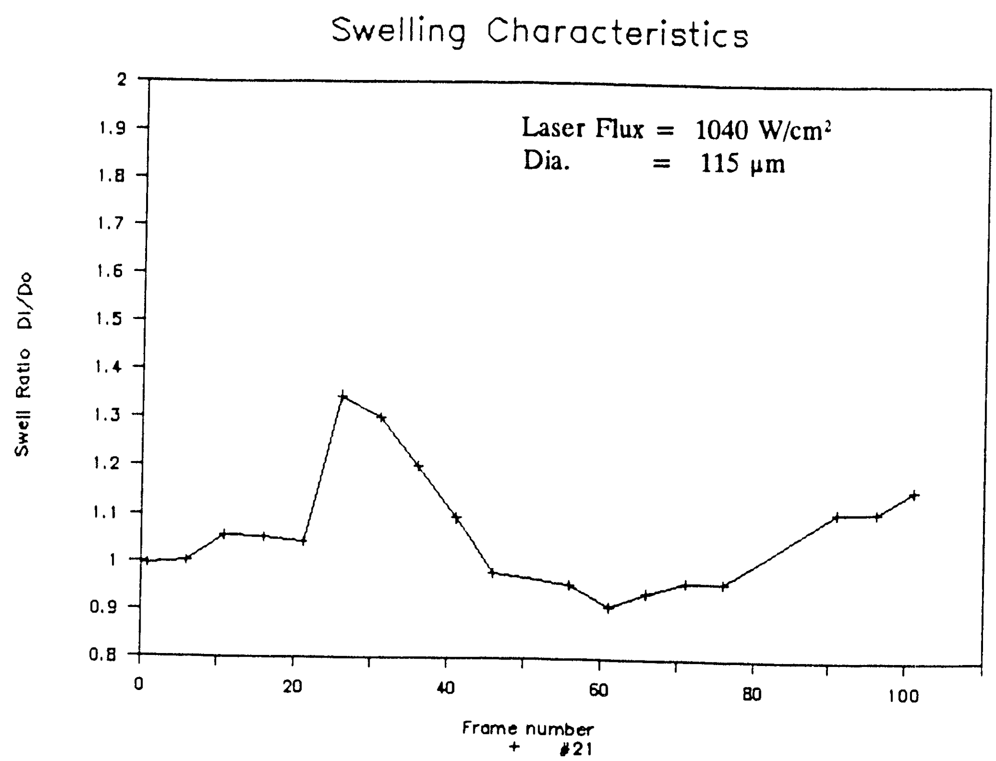


Fig. 23 Variation of swell ratio with time for hvA bituminous coal particle

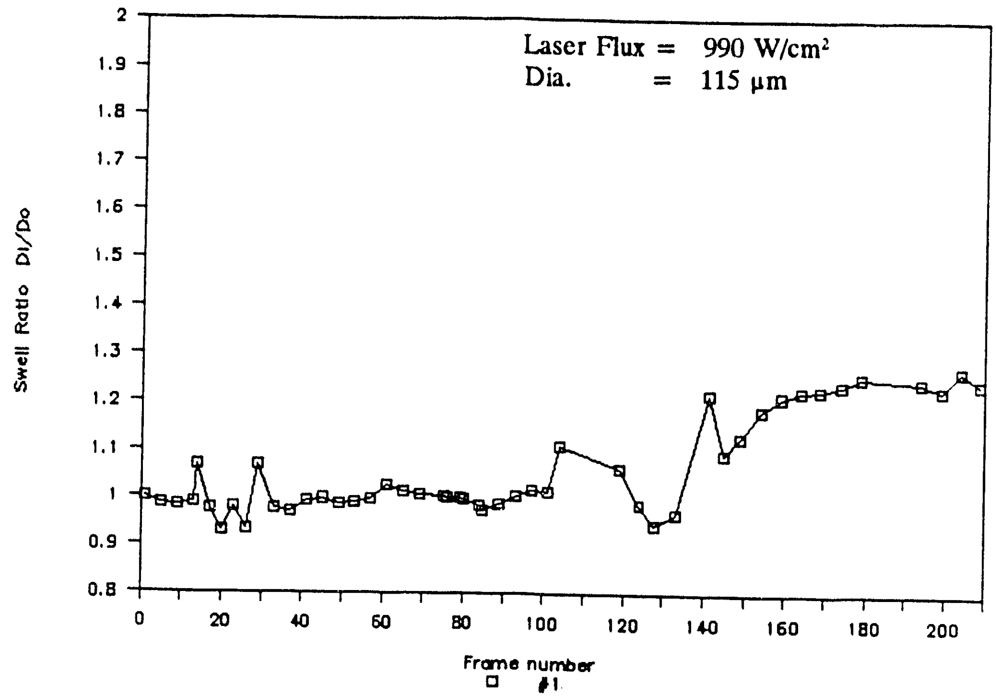
5.3 Complete history data

The swelling ratios were recalculated using a somewhat different approach from the data discussed above. In the second set of calculations the initial particle diameter was taken to be the first record frame image. The time axes for the graphs were also the record frames as discussed in section 4.1. Thus t = 0 corresponds to frame 1 for all the events. The complete analysis data are presented in APPENDIX B. In Table 4 the data for particle 1 is shown. The zero in column 8 represents the time of arrival of the laser heating pulse. The swell ratio plotted for all the events are shown in figures 24 through 34.

Part#	Record frm #	Area pxl	Permtr pxl	Dia. um	Crtd um	Ratio	Event frm # x.2 ms
1	1	7962	384	227.3791	126.0976	1.0000	
	5	7753	343	224.3750	124.4315	0.9868	
	9	7703	357	223.6503	124.0296	0.9836	
	13	7790	367	224.9097	124.7281	0.9891	
	14	9120	430	243.3531	134.9562	1.0703	
	17	7598	349	222.1208	123.1814	0.9769	
	20	6902	332	211.7030	117.4040	0.9311	
	23	7650	368	222.8796	123.6022	0.9802	
	26	6942	337	212.3156	117.7437	0.9338	
	29	9124	465	243.4065	134.9858	1.0705	
	33	7575	345	221.7843	122.9948	0.9754	
	37	7497	369	220.6395	122.3600	0.9704	
	41	7862	352	225.9467	125.3032	0.9937	
	45	7923	352	226.8216	125.7883	0.9975	
	49	7721	346	223.9115	124.1745	0.9847	
	53	7817	363	225.2992	124.9441	0.9909	
	57	7894	370	226.4061	125.5579	0.9957	
	61	8400	402	233.5496	129.5195	1.0271	
	65	8162	357	230.2172	127.6715	1.0125	
	69	8049	367	228.6180	126.7846	1.0054	
*	75	7993	380	227.8214	126.3428	1.0019	
	76	7954	361	227.2649	126.0342	0.9995	
	79	7953	351	227.2506	126.0263	0.9994	
	80	7902	354	226.5208	125.6215	0.9962	
	84	7591	352	223.4760	123.9330	0.9828	0
#	85	7555	344	221.4914	122.8324	0.9741	1
	89	7748	352	224.3026	124.3914	0.9865	5
	93	7995	308	227.8499	126.3586	1.0021	9
	97	8214	353	230.9494	128.0775	1.0157	13
	101	8159	380	230.1749	127.6480	1.0123	17
	104	9769	497	251.8631	139.6756	1.1077	20
	119	8959	395	241.1956	133.7597	1.0608	35
	124	7716	354	223.8389	124.1343	0.9844	40
	128	7076	353	214.3549	118.8747	0.9427	44
	133	7436	342	219.7401	121.8611	0.9664	49
	141	11813	412	276.9617	153.5945	1.2181	57
	145	9495	383	248.3059	137.7029	1.0920	61
	149	10156	402	256.8035	142.4154	1.1294	65
	154	11179	424	269.4270	149.4160	1.1849	70
	159	11723	428	275.9046	153.0083	1.2134	75
	164	11941	455	278.4581	154.4244	1.2246	80
	169	12021	459	279.3894	154.9408	1.2287	85
	174	12192	473	281.3695	156.0390	1.2374	90
	179	12560	498	285.5843	158.3764	1.2560	95
	194	12361	501	283.3129	157.1167	1.2460	110
	199	12001	482	279.1568	154.8119	1.2277	115
	204	12811	543	288.4238	159.9511	1.2685	120
	209	12274	498	282.3141	156.5628	1.2416	125

Table 4. Data for particle 1 showing complete history.The values in the last column represent the time between the arrival of the laser heating pulse and the end of the devolatilization process.

Swelling Characteristics



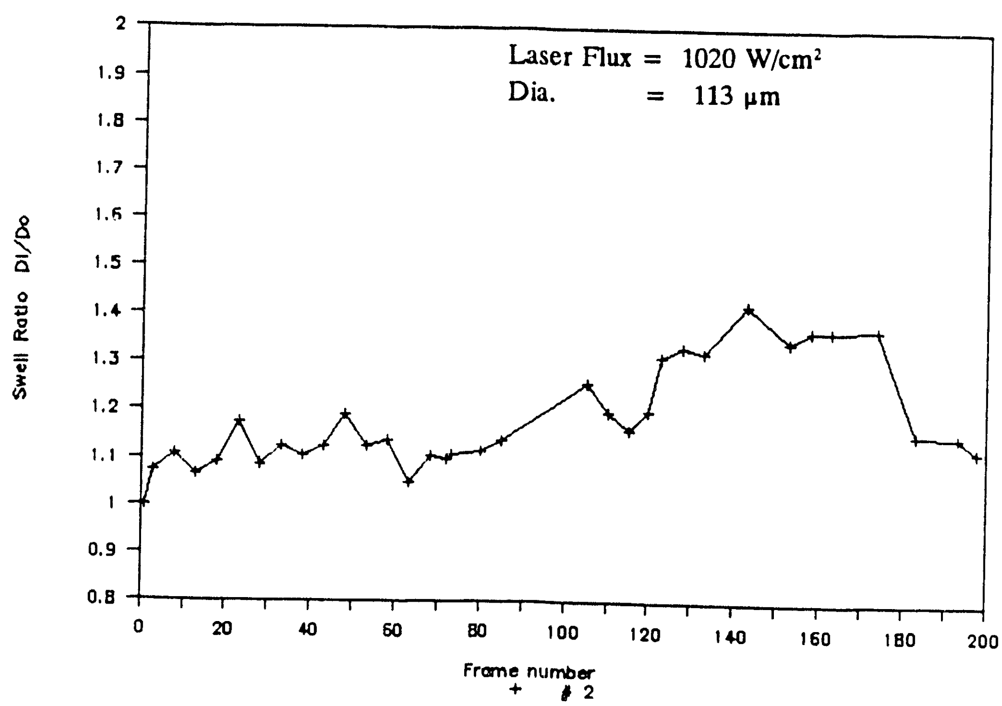
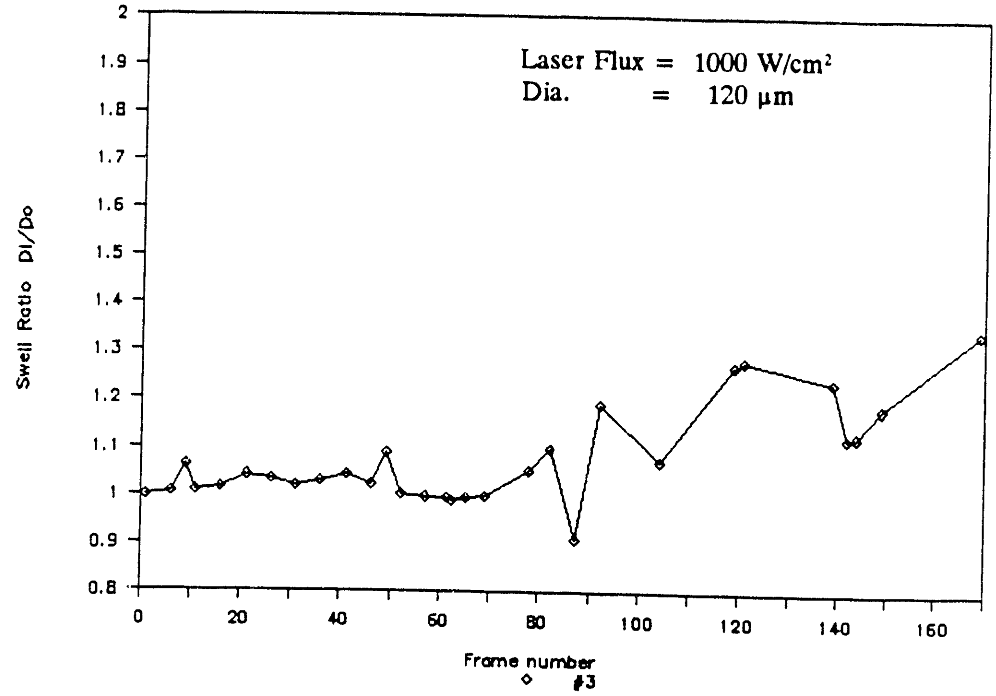


Fig. 24 Variation of swell ratio with time for hvA bituminous coal particle

Swelling Characteristics



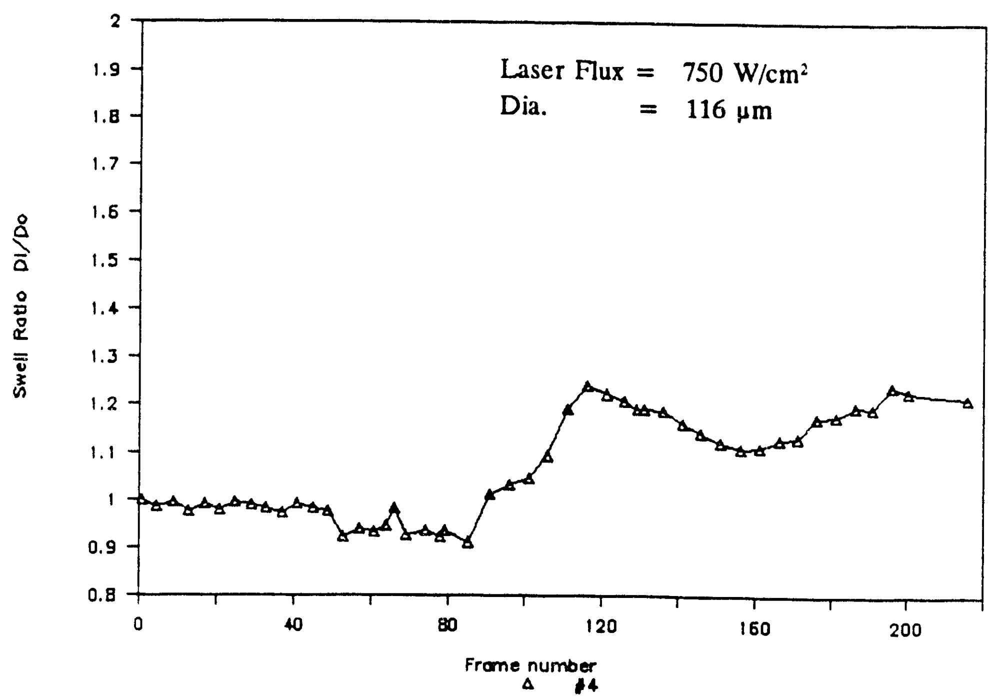


Fig. 25 Variation of swell ratio with time for hvA bituminous coal particle

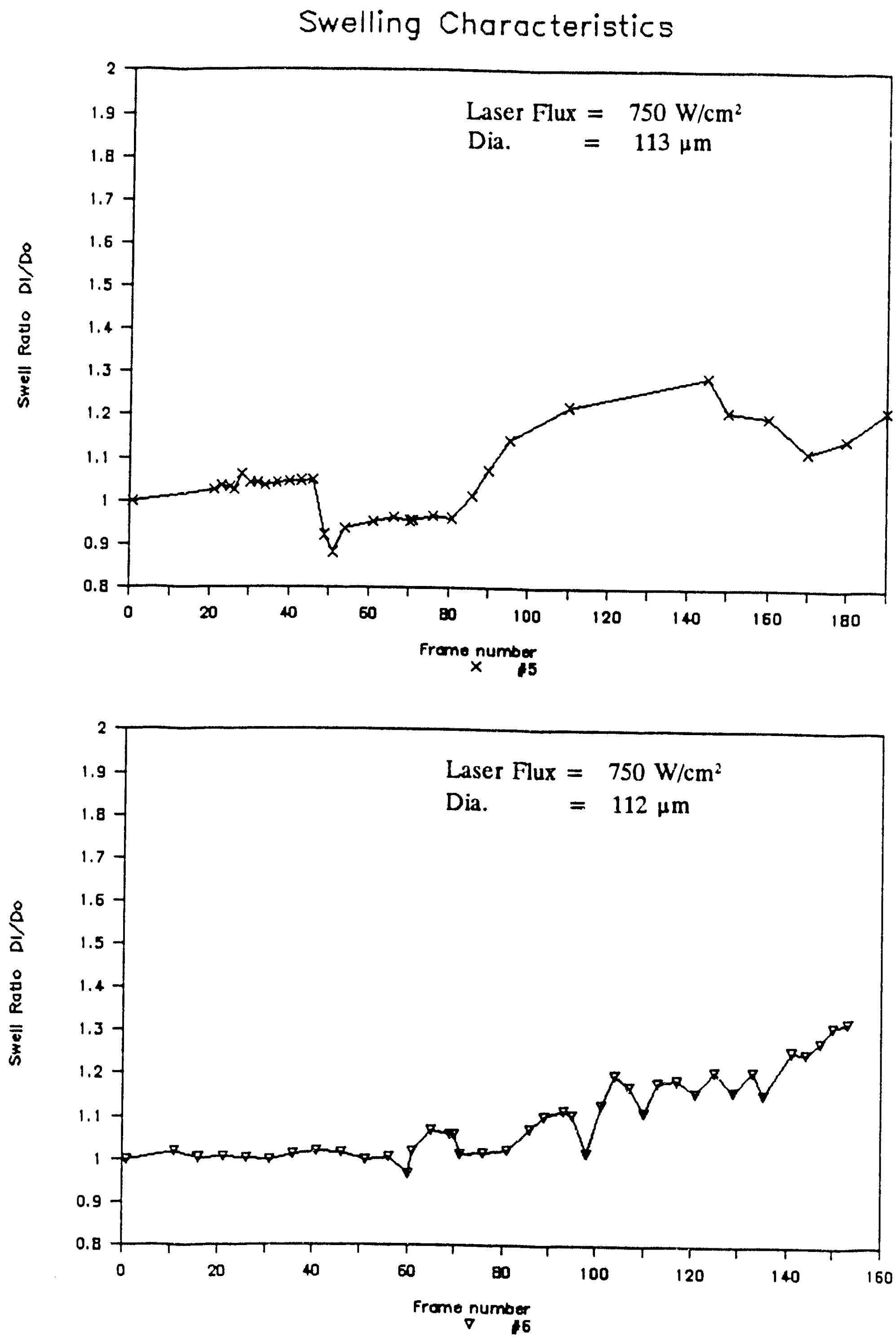


Fig. 26 Variation of swell ratio with time for hvA bituminous coal particle

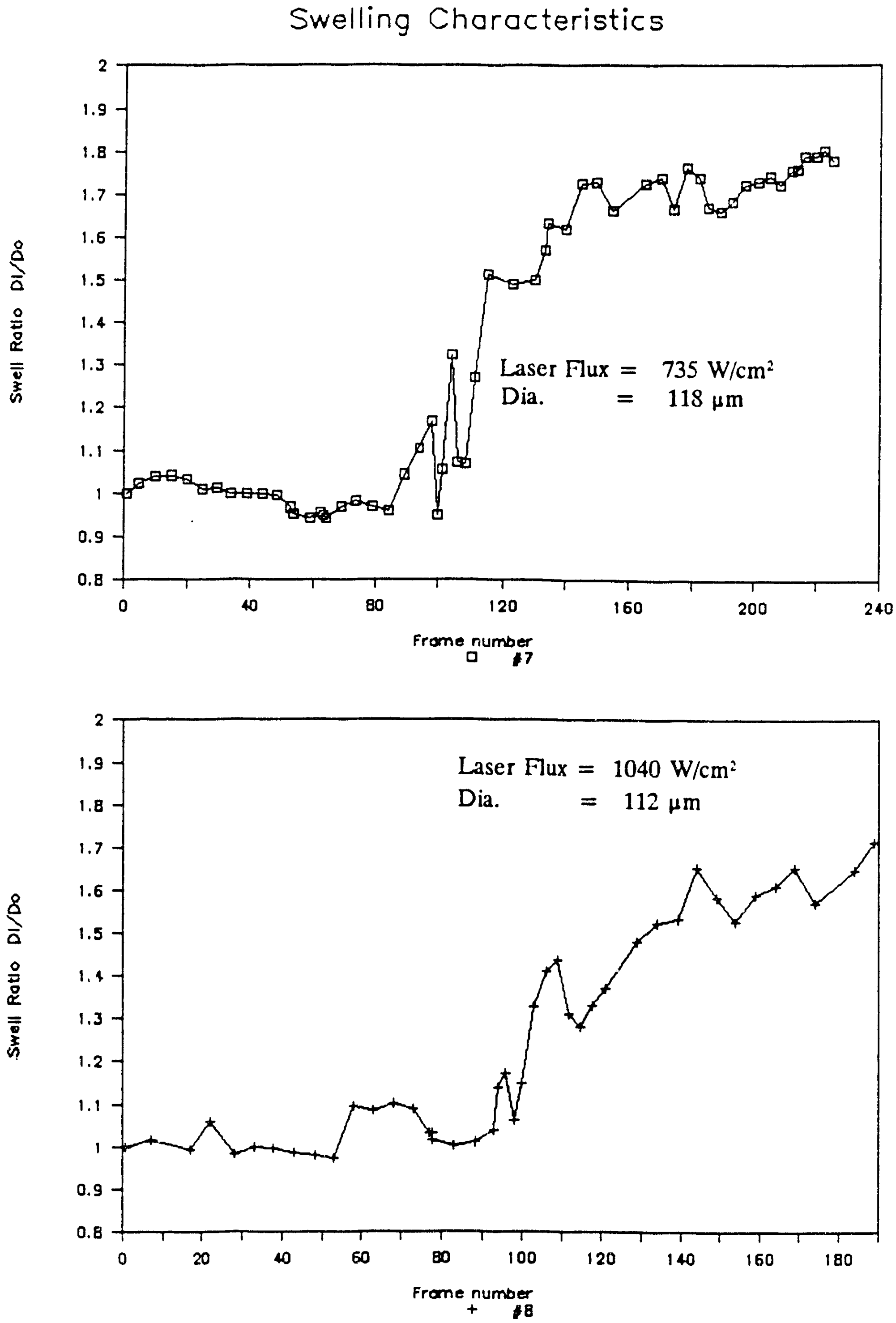


Fig. 27 Variation of swell ratio with time for hvA bituminous coal particle

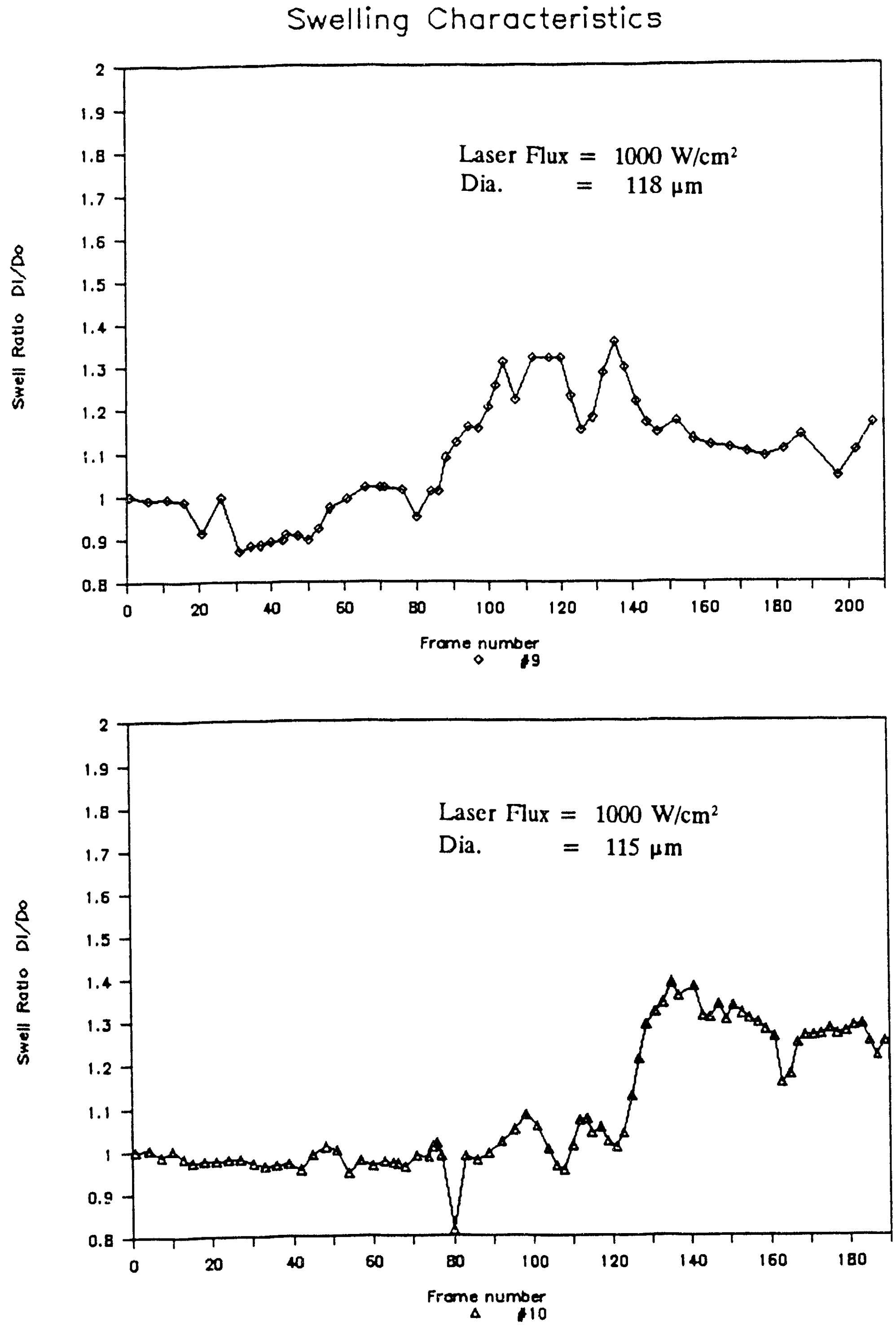


Fig. 28 Variation of swell ratio with time for hvA bituminous coal particle

Swelling Characteristics

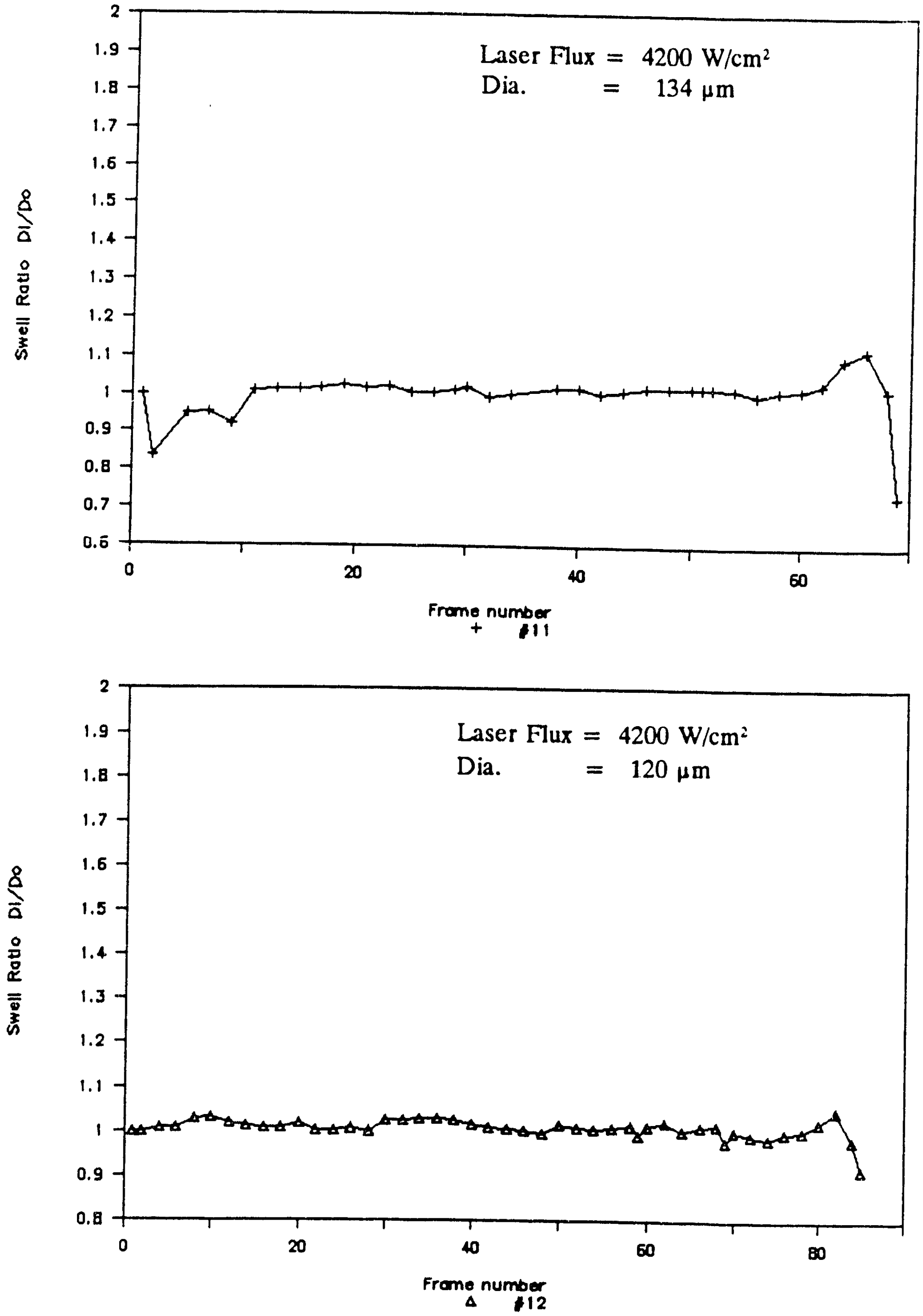


Fig. 29 Variation of swell ratio with time for hvA bituminous coal particle

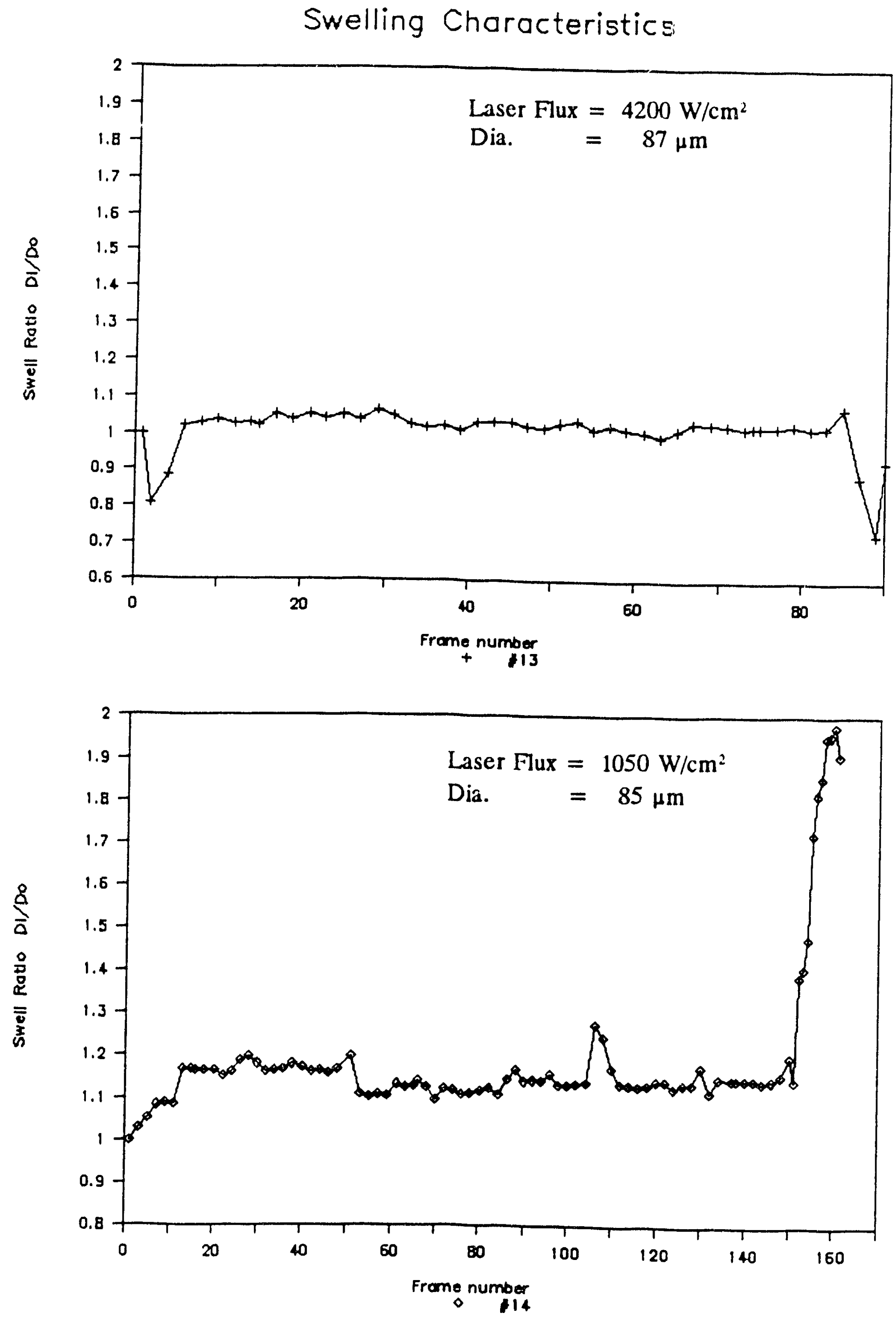


Fig. 30 Variation of swell ratio with time for hvA bituminous coal particle

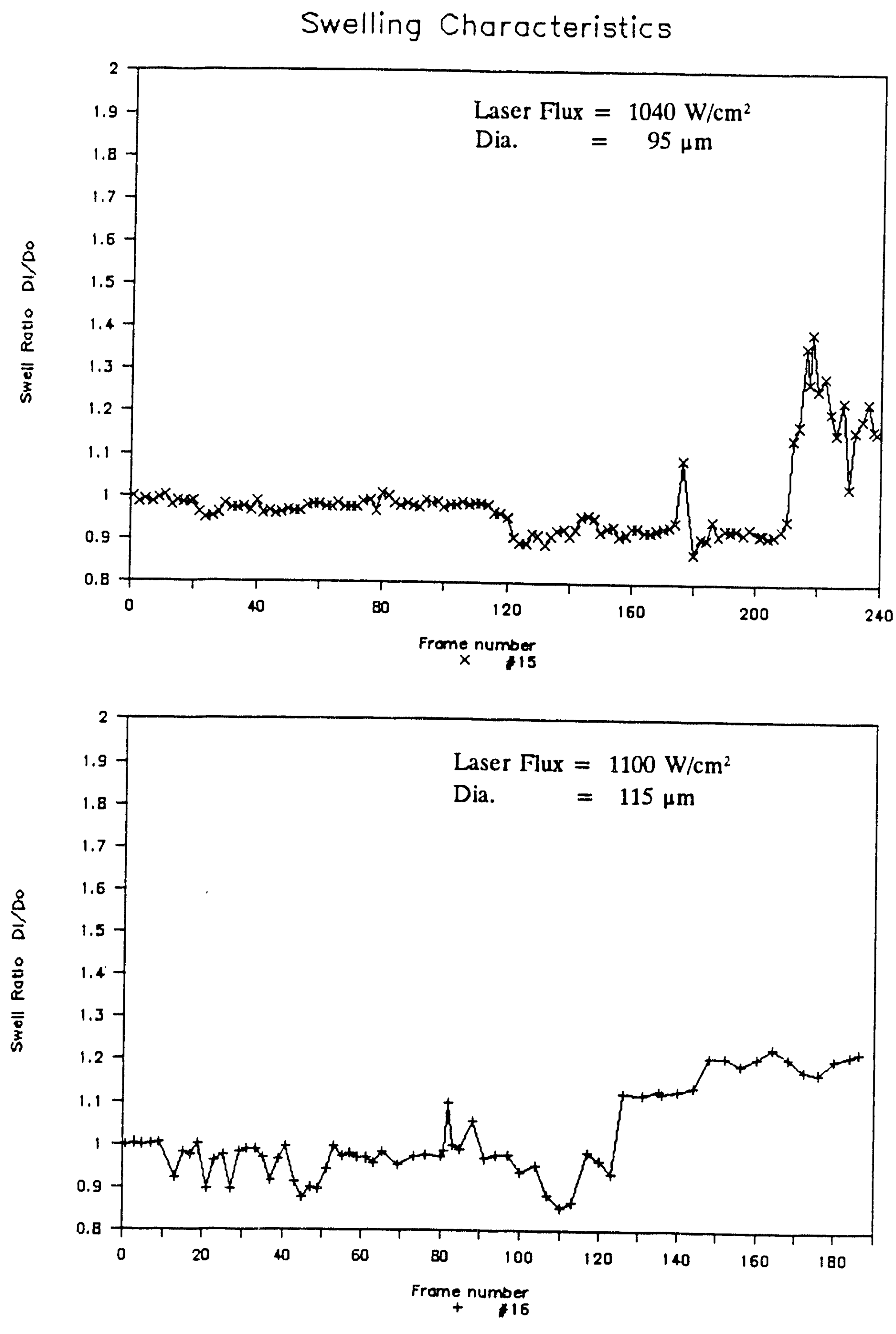
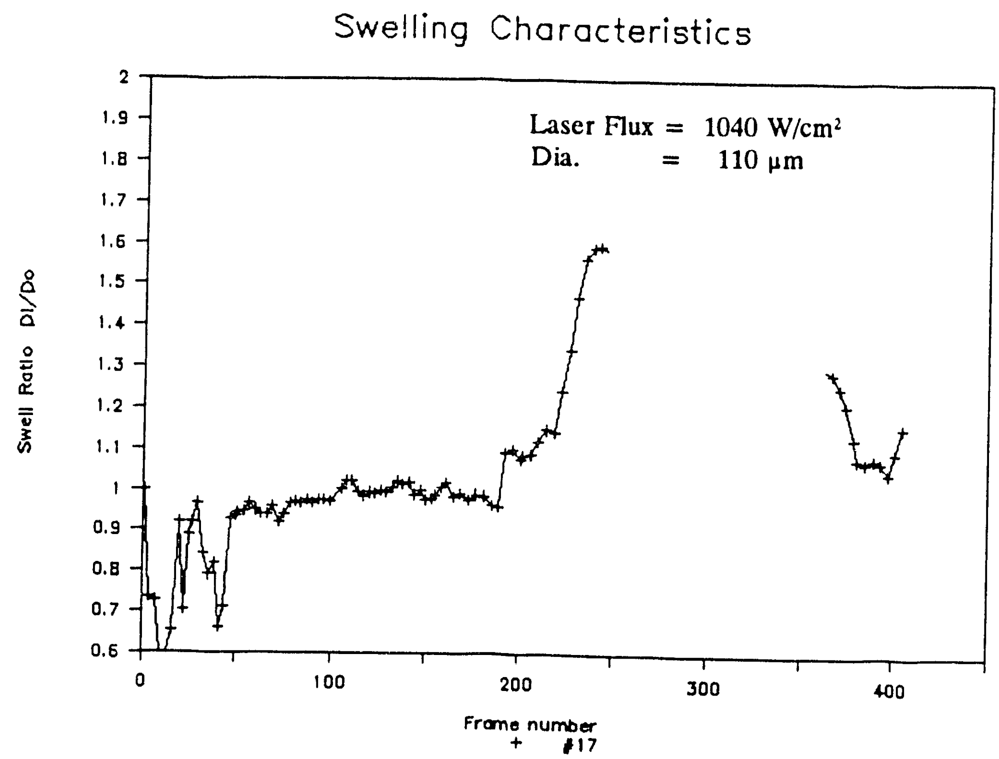


Fig. 31 Variation of swell ratio with time for hvA bituminous coal particle



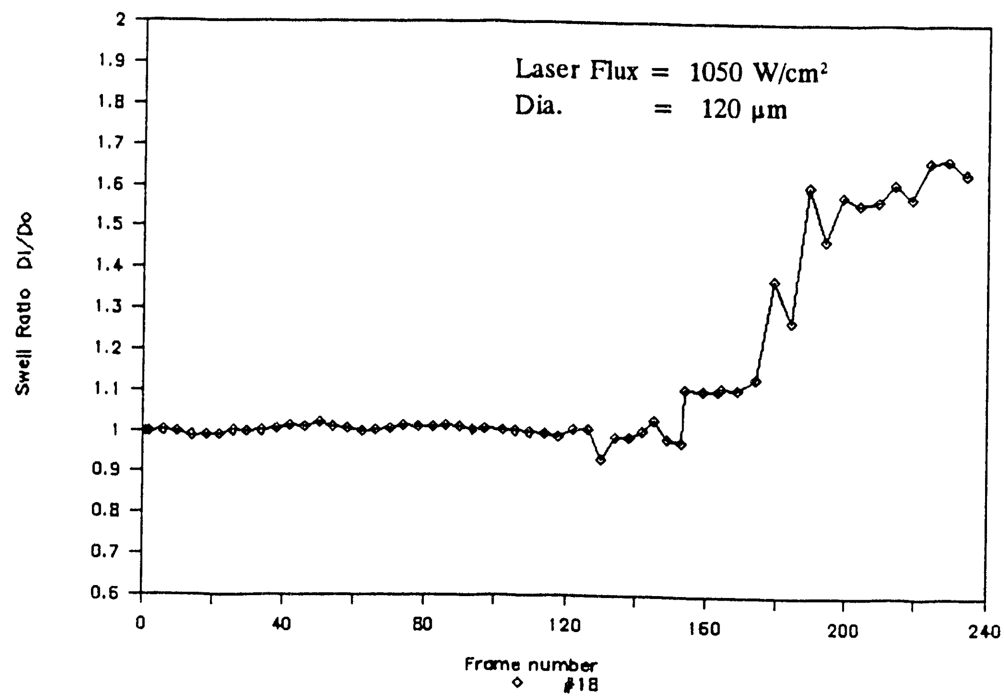


Fig. 32 Variation of swell ratio with time for hvA bituminous coal particle

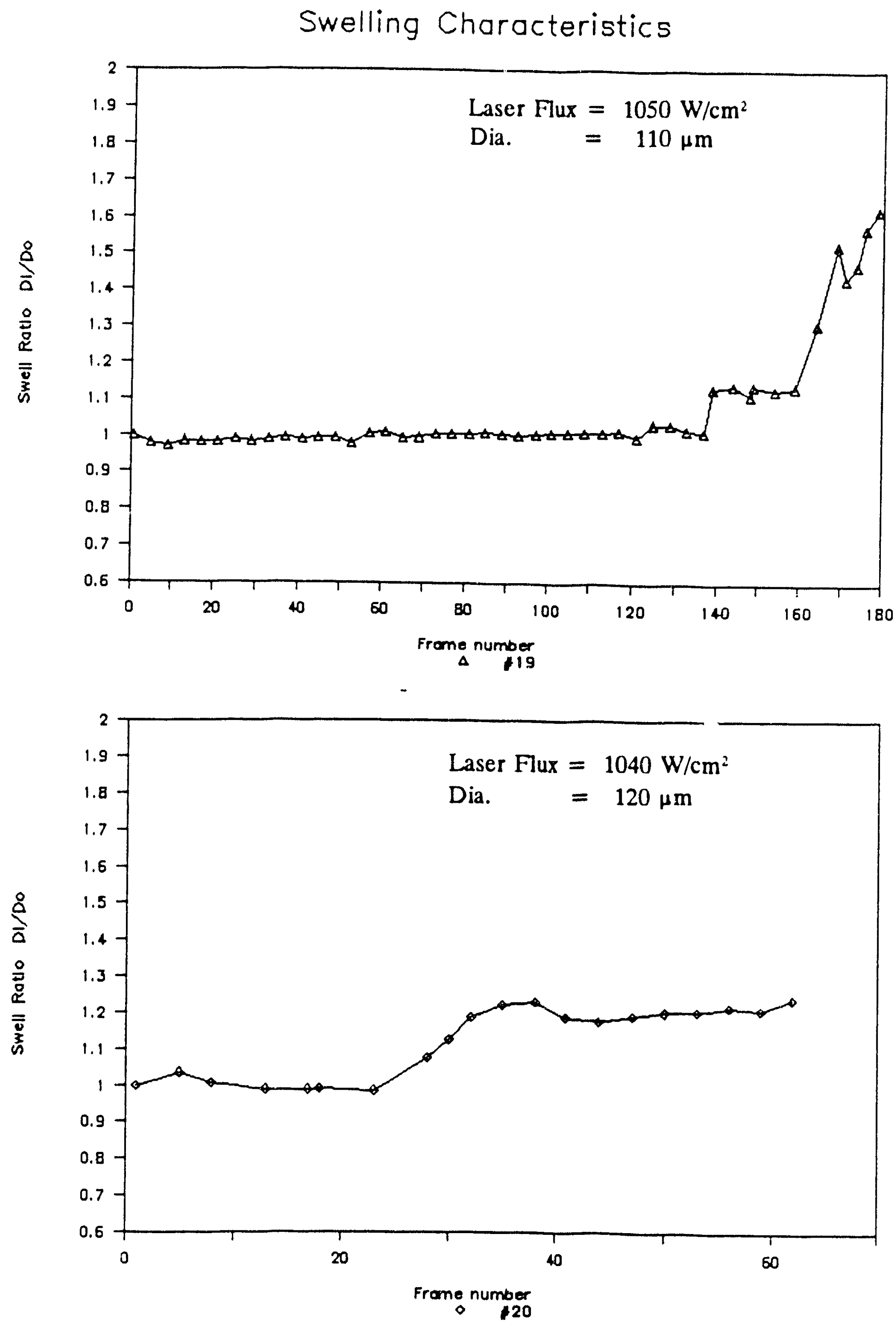


Fig. 33 Variation of swell ratio with time for hvA bituminous coal particle

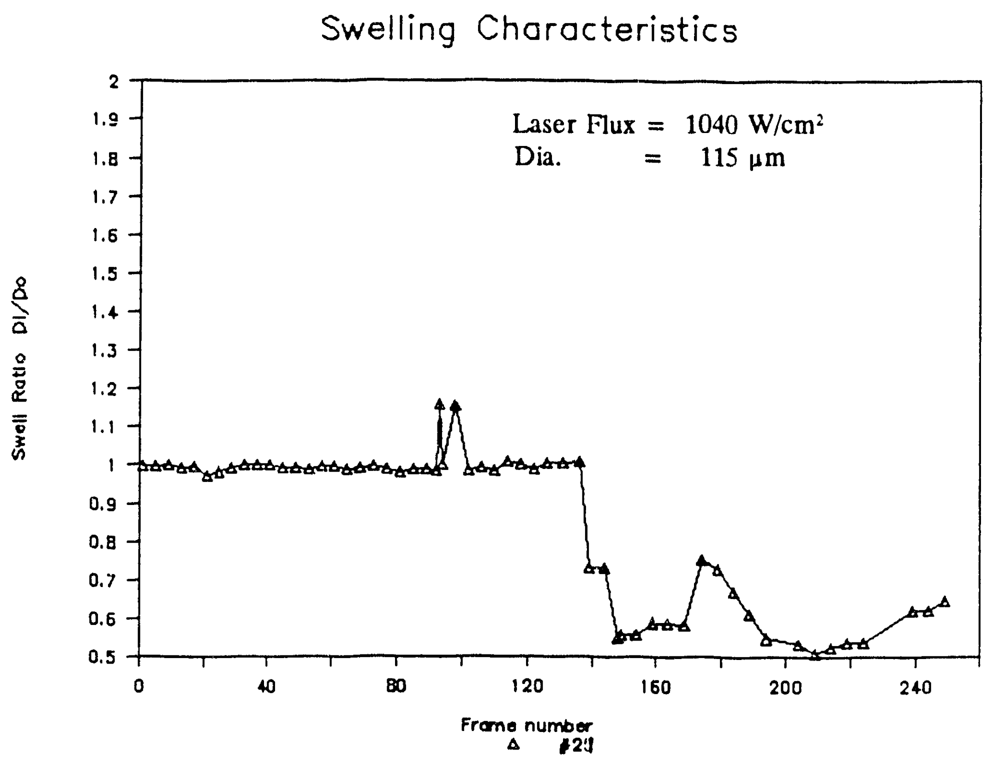


Fig. 34 Variation of swell ratio with time for hvA bituminous coal particle

6 Eliminating particle rotational effect

In analyzing the data particular attention was given to possible variation in the swelling data due to particle rotation. To illustrate the danger of misinterpreting the images from the film it is worth considering the problem posed in the series of frames shown in figure 35. The frames were taken from the data for particle 7. In (a), frame number 30, the image shown is the state of the particle a few milliseconds before the laser pulse was applied. In (b), the particle has already began to heat up and swelling. Comparing (a) and (b), however, it is clear that the orientation of the particle is different. In (c), the particle has positioned itself as if the image in (a), has turned in the counterclockwise direction with its lower part now in the horizontal position. The particle continues to swell but in (e), it appears either to have shrunk or broken up. A few frames after this, however, indicates that the image in (e), is a left side view of the image in (f). Cases such as indicated by the images in (b), and (e), if confirmed by the moving picture playback, were rejected as they clearly did not represent actual contraction. It is important to emphasize, however, that particles are known to undergo very rapid swelling followed immediately by contraction that can be several orders of magnitude smaller. Such changes are not readily discernable from still frame studies under the microscope but are made possible when observed in video playback. All twenty-one particles were carefully studied during playback to make possible a distinction between rotation and contraction.

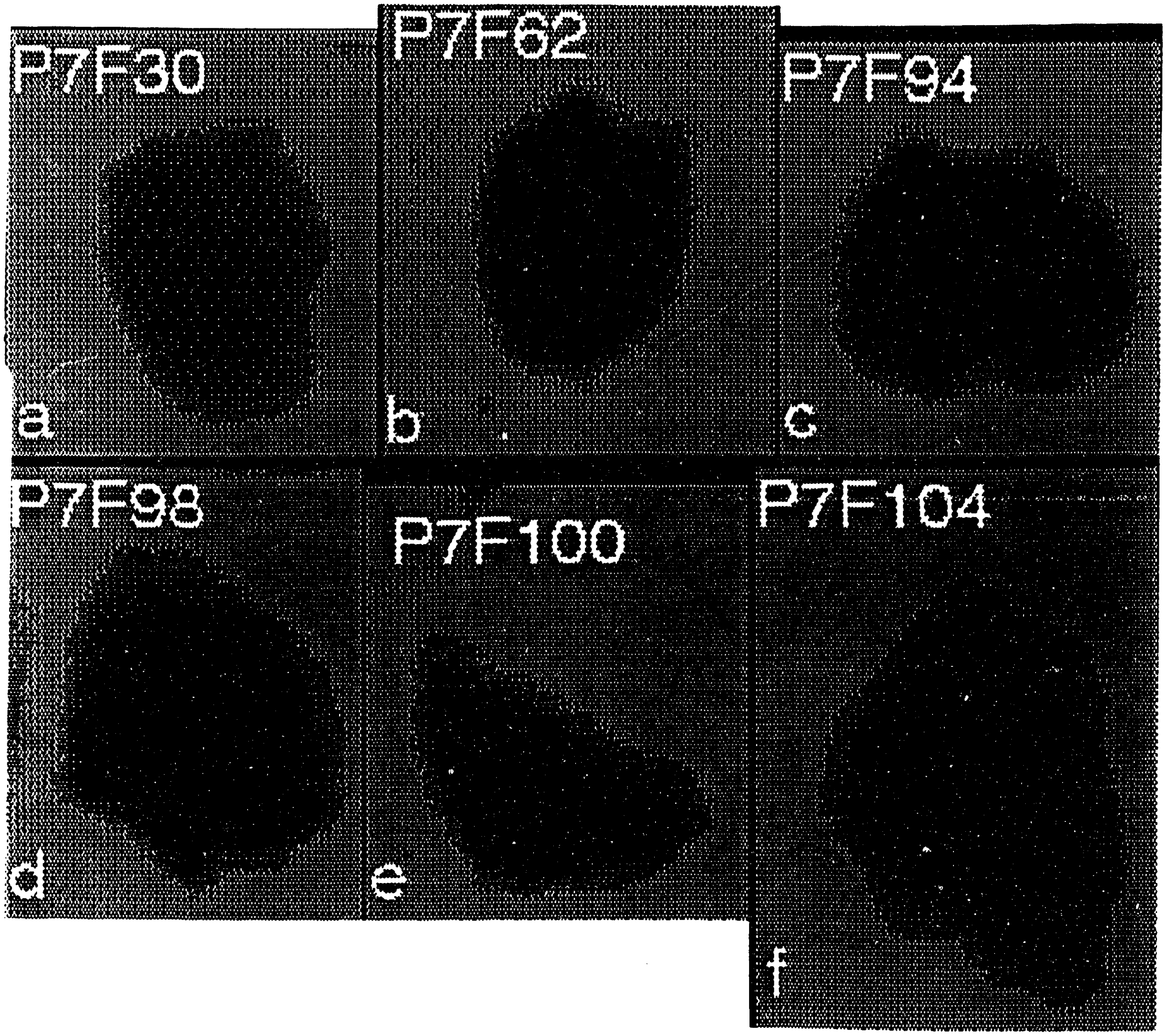


Fig. 35 Successive frames illustrating particle rotation

7 Conclusions

A

A video-enhanced microscopy system has been constructed and been successfully employed to analyze the particle size changes associated with rapid coal devolatilization. The system provides the following very important application features.

1. Arithmetic frame grabber board and software for real-time image capture, when analyzing dynamic events, processing and display of data. For observation of motionless samples,such as the 16 mm film frames, real-time processing was not required.

2. The frame grabber grabs images from any of up to four ordinary video cameras,VCRs, or still-video devices in real time.

3. The analysis is carried out by an array processor which digitizes and manipulates the image in the frame grabber.

4. Both frame grabber and array processor plug directly into any two of available expansion slots inside an AT compatible personal computer.

5. The setup provides capability for selecting video gain offset to obtain maximum resolution from low level video inputs.

6. Once captured,images can be displayed continuously or in freeze mode on an RGB analog video monitor.

7. The system, constructed at relatively low cost,is software driven and has proved to be fast,reliable and efficient.

B

For a fixed laser pulse intensity and varying particle size, the swelling ratio was greatest for particles of smaller diameters. At 750 W/cm^2 particle 6 swells quite steadily,almost linearly, until the event is completed. This is true also for particle 3 with an applied flux of 1000 W/cm^2. It appears, however, that for the most cases the magnitude of the swelling ratio favors the smaller sized particles. For a group of particles of equal diameter heated at different laser pulse strengths the higher flux values produced the greatest swelling ratios in most cases. In a few cases,however, the situation was different; the smaller flux intensities yielded the highest swelling ratios as evidenced in Fig. 14. It appears that at these flux values,less than 1000 W/cm^2, the particles are heated sufficiently slowly and have longer residence times causing increased swelling. Further studies are required to fully explain this phenomenon. It must be added, however,that since no two coals have exactly the same composition, even when taken from the same pack, the possibility of some coals yielding very high swelling ratios at slow heating rates cannot be overruled. The data obtained from the analyses show that the maximum swelling ratio for hvA bituminous coals heated with a laser beam is 1.8. This value is well within experimental error of the values reported in the literature, [3-5].

While there appears to be a trend towards some influence of the heating pulse strength on the swelling characteristics further studies are necessary to answer fully the following questions.

- Does the laser pulse strength affect the maximum value of the swelling ratio?
- For a given pulse strength do smaller particles swell higher than larger ones?
- Does particle shape play any role?.

8. Future Studies

It hoped that further studies leading to a resolution of the questions raised above will be conducted. For instance the data presented in Appendix A can be further explored to further this end. In particular the perimeter measurements can be used to investigate the particle shape effect. A further investigation could also verify the possibility of the influence of gas composition on the swelling ratio.

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APPENDIX A Analysis data

The complete analysis data for all the particles are presented in the following pages. The Lotus file, shown as printed, contains unintended spacing in some of the output data. Wherever this occurs the record is to be read as though the space did not exist. The "record frame" is in column 2. The asterix in column 1 indicates the point where calculation of the initial diameter begins. The pound sign "#" indicates the beginning of the laser heating pulse. The interval between events is shown in column 8. All the graphs are plotted from t(E) = 0.

Part#	Record frm #	Area pxl	Permtr pxl	Dia. um	Crtd um	Ratio	Event frm # x.2 ms
1	1	7962	384				
	5	7753	343				
	9	7703	357				
	13	7790	367				
	14	9120	430				
	17	7598	349				
	20	6902	332				
	23	7650	368				
	26	6942	337				
	29	9124	465				
	33	7575	345				
	37	7497	369				
	41	7862	352				
	45	7923	352				
	49	7721	346				
	53	7817	363				
	57	7894	370				
	61	8400	402				
	65	8162	357				
	69	8049	367				
*	75	7993	380				
	76	7954	361				
	79	7953	351				
	80	7902	354				
7899	84	7691	352	226.4720	125.5945	1.0000	0
#	85	7555	344	221.4914	122.8324	0.9780	1
	89	7748	352	224.3026	124.3914	0.9904	5
	93	7995	308	227.8499	126.3586	1.0061	9
	97	8214	353	230.9494	128.0775	1.0198	13
	101	8159	380	230.1749	127.6480	1.0164	17
	104	9769	497	251.8631	139.6756	1.1121	20
	119	8959	395	241.1956	133.7597	1.0650	35
	124	7716	354	223.8389	124.1343	0.9884	40
	128	7076	353	214.3549	118.8747	0.9465	44
	133	7436	342	219.7401	121.8611	0.9703	49
	141	11813	412	276.9617	153.5945	1.2229	57
	145	9495	383	248.3059	137.7029	1.0964	61
	149	10156	402	256.8035	142.4154	1.1339	65
	154	11179	424	269.4270	149.4160	1.1897	70
	159	11723	428	275.9046	153.0083	1.2183	75
	164	11941	455	278.4581	154.4244	1.2295	80
	169	12021	459	279.3894	154.9408	1.2337	85
	174	12192	473	281.3695	156.0390	1.2424	90
	179	12560	498	285.5843	158.3764	1.2610	95
	194	12361	501	283.3129	157.1167	1.2510	110
	199	12001	482	279.1568	154.8119	1.2326	115
	204	12811	543	288.4238	159.9511	1.2736	120
	209	12274	498	282.3141	156.5628	1.2466	125

5932	61	5888	312	196.2638	108.8419	1.0000	0
#	62	5827	297	194.5190	107.8743	0.9911	1
	65	5898	300	195.7005	108.5295	0.9971	4
	69	5941	300	196.4126	108.9244	1.0008	8
	78	6581	326	206.7214	114.6414	1.0533	17
	82	7179	334	215.9094	119.7368	1.1001	21
	87	4911	316	178.5766	99.03317	0.9099	26
	92	8467	367	234.4792	130.0350	1.1947	31
	104	6840	360	210.7500	116.8755	1.0738	43
	119	9609	396	249.7921	138.5271	1.2727	58
	121	9746	337	251.5665	139.5111	1.2818	60
	139	9117	376	243.3131	134.9341	1.2397	78
	142	7489	353	220.5218	122.2947	1.1236	81
	144	7553	367	221.4620	122.8161	1.1284	83
	149	8335	442	232.6443	129.0174	1.1854	88
	169	10708	474	263.6900	146.2345	1.3435	108
4	1	5967	353				
	5	5793	322				
	9	5926	319				
	13	5672	312				
	17	5898	315				
	21	5739	313				
	25	5930	322				
	29	5843	310				
	33	5765	320				
	37	5635	311				
	41	5873	349				
	45	5752	313				
	49	5690	310				
	53	5083	297				
	57	5260	299				
	61	5178	295				
	64	5351	301				
	66	5778	346				
*	69	5107	307				
	74	5245	302				
5142	78	5074	293	182.7282	101.3355	1.0000	0
#	79	5215	300	184.0207	102.0523	1.0071	1
	85	4953	289	179.3386	99.45575	0.9814	7
	91	6112	331	199.2192	110.4809	1.0902	13
	96	6381	353	203.5560	112.8860	1.1140	18
	101	6536	326	206.0134	114.2488	1.1274	23
	106	7142	342	215.3523	119.4278	1.1785	28
	111	8491	360	234.8113	130.2192	1.2850	33
	116	9201	377	244.4314	135.5542	1.3377	38
	121	8926	376	240.7509	133.5131	1.3175	43
	126	8711	375	237.8338	131.8954	1.3016	48
	129	8489	391	234.7836	130.2039	1.2849	51

		131	8485	377	234.7283	130.1732	1.2846	53
		136	8416	384	233.7720	129.6428	1.2793	58
		141	8056	356	228.7174	126.8397	1.2517	63
		146	7771	384	224.6353	124.5759	1.2293	68
		151	7529	536	221.1099	122.6208	1.2100	73
		156	7335	359	218.2426	121.0307	1.1944	78
		161	7396	363	219.1482	121.5329	1.1993	83
		166	7609	373	222.2815	123.2706	1.2165	88
		171	7673	375	223.2144	123.7879	1.2216	93
		176	8251	392	231.4690	128.3657	1.2667	98
		181	8290	407	232.0154	128.6687	1.2697	103
		186	8559	402	235.7497	130.7396	1.2902	108
		191	8498	440	234.9081	130.2729	1.2856	113
		196	9200	476	244.4182	135.5469	1.3376	118
		200	9010	451	241.8811	134.1399	1.3237	122
		216	8827	504	239.4121	132.7707	1.3102	138

	5	1	6236	333				
		21	6564	335				
		23	6708	337				
		25	6669	334				
		26	6559	362				
		28	7039	361				
		30	6770	346				
		32	6779	348				
		34	6680	335				
		37	6770	345				
		40	6831	348				
		43	6845	338				
		46	6866	346				
		49	5293	305				
		51	4846	297				
		54	5469	311				
*		61	5648	318				
		66	5768	330				
	5699	70	5681	320	192.3707	106.6829	1.0000	0
#		71	5692	309	192.2525	106.6174	0.9994	1
		76	5815	311	194.3186	107.7632	1.0101	6
		81	5764	307	193.4646	107.2896	1.0057	11
		86	6395	325	203.7792	113.0097	1.0593	16
		90	7158	353	215.5934	119.5615	1.1207	20
		95	8142	364	229.9350	127.5150	1.1953	25
		110	9285	468	245.5447	136.1716	1.2764	40
		145	10326	437	258.9439	143.6024	1.3461	75
		150	9087	340	242.9125	134.7119	1.2627	80
		160	8907	377	240.4946	133.3710	1.2502	90
		170	7779	347	224.7509	124.6400	1.1683	100
		180	8184	346	230.5273	127.8434	1.1983	110
		190	9137	376	243.5799	135.0820	1.2662	120

	6	1	6534	333				
		11	6770	337				
		16	6593	326				
		21	6629	325				
		26	6567	328				
		31	6538	317				
		36	6685	326				
		41	6780	335				
		46	6757	331				
		51	6518	333				
		56	6607	323				
*		60	6093	306				
		61	6807	334				
		65	7469	341				
	6928	69	7342	349	212.0975	117.6228	1.0000	0
#		70	7341	347	218.3319	121.0802	1.0294	1
		71	6685	317	208.3484	115.5437	0.9823	2
		76	6755	325	209.4364	116.1471	0.9875	7
		81	6817	333	210.3954	116.6789	0.9920	12
		86	7496	355	220.6248	122.3518	1.0402	17
		89	7925	355	226.8502	125.8042	1.0696	20
		93	8141	370	229.9209	127.5071	1.0840	24
		95	8000	362	227.9211	126.3981	1.0746	26
		98	6752	332	209.3899	116.1213	0.9872	29
		101	8310	377	232.2951	128.8238	1.0952	32
		104	9393	400	246.9686	136.9613	1.1644	35
		107	8982	374	241.5050	133.9313	1.1387	38
		110	8087	368	229.1571	127.0835	1.0804	41
		113	9133	396	243.5265	135.0524	1.1482	44
		117	9208	409	244.5244	135.6058	1.1529	48
		121	8773	386	238.6787	132.3639	1.1253	52
		125	9535	421	248.8284	137.9926	1.1732	56
		129	8837	393	239.5477	132.8459	1.1294	60
		133	9549	417	249.0110	138.0939	1.1740	64
		135	8742	379	238.2566	132.1299	1.1233	66
		141	10312	446	258.7683	143.5050	1.2200	72
		144	10227	420	257.6996	142.9123	1.2150	75
		147	10671	420	263.2341	145.9816	1.2411	78
		150	11286	473	270.7133	150.1294	1.2764	81
		153	11447	466	272.6374	151.1964	1.2854	84
	7	1	7123	342				
		5	7468	351				
		10	7707	347				
		15	7719	358				
		20	7585	346				
		25	7245	343				
		30	7302	342				
		34	7113	332				
		39	7102	336				

		44	7123	328				
		49	7070	335				
*		53	6675	329				
		54	6475	317				
		59	6341	316				
	6500	62	6509	312	205.4453	113.9337	1.0000	0
#		63	6406	308	203.9544	113.1069	0.9927	1
		64	6314	312	202.4845	112.2917	0.9856	2
		69	6699	319	208.5665	115.6646	1.0152	7
		74	6887	334	211.4728	117.2764	1.0293	12
		79	6709	329	208.7221	115.7509	1.0159	17
		84	6570	317	206.5486	114.5456	1.0054	22
		89	7762	355	224.5052	124.5037	1.0928	27
		94	8707	368	237.7792	131.8651	1.1574	32
		98	9746	396	251.5665	139.5111	1.2245	36
		100	6434	339	204.3996	113.3538	0.9949	38
		101	7930	361	226.9218	125.8439	1.1045	39
		104	12509	468	285.0039	158.0545	1.3872	42
		106	8212	406	230.9213	128.0619	1.1240	44
		108	8163	398	230.2313	127.6793	1.1206	46
		111	11501	431	273.2797	151.5526	1.3302	49
		115	16302	507	325.3569	180.4330	1.5837	53
		123	15811	549	320.4197	177.6950	1.5596	61
		130	16047	510	322.8022	179.0163	1.5712	68
		133	17561	560	337.6869	187.2709	1.6437	71
		134	19035	544	351.5734	194.9719	1.7113	72
		140	18716	532	348.6150	193.3313	1.6969	78
		145	21209	584	371.1075	205.8049	1.8064	83
		150	21322	621	372.0948	206.3524	1.8112	88
		155	19696	534	357.6256	198.3283	1.7407	93
		165	21266	593	371.6058	206.0813	1.8088	103
		170	21547	597	374.0529	207.4383	1.8207	108
		174	19795	542	358.5233	198.8261	1.7451	112
		178	22153	605	379.2764	210.3352	1.8461	116
		182	21536	600	373.9574	207.3854	1.8202	120
		185	19838	552	358.9124	199.0419	1.7470	123
		189	19598	563	356.7348	197.8343	1.7364	127
		193	20216	571	362.3157	200.9293	1.7636	131
		197	21162	608	370.6960	205.5767	1.8044	135
		201	21326	591	372.1297	206.3718	1.8113	139
		205	21598	593	374.4953	207.6837	1.8228	143
		208	21136	613	370.4682	205.4504	1.8032	146
		212	21982	651	377.8098	209.5218	1.8390	150
		214	22059	675	378.4709	209.8885	1.8422	152
		216	22786	712	384.6570	213.3191	1.8723	154
		220	22807	720	384.8342	213.4173	1.8732	158
		222	23111	686	387.3905	214.8350	1.8856	160
		225	22557	668	382.7192	212.2444	1.8629	163

	8	2	4859	281				
		7	5015	285				
		17	4796	288				
		22	5440	298				
		28	4697	288				
		33	4852	280				
		38	4814	286				
		43	4723	269				
		48	4666	278				
		53	4600	273				
		58	5841	298				
		63	5723	308				
*		68	5898	322				
		73	5761	314				
	5616	77	5188	272	190.9590	105.9001	1.0000	0
#		78	5188	280	183.5437	101.7877	0.9612	1
		78	5012	273	180.4035	100.0463	0.9447	1
		83	4886	281	178.1215	98.78078	0.9328	6
		88	4965	283	179.5557	99.57615	0.9403	11
		93	5264	300	184.8832	102.5306	0.9682	16
		94	6289	322	202.0833	112.0692	1.0583	17
		96	6684	353	208.3329	115.5351	1.0910	19
		98	5478	307	188.6038	104.5939	0.9877	21
		100	6424	351	204.2407	113.2657	1.0696	23
		103	8548	398	235.5981	130.6555	1.2338	26
		106	9673	452	250.6226	138.9876	1.3124	29
		109	10024	458	255.1292	141.4869	1.3360	32
		112	8351	400	232.8675	129.1412	1.2195	35
		115	7968	380	227.4648	126.1451	1.1912	38
		118	8595	395	236.2449	131.0142	1.2371	41
		121	9119	382	243.3398	134.9488	1.2743	44
		129	10647	404	262.9379	145.8174	1.3769	52
		134	11298	452	270.8572	150.2091	1.4184	57
		139	11410	448	272.1964	150.9518	1.4254	62
		144	13270	498	293.5452	162.7913	1.5372	67
		149	12186	470	281.3003	156.0006	1.4731	72
		154	11328	438	271.2165	150.4084	1.4203	77
		159	12280	465	282.3831	156.6011	1.4788	82
		164	12579	469	285.8003	158.4961	1.4967	87
		169	13272	485	293.5673	162.8035	1.5373	92
		174	11978	459	278.8892	154.6635	1.4605	97
		184	13185	493	292.6036	162.2690	1.5323	107
		189	14233	519	304.0099	168.5947	1.5920	112
	9	1	5571	308				
		6	5444	369				
		11	5503	312				
		16	5401	311				
		21	4645	286				
		26	5529	314				

		31	4217	274				
		34	4340	274				
		37	4362	271				
		40	4454	276				
		43	4493	277				
		44	4603	275				
		47	4562	281				
		50	4480	280				
		53	4747	291				
		56	5257	313				
*		61	5501	377				
		66	5792	364				
	5695	70	5792	364	192.3031	106.6455	1.0000	0
#		71	5791	364	193.9172	107.5406	1.0084	1
		76	5719	327	192.7079	106.8699	1.0021	6
		80	5037	324	180.8529	100.2955	0.9405	10
		84	5684	311	192.1173	106.5424	0.9990	14
		86	5688	337	192.1849	106.5799	0.9994	16
		88	6588	341	206.8313	114.7024	1.0755	18
		91	7036	349	213.7482	118.5382	1.1115	21
		94	7480	357	220.3892	122.2211	1.1461	24
		97	7428	367	219.6218	121.7956	1.1421	27
		100	8107	393	229.4403	127.2406	1.1931	30
		102	8767	393	238.5970	132.3187	1.2407	32
		104	9579	405	249.4018	138.3107	1.2969	34
		107	8332	366	232.6024	128.9942	1.2096	37
		112	9735	385	251.4245	139.4324	1.3074	42
		117	9735	385	251.4245	139.4324	1.3074	47
		120	9706	392	251.0497	139.2245	1.3055	50
		123	8432	355	233.9941	129.7660	1.2168	53
		126	7377	359	218.8666	121.3767	1.1381	56
		129	7763	344	224.5196	124.5118	1.1675	59
		132	9196	374	244.3650	135.5174	1.2707	62
		135	10280	415	258.3664	143.2822	1.3435	65
		138	9370	394	246.6660	136.7935	1.2827	68
		141	8276	382	231.8194	128.5600	1.2055	71
		144	7614	371	222.3545	123.3111	1.1563	74
		147	7299	351	217.7064	120.7333	1.1321	77
		152	7650	356	222.8796	123.6022	1.1590	82
		157	7121	354	215.0354	119.2521	1.1182	87
		162	6950	346	212.4379	117.8116	1.1047	92
		167	6839	352	210.7346	116.8670	1.0958	97
		172	6726	340	208.9864	115.8975	1.0868	102
		177	6596	345	206.9569	114.7720	1.0762	107
		182	6806	344	210.2256	116.5847	1.0932	112
		187	7227	360	216.6300	120.1364	1.1265	117
		197	6068	346	198.5008	110.0825	1.0322	127
		202	6759	362	209.4984	116.1814	1.0894	132
		207	7578	362	221.8282	123.0192	1.1535	137

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		10	6864	323				
		13	6606	323				
		15	6441	324				
		18	6513	319				
		21	6519	320				
		24	6556	314				
		27	6545	316				
		30	6406	319				
		33	6339	315				
		36	6371	310				
		39	6408	316				
		42	6212	306				
		45	6679	318				
		48	6924	325				
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		54	6113	310				
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		63	6440	316				
		65	6395	314				
*		66	6390	313				
		68	6277	312				
		71	6619	321				
		74	6587	320				
	6559	75	6923	341	206.3787	114.4514	1.0000	0
#		76	7051	341	213.9759	118.6645	1.0368	1
		77	6627	318	207.4426	115.0414	1.0052	2
		80	4508	288	171.0927	94.88284	0.8290	5
		83	6631	320	207.5052	115.0761	1.0055	8
		86	6490	316	205.2872	113.8460	0.9947	11
		89	6719	322	208.8776	115.8372	1.0121	14
		92	7074	344	214.3246	118.8579	1.0385	17
		95	7486	347	220.4776	122.2702	1.0683	20
		98	7973	363	227.5362	126.1846	1.1025	23
		98	7973	363	227.5362	126.1846	1.1025	23
		101	7621	361	222.4567	123.3677	1.0779	26
		104	6853	345	210.9502	116.9865	1.0222	29
		106	6308	341	202.3883	112.2384	0.9807	31
		108	6208	340	200.7777	111.3452	0.9729	33
		110	6969	365	212.7281	117.9725	1.0308	35
		112	7780	371	224.7653	124.6480	1.0891	37
		114	7857	374	225.8749	125.2633	1.0945	39
		115	7367	358	218.7182	121.2944	1.0598	40
		117	7553	362	221.4620	122.8161	1.0731	42
		119	7107	360	214.8239	119.1348	1.0409	44
		121	6897	332	211.6263	117.3615	1.0254	46

	123	7376	343	218.8517	121.3685	1.0604	48
	125	8637	363	236.8214	131.3340	1.1475	50
	127	9997	390	254.7853	141.2962	1.2346	52
	129	11359	420	271.5874	150.6141	1.3160	54
	131	11883	438	277.7810	154.0489	1.3460	56
	133	12302	450	282.6360	156.7413	1.3695	58
	135	13160	458	292.3260	162.1151	1.4165	60
	137	12585	463	285.8684	158.5339	1.3852	62
	141	12986	474	290.3871	161.0398	1.4071	66
	143	11738	473	276.0811	153.1062	1.3377	68
	145	11689	442	275.5042	152.7863	1.3349	70
	147	12188	483	281.3234	156.0134	1.3631	72
	149	11551	450	273.8731	151.8817	1.3270	74
	151	12130	494	280.6532	155.6417	1.3599	76
	153	11822	486	277.0672	153.6530	1.3425	78
	155	11611	465	274.5835	152.2756	1.3305	80
	157	11455	476	272.7326	151.2492	1.3215	82
	159	11158	468	269.1738	149.2756	1.3043	84
	161	10849	468	265.4205	147.1941	1.2861	86
	163	9119	417	243.3398	134.9488	1.1791	88
	165	9432	432	247.4808	137.2453	1.1992	90
	167	10608	452	262.4559	145.5500	1.2717	92
	169	10912	454	266.1900	147.6209	1.2898	94
	171	10908	463	266.1412	147.5938	1.2896	96
	173	10977	456	266.9816	148.0599	1.2936	98
	175	11182	465	269.4631	149.4360	1.3057	100
	177	10955	464	266.7140	147.9114	1.2924	102
	179	11084	453	268.2797	148.7798	1.2999	104
	181	11341	465	271.3721	150.4947	1.3149	106
	183	11380	468	271.8383	150.7533	1.3172	108
	185	10672	481	263.2464	145.9885	1.2755	110
	187	10143	455	256.6391	142.3242	1.2435	112
	189	10712	456	263.7393	146.2618	1.2779	114

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	7	5751	324
	9	5381	314
	11	6472	325
	13	6512	323
	15	6536	327
	17	6597	340
	19	6675	326
	21	6552	325

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		25	6450	321				
		27	6443	321				
		29	6507	324				
		30	6608	331				
		32	6285	316				
		34	6372	322				
		38	6562	335				
		40	6591	325				
*		42	6365	320				
		44	6456	322				
		46	6570	325				
		48	6595	347				
		50	6586	326				
	6526	51	6586	326	205.8610	114.1643	1.0000	0
#		52	6553	325	206.2812	114.3973	1.0020	1
		54	6541	331	206.0922	114.2925	1.0011	3
		56	6328	318	202.7089	112.4162	0.9847	5
		58	6464	321	204.8756	113.6178	0.9952	7
		60	6513	322	205.6506	114.0476	0.9990	9
		62	6728	331	209.0174	115.9147	1.0153	11
		64	7600	359	222.1500	123.1976	1.0791	13
		66	7919	382	226.7643	125.7566	1.1015	15
		68	6517	356	205.7138	114.0826	0.9993	17
		69	3427	281	149.1752	82.72805	0.7246	18

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	6	5980	294
	8	6231	304
	10	6249	316
	12	6116	303
	14	6027	303
	16	5998	307
	18	5993	295
	20	6112	306
	22	5913	297
	24	5903	294
	26	5972	298
	28	5890	297
	30	6174	305
	32	6168	307
	34	6219	303
	36	6212	312
	38	6194	305

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		42	5976	294				
		44	5940	300				
		46	5909	296				
		48	5832	298				
		50	6061	306				
		52	6004	299				
		54	5937	304				
		56	5977	299				
		58	6052	318				
*		59	5800	296				
		60	6038	308				
		62	6166	315				
		64	5912	295				
		66	6016	299				
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		74	5732	291	192.9268	106.9913	0.9774	6
		76	5880	303	195.4016	108.3638	0.9900	8
		78	5916	297	195.9989	108.6950	0.9930	10
		80	6146	304	199.7725	110.7878	1.0121	12
		82	6469	323	204.9548	113.6617	1.0384	14
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		85	4937	275	179.0487	99.29498	0.9071	17
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		10	7137	376				
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		14	7067	372				
		15	6924	371				
		17	7347	384				
		19	7176	367				
		21	7364	379				
		23	7215	369				
		25	7343	379				
		27	7143	384				
		29	7530	387				
		31	7316	377				
		33	7000	367				
		35	6898	380				
		37	6937	373				
		39	6790	369				

		41	7096	370				
		43	7080	390				
		45	7108	369				
		47	6930	371				
		49	6912	364				
		51	7074	374				
		53	7171	384				
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		59	6846	364				
		61	6716	362				
		63	6590	358				
*		65	6847	361				
		67	7111	369				
		69	7039	363				
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		73	6874	366				
	6967	74	6953	366	212.6899	117.9513	1.0000	0
#		75	6953	366	212.4837	117.8370	0.9990	1
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		79	7019	361	213.4898	118.3950	1.0038	5
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		83	6946	373	212.3767	117.7777	0.9985	9
		85	7662	385	223.0543	123.6991	1.0487	11
		87	5233	293	184.3380	102.2282	0.8667	13
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		90	5717	298	192.6742	106.8513	0.9059	16
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		5	11680	456				
		7	12362	459				
		9	12506	460				
		11	12430	497				
		13	14338	518				
		15	14379	498				
		16	14261	490				
		18	14309	488				
		20	14320	487				
		22	13934	490				
		24	14172	488				
		26	14875	523				
		28	15142	534				
		30	14665	536				
		32	14239	530				
		34	14334	519				
		36	14365	530				
		38	14659	527				
		40	14457	524				
		42	14219	505				

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	48	14382	512				
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	53	12977	494				
	55	12799	489				
	57	12936	491				
	59	12863	493				
	61	13524	485				
	63	13345	519				
	65	13405	491				
	66	13753	499				
	68	13339	484				
	70	12631	493				
	72	13267	483				
	74	13188	480				
	76	12917	457				
	78	13029	474				
	80	13172	473				
	82	13319	486				
	84	12900	469				
	86	13826	515				
	88	14355	504				
	90	13691	514				
	92	13766	510				
	94	13698	527				
	96	14108	520				
	98	13506	501				
	100	13492	513				
	102	13594	521				
	104	13673	522				
	106	17093	635				
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	118	13495	526				
	120	13729	519				
	122	13740	511				
	124	13309	527				
	126	13551	494				
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	130	14502	506				
	132	13129	469				
	134	13909	508				
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#	138	13816	510	299.5234	166.1066	1.0013	1
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	146	13768	534	299.0026	165.8178	0.9996	9
	148	14081	512	302.3823	167.6920	1.0109	11
	150	15089	566	313.0184	173.5905	1.0464	13
	151	13721	477	298.4918	165.5345	0.9979	14
	152	20279	619	362.8798	201.2421	1.2131	15
	153	20825	615	367.7326	203.9333	1.2294	16
	154	22960	734	386.1229	214.1320	1.2908	17
	155	31221	880	450.2596	249.7003	1.5053	18
	156	34758	873	475.0803	263.4651	1.5882	19
	157	36221	892	484.9755	268.9527	1.6213	20
	158	40085	959	510.1884	282.9350	1.7056	21
	159	40313	1077	511.6373	283.7385	1.7105	22
	160	41181	980	517.1161	286.7769	1.7288	23
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	5	12962	499				
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	9	13062	546				
	11	13284	531				
	13	12651	512				
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	19	12847	552				
	20	12916	534				
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	32	12492	490				
	34	12496	507				
	36	12538	479				
	38	12360	479				
	40	12935	499				
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	44	12305	487				
	46	12149	486				
	48	12254	488				
	50	12387	487				
	52	12302	487				
	54	12321	481				
	56	12644	482				
	58	12712	488				
	60	12706	485				
	62	12600	494				
	64	12526	489				
	66	12821	495				

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72	12553	493
74	12878	493
76	13012	492
78	12367	480
80	13395	505
82	13277	505
84	12805	499
86	12683	495
88	12804	501
90	12615	494
92	12545	498
94	13031	498
96	12838	505
98	12882	500
100	12576	493
102	12742	477
104	12757	502
106	12914	500
108	12767	495
110	12830	513
112	12792	498
114	12756	490
116	12271	497
118	12239	500
120	12002	487
122	10829	479
124	10506	467
126	10520	482
128	11072	487
130	10962	464
132	10415	475
134	10925	465
136	11268	477
138	11308	478
140	10912	470
142	11296	464
144	12054	481
146	12177	494
148	11963	476
150	11160	475
152	11400	480
154	11458	471
156	10925	482
158	11041	467
160	11382	476
162	11430	466
164	11187	472
166	11134	487
168	11285	495

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		172	11514	491				
		174	11725	471				
		176	15663	595				
		180	9999	424				
		182	10837	457				
		184	10777	437				
		186	11835	459				
		188	10969	479				
		190	11337	462				
*		192	11285	461				
		194	11324	473				
		196	11110	469				
		198	11421	476				
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#		202	11050	461	267.8679	148.5514	0.9917	1
		204	10889	460	265.9093	147.4652	0.9845	3
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		208	11330	458	271.2405	150.4217	1.0042	7
		210	11865	478	277.5706	153.9322	1.0276	9
		212	17097	556	333.1958	184.7803	1.2336	11
		214	18073	624	342.5742	189.9813	1.2683	13
		216	24195	613	396.3715	219.8156	1.4675	15
		217	21342	642	372.2692	206.4492	1.3782	16
		218	25408	703	406.1859	225.2583	1.5038	17
		220	20740	625	366.9813	203.5167	1.3587	19
		222	21815	682	376.3719	208.7244	1.3934	21
		224	19095	647	352.1271	195.2790	1.3037	23
		226	17457	598	336.6855	186.7155	1.2465	25
		228	19933	656	359.7708	199.5179	1.3320	27
		230	13842	524	299.8051	166.2628	1.1100	29
		232	17728	662	339.2887	188.1592	1.2561	31
		234	18529	679	346.8691	192.3630	1.2842	33
		236	19769	676	358.2877	198.6955	1.3265	35
		238	17826	636	340.2252	188.6786	1.2596	37
		239	17568	620	337.7542	187.3082	1.2505	38
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		7	56255	1014				
		9	56512	1037				
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		17	53147	1302				
		19	56141	1052				
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		25	53222	1229				
		27	44977	1781				

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	33	54786	1173				
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	39	52271	1476				
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	59	52593	1140				
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	76	53166	997				
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	91	52383	1118				
	94	53103	1272				
	97	53115	1181				
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	104	50697	1453				
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	110	40828	1856				
	113	41903	1636				
	117	53951	1061				
	120	51825	1493				
	123	48675	2006				
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	168	34529	736	727.7265	403.5750	1.0743	33

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	7	19603	1286				
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	13	13291	758				
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	19	31449	953				
	22	18460	1483				
	25	29258	1240				
	26	31413	978				
	29	34554	807				
	32	26290	1389				
	35	23180	1604				
	38	24946	1889				
	41	16139	910				
	44	18782	1619				
	47	31906	891				
	50	32428	898				
	51	32997	840				
	54	33362	797				
	57	34612	794				
	60	33436	908				
	63	32760	921				
	66	32811	980				
	69	33987	817				
	72	31457	931				
	75	32651	1036				
	78	34601	791				
	81	34973	867				
	84	34722	846				
	87	35270	837				
	90	34527	977				
	93	35316	918				
	96	35153	834				
	99	34959	965				
	105	37223	853				
	108	38668	846				
	111	38545	838				
	114	36706	851				
	117	35902	942				
	120	36508	847				
	123	36395	837				

	126	37014	811				
	129	36677	834				
	132	37568	866				
	135	38559	853				
	138	37999	822				
	141	38364	825				
	144	36187	805				
	147	37018	827				
	150	35112	975				
	153	35382	946				
	155	36124	814				
	158	37378	833				
	161	38333	823				
	165	35718	801				
	169	36334	809				
	173	35319	793				
	177	36175	807				
	181	35892	821				
	185	34275	782				
	189	34189	797				
* 2.5x	192	18632	608				
	197	18967	641				
18583	201	18149	585	533.8634	296.0644	1.0000	0
#	202	18429	574	531.6515	294.8378	0.9959	1
	206	18488	594	532.5019	295.3093	0.9974	5
	210	19580	580	548.0025	303.9055	1.0265	9
	214	20636	585	562.5860	311.9931	1.0538	13
	218	20407	579	559.4558	310.2572	1.0479	17
	222	24243	640	609.7746	338.1625	1.1422	21
	226	28327	687	659.1382	365.5380	1.2347	25
	230	33955	760	721.6524	400.2065	1.3518	29
	234	38318	853	766.6155	425.1417	1.4360	33
	234	38318	853	766.6155	425.1417	1.4360	33
	238	39664	873	779.9638	432.5442	1.4610	37
	242	39811	843	781.4078	433.3450	1.4637	41
	367	26089	716	632.5646	350.8011	1.1849	166
	371	24674	682	615.1711	341.1552	1.1523	170
	375	22943	688	593.2002	328.9708	1.1111	174
	379	20000	637	553.8487	307.1477	1.0374	178
	381	18247	590	529.0198	293.3783	0.9909	180
	385	18000	570	525.4270	291.3859	0.9842	184
	389	18308	597	529.9033	293.8683	0.9926	188
	393	17996	576	525.3686	291.3535	0.9841	192
	397	17138	567	512.6916	284.3232	0.9603	196
	401	18780	592	536.6906	297.6323	1.0053	200
	405	21036	609	568.0123	315.0024	1.0640	204

18	1	52537	897				
	2	52537	897				
	6	52652	895				
	10	52349	896				
	14	51407	899				
	18	51584	888				
	22	51655	896				
	26	52621	901				
	30	52349	919				
	34	52647	921				
	38	53097	939				
	42	53970	945				
	46	53804	915				
	50	54851	946				
	54	53794	944				
	58	53239	945				
	62	52457	945				
	66	52975	929				
	70	53432	950				
	74	53999	931				
	78	53503	931				
	82	53505	921				
	86	54055	946				
	90	53706	946				
	94	52946	926				
	17	53133	960				
	102	52969	931				
	106	52674	927				
	110	52261	915				
	114	52082	900				
	118	51375	890				
	122	53361	913				
	126	53296	924				
	130	45876	829				
	134	51367	894				
	138	51180	886				
	142	52821	899				
	145	55624	948				
	149	50716	890				
	153	50202	896				
* 2.5x	154	27232	654				
	159	27094	646				
27130	163	27064	643	322.5307	178.8657	1.0000	0
#	164	27420	641	324.2499	179.8191	1.0053	1
	169	27293	636	323.4981	179.4022	1.0030	6
	174	28698	659	331.7202	183.9620	1.0285	11
	179	41949	815	401.0578	222.4145	1.2435	16
	184	36137	898	372.2393	206.4326	1.1541	21
	189	57017	1072	467.5718	259.3011	1.4497	26
	194	48066	1021	429.3042	238.0791	1.3310	31
	199	55419	1052	460.9730	255.6416	1.4292	36

	204	54101	990	455.4585	252.5834	1.4121	41
	209	54812	1064	458.4416	254.2378	1.4214	46
	214	57826	1135	470.8773	261.1342	1.4599	51
	219	55231	1073	460.1905	255.2076	1.4268	56
	224	61606	1124	486.0239	269.5341	1.5069	61
	229	61836	1130	486.9304	270.0368	1.5097	66
	234	59494	1121	477.6203	264.8737	1.4809	71

19	1	45346	893				
	5	43445	960				
	9	42918	877				
	13	44065	929				
	17	43748	914				
	21	43937	949				
	25	44624	928				
	29	44025	889				
	33	44612	918				
	37	44802	929				
	41	44631	924				
	45	45005	900				
	49	44815	933				
	53	43596	884				
	57	46107	912				
	61	46334	936				
	65	44859	907				
	69	45105	901				
	73	45797	930				
	77	45803	922				
	81	45881	933				
	85	46298	915				
	89	46104	926				
	93	45520	892				
	97	45968	925				
	101	46446	914				
	105	46368	906				
	109	46315	911				
	113	46449	923				
	117	46784	915				
	121	45405	883				
	125	48670	911				
	129	48422	948				
	133	46949	909				
	137	46581	923				
* 2.5x	139	24679	659				
	144	25012	668				
24527	148	23891	642	306.6700	170.0699	1.0000	0
#	149	25033	661	309.8151	171.8140	1.0103	1
	154	24529	647	306.6804	170.0756	1.0000	6

	159	24982	664	309.4993	171.6389	1.0092	11
	164	33135	782	356.4426	197.6722	1.1623	16
	169	45031	893	415.5296	230.4401	1.3550	21
	171	39633	854	389.8294	216.1876	1.2712	23
	174	41692	840	399.8274	221.7321	1.3038	26
	176	47596	958	427.2001	236.9122	1.3930	28
	179	50860	985	441.6054	244.9009	1.4400	31
2.5x							
20	1	29481	722				
	5	31641	735				
*	8	29959	751				
	13	28868	749				
29220	17	28833	734	334.7235	185.6275	1.0000	0
#	18	28998	763	333.4496	184.9210	0.9962	1
	23	28631	741	331.3328	183.7471	0.9899	6
	28	34070	812	361.4367	200.4418	1.0798	11
	30	37571	849	379.5531	210.4886	1.1339	13
	32	41594	872	399.3572	221.4714	1.1931	15
	35	44087	957	411.1511	228.0119	1.2283	18
	38	44704	984	414.0181	229.6019	1.2369	21
	41	41730	932	400.0095	221.8331	1.1950	24
	44	40797	906	395.5125	219.3392	1.1816	27
	47	41990	917	401.2537	222.5231	1.1988	30
	50	42618	937	404.2432	224.1810	1.2077	33
	53	42782	980	405.0202	224.6119	1.2100	36
	56	43529	1042	408.5409	226.5643	1.2205	39
	59	43088	1035	406.4661	225.4137	1.2143	42
	62	45261	1059	416.5894	231.0278	1.2446	45
21	1	42635	857				
	5	42516	893				
	9	42722	894				
	13	42170	894				
	17	42616	920				
	21	40433	905				
	25	41238	926				
	29	42256	920				
	33	42713	909				
	37	42730	908				
	41	42672	934				
	45	42129	908				
	49	42121	883				
	53	41577	879				
	57	42314	903				
	61	42560	879				

	65	41673	903				
	69	42075	900				
	73	42334	895				
	77	41868	882				
	81	41126	852				
	85	41600	882				
	89	41682	885				
	92	41571	869				
	93	57409	1064				
	94	42885	871				
	98	57044	1016				
	102	41416	866				
	106	41981	889				
	110	41364	870				
	114	43627	889				
	118	42652	872				
	122	41862	846				
	126	43229	903				
	131	43062	906				
	136	43601	912				
* 2.5x	139	22772	632				
	144	22866	657				
22519	148	21919	637	293.8466	162.9584	1.0000	0
#	149	22345	633	292.7092	162.3276	0.9961	1
	154	22631	661	294.5764	163.3631	1.0025	6
	159	25112	689	310.3036	172.0849	1.0560	11
	164	24996	627	309.5861	171.6870	1.0536	16
	169	24450	677	306.1862	169.8015	1.0420	21
	174	40811	821	395.5804	219.3769	1.3462	26
	179	38174	818	382.5868	212.1710	1.3020	31
	184	32523	742	353.1356	195.8382	1.2018	36
	189	26955	680	321.4888	178.2879	1.0941	41
	194	21662	626	288.2009	159.8275	0.9808	46
	204	20563	575	280.7950	155.7204	0.9556	56
	209	18670	578	267.5582	148.3796	0.9105	61
	214	19904	600	276.2589	153.2048	0.9401	66
	219	20855	609	282.7817	156.8221	0.9623	71
	224	20927	597	283.2694	157.0926	0.9640	76
	239	27794	710	326.4538	181.0413	1.1110	91
	244	27791	691	326.4361	181.0316	1.1109	96
	249	30200	683	340.2903	188.7147	1.1581	101

APPENDIX B Complete history data

Complete history analysis of the events beginning from the first photographic frame which also serves as the initial particle diameter frame. With this analysis t(E) = 0 is also record frame 1. The figures in column 8 represent the period from the initiation of the laser heating pulse to the end of the devolatilization process.

Part#	Record frm #	Area pxl	Permtr pxl	Dia. um	Crtd um	Ratio	Event frm # x.2 ms
1	1	7962	384	227.3791	126.0976	1.0000	
	5	7753	343	224.3750	124.4315	0.9868	
	9	7703	357	223.6503	124.0296	0.9836	
	13	7790	367	224.9097	124.7281	0.9891	
	14	9120	430	243.3531	134.9562	1.0703	
	17	7598	349	222.1208	123.1814	0.9769	
	20	6902	332	211.7030	117.4040	0.9311	
	23	7650	368	222.8796	123.6022	0.9802	
	26	6942	337	212.3156	117.7437	0.9338	
	29	9124	465	243.4065	134.9858	1.0705	
	33	7575	345	221.7843	122.9948	0.9754	
	37	7497	369	220.6395	122.3600	0.9704	
	41	7862	352	225.9467	125.3032	0.9937	
	45	7923	352	226.8216	125.7883	0.9975	
	49	7721	346	223.9115	124.1745	0.9847	
	53	7817	363	225.2992	124.9441	0.9909	
	57	7894	370	226.4061	125.5579	0.9957	
	61	8400	402	233.5496	129.5195	1.0271	
	65	8162	357	230.2172	127.6715	1.0125	
	69	8049	367	228.6180	126.7846	1.0054	
*	75	7993	380	227.8214	126.3428	1.0019	
	76	7954	361	227.2649	126.0342	0.9995	
	79	7953	351	227.2506	126.0263	0.9994	
	80	7902	354	226.5208	125.6215	0.9962	
	84	7691	352	223.4760	123.9330	0.9828	0
#	85	7555	344	221.4914	122.8324	0.9741	1
	89	7748	352	224.3026	124.3914	0.9865	5
	93	7995	308	227.8499	126.3586	1.0021	9
	97	8214	353	230.9494	128.0775	1.0157	13
	101	8159	380	230.1749	127.6480	1.0123	17
	104	9769	497	251.8631	139.6756	1.1077	20
	119	8959	395	241.1956	133.7597	1.0608	35
	124	7716	354	223.8389	124.1343	0.9844	40
	128	7076	353	214.3549	118.8747	0.9427	44
	133	7436	342	219.7401	121.8611	0.9664	49
	141	11813	412	276.9617	153.5945	1.2181	57
	145	9495	383	248.3059	137.7029	1.0920	61
	149	10156	402	256.8035	142.4154	1.1294	65
	154	11179	424	269.4270	149.4160	1.1849	70
	159	11723	428	275.9046	153.0083	1.2134	75
	164	11941	455	278.4581	154.4244	1.2246	80
	169	12021	459	279.3894	154.9408	1.2287	85
	174	12192	473	281.3695	156.0390	1.2374	90
	179	12560	498	285.5843	158.3764	1.2560	95
	194	12361	501	283.3129	157.1167	1.2460	110
	199	12001	482	279.1568	154.8119	1.2277	115
	204	12811	543	288.4238	159.9511	1.2685	120
	209	12274	498	282.3141	156.5628	1.2416	125

		61	5888	312	195.5345	108.4375	0.9950	0
#		62	5827	297	194.5190	107.8743	0.9899	1
		65	5898	300	195.7005	108.5295	0.9959	4
		69	5941	300	196.4126	108.9244	0.9995	8
		78	6581	326	206.7214	114.6414	1.0520	17
		82	7179	334	215.9094	119.7368	1.0987	21
		87	4911	316	178.5766	99.03317	0.9087	26
		92	8467	367	234.4792	130.0350	1.1932	31
		104	6840	360	210.7500	116.8755	1.0725	43
		119	9609	396	249.7921	138.5271	1.2711	58
		121	9746	337	251.5665	139.5111	1.2802	60
		139	9117	376	243.3131	134.9341	1.2382	78
		142	7489	353	220.5218	122.2947	1.1222	81
		144	7553	367	221.4620	122.8161	1.1270	83
		149	8335	442	232.6443	129.0174	1.1839	88
		169	10708	474	263.6900	146.2345	1.3419	108
	4	1	5967	353	196.8419	109.1625	1.0000	
		5	5793	322	193.9507	107.5591	0.9853	
		9	5926	319	196.1645	108.7868	0.9966	
		13	5672	312	191.9144	106.4299	0.9750	
		17	5898	315	195.7005	108.5295	0.9942	
		21	5739	313	193.0446	107.0567	0.9807	
		25	5930	322	196.2307	108.8235	0.9969	
		29	5843	310	194.7859	108.0223	0.9896	
		33	5765	320	193.4814	107.2989	0.9829	
		37	5635	311	191.2875	106.0822	0.9718	
		41	5873	349	195.2853	108.2993	0.9921	
		45	5752	313	193.2631	107.1778	0.9818	
		49	5690	310	192.2187	106.5986	0.9765	
		53	5083	297	181.6768	100.7524	0.9230	
		57	5260	299	184.8129	102.4916	0.9389	
		61	5178	295	183.3667	101.6896	0.9315	
		64	5351	301	186.4048	103.3744	0.9470	
		66	5778	346	193.6994	107.4198	0.9840	
*		69	5107	307	182.1052	100.9900	0.9251	
		74	5245	302	184.5492	102.3454	0.9376	
		78	5074	293	181.5159	100.6632	0.9221	0
#		79	5215	300	184.0207	102.0523	0.9349	1
		85	4953	289	179.3386	99.45575	0.9111	7
		91	6112	331	199.2192	110.4809	1.0121	13
		96	6381	353	203.5560	112.8860	1.0341	18
		101	6536	326	206.0134	114.2488	1.0466	23
		106	7142	342	215.3523	119.4278	1.0940	28
		111	8491	360	234.8113	130.2192	1.1929	33
		116	9201	377	244.4314	135.5542	1.2418	38
		121	8926	376	240.7509	133.5131	1.2231	43
		126	8711	375	237.8338	131.8954	1.2082	48
		129	8489	391	234.7836	130.2039	1.1928	51

		131	8485	377	234.7283	130.1732	1.1925	53
		136	8416	384	233.7720	129.6428	1.1876	58
		141	8056	356	228.7174	126.8397	1.1619	63
		146	7771	384	224.6353	124.5759	1.1412	68
		151	7529	536	221.1099	122.6208	1.1233	73
		156	7335	359	218.2426	121.0307	1.1087	78
		161	7396	363	219.1482	121.5329	1.1133	83
		166	7609	373	222.2815	123.2706	1.1292	88
		171	7673	375	223.2144	123.7879	1.1340	93
		176	8251	392	231.4690	128.3657	1.1759	98
		181	8290	407	232.0154	128.6687	1.1787	103
		186	8559	402	235.7497	130.7396	1.1977	108
		191	8498	440	234.9081	130.2729	1.1934	113
		196	9200	476	244.4182	135.5469	1.2417	118
		200	9010	451	241.8811	134.1399	1.2288	122
		216	8827	504	239.4121	132.7707	1.2163	138
	5	1	6236	333	201.2299	111.5960	1.0000	
		21	6564	335	206.4542	114.4932	1.0260	
		23	6708	337	208.7065	115.7423	1.0372	
		25	6669	334	208.0990	115.4053	1.0341	
		26	6559	362	206.3756	114.4496	1.0256	
		28	7039	361	213.7938	118.5635	1.0624	
		30	6770	346	209.6688	116.2759	1.0419	
		32	6779	348	209.8081	116.3532	1.0426	
		34	6680	335	208.2705	115.5005	1.0350	
		37	6770	345	209.6688	116.2759	1.0419	
		40	6831	348	210.6113	116.7986	1.0466	
		43	6845	338	210.8270	116.9182	1.0477	
		46	6866	346	211.1502	117.0975	1.0493	
		49	5293	305	185.3918	102.8126	0.9213	
		51	4846	297	177.3909	98.37561	0.8815	
		54	5469	311	188.4488	104.5080	0.9365	
*		61	5648	318	191.5080	106.2045	0.9517	
		66	5768	330	193.5317	107.3268	0.9617	
		70	5681	320	192.0666	106.5143	0.9545	0
#		71	5692	309	192.2525	106.6174	0.9554	1
		76	5815	311	194.3186	107.7632	0.9657	6
		81	5764	307	193.4646	107.2896	0.9614	11
		86	6395	325	203.7792	113.0097	1.0127	16
		90	7158	353	215.5934	119.5615	1.0714	20
		95	8142	364	229.9350	127.5150	1.1426	25
		110	9285	468	245.5447	136.1716	1.2202	40
		145	10326	437	258.9439	143.6024	1.2868	75
		150	9087	340	242.9125	134.7119	1.2071	80
		160	8907	377	240.4946	133.3710	1.1951	90
		170	7779	347	224.7509	124.6400	1.1169	100

	180	8184	346	230.5273	127.8434	1.1456	110
	190	9137	376	243.5799	135.0820	1.2105	120
6	1	6534	333	205.9819	114.2313	1.0000	
	11	6770	337	209.6688	116.2759	1.0179	
	16	6593	326	206.9098	114.7459	1.0045	
	21	6629	325	207.4739	115.0587	1.0072	
	26	6567	328	206.5014	114.5194	1.0025	
	31	6538	317	206.0450	114.2663	1.0003	
	36	6685	326	208.3484	115.5437	1.0115	
	41	6780	335	209.8236	116.3618	1.0187	
	46	6757	331	209.4674	116.1643	1.0169	
	51	6518	333	205.7296	114.0914	0.9988	
	56	6607	323	207.1294	114.8676	1.0056	
*	60	6093	306	198.9093	110.3090	0.9657	
	61	6807	334	210.2410	116.5933	1.0207	
	65	7469	341	220.2271	122.1312	1.0692	
	69	7342	349	218.3467	121.0885	1.0600	0
#	70	7341	347	218.3319	121.0802	1.0600	1
	71	6685	317	208.3484	115.5437	1.0115	2
	76	6755	325	209.4364	116.1471	1.0168	7
	81	6817	333	210.3954	116.6789	1.0214	12
	86	7496	355	220.6248	122.3518	1.0711	17
	89	7925	355	226.8502	125.8042	1.1013	20
	93	8141	370	229.9209	127.5071	1.1162	24
	95	8000	362	227.9211	126.3981	1.1065	26
	98	6752	332	209.3899	116.1213	1.0165	29
	101	8310	377	232.2951	128.8238	1.1277	32
	104	9393	400	246.9686	136.9613	1.1990	35
	107	8982	374	241.5050	133.9313	1.1725	38
	110	8087	368	229.1571	127.0835	1.1125	41
	113	9133	396	243.5265	135.0524	1.1823	44
	117	9208	409	244.5244	135.6058	1.1871	48
	121	8773	386	238.6787	132.3639	1.1587	52
	125	9535	421	248.8284	137.9926	1.2080	56
	129	8837	393	239.5477	132.8459	1.1630	60
	133	9549	417	249.0110	138.0939	1.2089	64
	135	8742	379	238.2566	132.1299	1.1567	66
	141	10312	446	258.7683	143.5050	1.2563	72
	144	10227	420	257.6996	142.9123	1.2511	75
	147	10671	420	263.2341	145.9816	1.2779	78
	150	11286	473	270.7133	150.1294	1.3143	81
	153	11447	466	272.6374	151.1964	1.3236	84
7	1	7123	342	215.0656	119.2688	1.0000	
	5	7468	351	220.2124	122.1231	1.0239	
	10	7707	347	223.7084	124.0618	1.0402	
	15	7719	358	223.8825	124.1584	1.0410	
	20	7585	346	221.9307	123.0760	1.0319	

	25	7245	343	216.8996	120.2859	1.0085	
	30	7302	342	217.7511	120.7582	1.0125	
	34	7113	332	214.9146	119.1851	0.9993	
	39	7102	336	214.7484	119.0929	0.9985	
	44	7123	328	215.0656	119.2688	1.0000	
	49	7070	335	214.2640	118.8243	0.9963	
*	53	6675	329	208.1925	115.4572	0.9680	
	54	6475	317	205.0498	113.7144	0.9534	
	59	6341	316	202.9170	112.5316	0.9435	
	62	6509	312	205.5875	114.0126	0.9559	0
#	63	6406	308	203.9544	113.1069	0.9483	1
	64	6314	312	202.4845	112.2917	0.9415	2
	69	6699	319	208.5665	115.6646	0.9698	7
	74	6887	334	211.4728	117.2764	0.9833	12
	79	6709	329	208.7221	115.7509	0.9705	17
	84	6570	317	206.5486	114.5456	0.9604	22
	89	7762	355	224.5052	124.5037	1.0439	27
	94	8707	368	237.7792	131.8651	1.1056	32
	98	9746	396	251.5665	139.5111	1.1697	36
	100	6434	339	204.3996	113.3538	0.9504	38
	101	7930	361	226.9218	125.8439	1.0551	39
	104	12509	468	285.0039	158.0545	1.3252	42
	106	8212	406	230.9213	128.0619	1.0737	44
	108	8163	398	230.2313	127.6793	1.0705	46
	111	11501	431	273.2797	151.5526	1.2707	49
	115	16302	507	325.3569	180.4330	1.5128	53
	123	15811	549	320.4197	177.6950	1.4899	61
	130	16047	510	322.8022	179.0163	1.5009	68
	133	17561	560	337.6869	187.2709	1.5702	71
	134	19035	544	351.5734	194.9719	1.6347	72
	140	18716	532	348.6150	193.3313	1.6210	78
	145	21209	584	371.1075	205.8049	1.7256	83
	150	21322	621	372.0948	206.3524	1.7301	88
	155	19696	534	357.6256	198.3283	1.6629	93
	165	21266	593	371.6058	206.0813	1.7279	103
	170	21547	597	374.0529	207.4383	1.7392	108
	174	19795	542	358.5233	198.8261	1.6670	112
	178	22153	605	379.2764	210.3352	1.7635	116
	182	21536	600	373.9574	207.3854	1.7388	120
	185	19838	552	358.9124	199.0419	1.6689	123
	189	19598	563	356.7348	197.8343	1.6587	127
	193	20216	571	362.3157	200.9293	1.6847	131
	197	21162	608	370.6960	205.5767	1.7236	135
	201	21326	591	372.1297	206.3718	1.7303	139
	205	21598	593	374.4953	207.6837	1.7413	143
	208	21136	613	370.4682	205.4504	1.7226	146
	212	21982	651	377.8098	209.5218	1.7567	150
	214	22059	675	378.4709	209.8885	1.7598	152
	216	22786	712	384.6570	213.3191	1.7886	154
	220	22807	720	384.8342	213.4173	1.7894	158

		222	23111	686	387.3905	214.8350	1.8013	160
		225	22557	668	382.7192	212.2444	1.7795	163
	8	1	4859	281	177.6286	98.50747	1.0000	
		7	5015	285	180.4575	100.0762	1.0159	
		17	4796	288	176.4733	97.86678	0.9935	
		22	5440	298	187.9485	104.2305	1.0581	
		28	4697	288	174.6424	96.85142	0.9832	
		33	4852	280	177.5006	98.43649	0.9993	
		38	4814	286	176.8042	98.05026	0.9954	
		43	4723	269	175.1251	97.11911	0.9859	
		48	4666	278	174.0652	96.53128	0.9799	
		53	4600	273	172.8297	95.84614	0.9730	
		58	5841	298	194.7525	108.0038	1.0964	
		63	5723	308	192.7753	106.9073	1.0853	
*		68	5898	322	195.7005	108.5295	1.1017	
		73	5761	314	193.4142	107.2617	1.0889	
		77	5188	272	183.5437	101.7877	1.0333	0
#		78	5188	280	183.5437	101.7877	1.0333	1
		78	5012	273	180.4035	100.0463	1.0156	1
		83	4886	281	178.1215	98.78078	1.0028	6
		88	4965	283	179.5557	99.57615	1.0108	11
		93	5264	300	184.8832	102.5306	1.0408	16
		94	6289	322	202.0833	112.0692	1.1377	17
		96	6684	353	208.3329	115.5351	1.1729	19
		98	5478	307	188.6038	104.5939	1.0618	21
		100	6424	351	204.2407	113.2657	1.1498	23
		103	8548	398	235.5981	130.6555	1.3264	26
		106	9673	452	250.6226	138.9876	1.4109	29
		109	10024	458	255.1292	141.4869	1.4363	32
		112	8351	400	232.8675	129.1412	1.3110	35
		115	7968	380	227.4648	126.1451	1.2806	38
		118	8595	395	236.2449	131.0142	1.3300	41
		121	9119	382	243.3398	134.9488	1.3699	44
		129	10647	404	262.9379	145.8174	1.4803	52
		134	11298	452	270.8572	150.2091	1.5249	57
		139	11410	448	272.1964	150.9518	1.5324	62
		144	13270	498	293.5452	162.7913	1.6526	67
		149	12186	470	281.3003	156.0006	1.5836	72
		154	11328	438	271.2165	150.4084	1.5269	77
		159	12280	465	282.3831	156.6011	1.5897	82
		164	12579	469	285.8003	158.4961	1.6090	87
		169	13272	485	293.5673	162.8035	1.6527	92
		174	11978	459	278.8892	154.6635	1.5701	97
		184	13185	493	292.6036	162.2690	1.6473	107
		189	14233	519	304.0099	168.5947	1.7115	112

	9	1	5571	308	190.1981	105.4781	1.0000	
		6	5444	369	188.0176	104.2689	0.9885	
		11	5503	312	189.0337	104.8323	0.9939	
		16	5401	311	187.2736	103.8562	0.9846	
		21	4645	286	173.6730	96.31381	0.9131	
		26	5529	314	189.4798	105.0797	0.9962	
		31	4217	274	165.4784	91.76932	0.8700	
		34	4340	274	167.8744	93.09805	0.8826	
		37	4362	271	168.2993	93.33371	0.8849	
		40	4454	276	170.0649	94.31284	0.8941	
		43	4493	277	170.8078	94.72485	0.8981	
		44	4603	275	172.8861	95.87739	0.9090	
		47	4562	281	172.1144	95.44943	0.9049	
		50	4480	280	170.5605	94.58771	0.8968	
		53	4747	291	175.5695	97.36555	0.9231	
		56	5257	313	184.7602	102.4624	0.9714	
*		61	5501	377	188.9994	104.8133	0.9937	
		66	5792	364	193.9339	107.5499	1.0196	
		70	5792	364	193.9339	107.5499	1.0196	0
#		71	5791	364	193.9172	107.5406	1.0196	1
		76	5719	327	192.7079	106.8699	1.0132	6
		80	5037	324	180.8529	100.2955	0.9509	10
		84	5684	311	192.1173	106.5424	1.0101	14
		86	5688	337	192.1849	106.5799	1.0104	16
		88	6588	341	206.8313	114.7024	1.0875	18
		91	7036	349	213.7482	118.5382	1.1238	21
		94	7480	357	220.3892	122.2211	1.1587	24
		97	7428	367	219.6218	121.7956	1.1547	27
		100	8107	393	229.4403	127.2406	1.2063	30
		102	8767	393	238.5970	132.3187	1.2545	32
		104	9579	405	249.4018	138.3107	1.3113	34
		107	8332	366	232.6024	128.9942	1.2229	37
		112	9735	385	251.4245	139.4324	1.3219	42
		117	9735	385	251.4245	139.4324	1.3219	47
		120	9706	392	251.0497	139.2245	1.3199	50
		123	8432	355	233.9941	129.7660	1.2303	53
		126	7377	359	218.8666	121.3767	1.1507	56
		129	7763	344	224.5196	124.5118	1.1805	59
		132	9196	374	244.3650	135.5174	1.2848	62
		135	10280	415	258.3664	143.2822	1.3584	65
		138	9370	394	246.6660	136.7935	1.2969	68
		141	8276	382	231.8194	128.5600	1.2188	71
		144	7614	371	222.3545	123.3111	1.1691	74
		147	7299	351	217.7064	120.7333	1.1446	77
		152	7650	356	222.8796	123.6022	1.1718	82
		157	7121	354	215.0354	119.2521	1.1306	87
		162	6950	346	212.4379	117.8116	1.1169	92
		167	6839	352	210.7346	116.8670	1.1080	97
		172	6726	340	208.9864	115.8975	1.0988	102
		177	6596	345	206.9569	114.7720	1.0881	107
		182	6806	344	210.2256	116.5847	1.1053	112

	187	7227	360	216.6300	120.1364	1.1390	117
	197	6068	346	198.5008	110.0825	1.0437	127
	202	6759	362	209.4984	116.1814	1.1015	132
	207	7578	362	221.8282	123.0192	1.1663	137
10	1	6821	338	210.4571	116.7131	1.0000	
	4	6865	340	211.1348	117.0889	1.0032	
	7	6614	321	207.2391	114.9285	0.9847	
	10	6864	323	211.1194	117.0804	1.0031	
	13	6606	323	207.1137	114.8589	0.9841	
	15	6441	324	204.5108	113.4154	0.9717	
	18	6513	319	205.6506	114.0476	0.9772	
	21	6519	320	205.7453	114.1001	0.9776	
	24	6556	314	206.3284	114.4234	0.9804	
	27	6545	316	206.1552	114.3274	0.9796	
	30	6406	319	203.9544	113.1069	0.9691	
	33	6339	315	202.8850	112.5138	0.9640	
	36	6371	310	203.3964	112.7975	0.9665	
	39	6408	316	203.9862	113.1245	0.9693	
	42	6212	306	200.8423	111.3810	0.9543	
	45	6679	318	208.2549	115.4918	0.9895	
	48	6924	325	212.0401	117.5910	1.0075	
	51	6797	318	210.0865	116.5076	0.9982	
	54	6113	310	199.2355	110.4899	0.9467	
	57	6485	314	205.2081	113.8022	0.9751	
	60	6333	319	202.7889	112.4606	0.9636	
	63	6440	316	204.4949	113.4066	0.9717	
	65	6395	314	203.7792	113.0097	0.9683	
*	66	6390	313	203.6995	112.9655	0.9679	
	68	6277	312	201.8904	111.9622	0.9593	
	71	6619	321	207.3174	114.9719	0.9851	
	74	6587	320	206.8156	114.6937	0.9827	
	75	6923	341	212.0248	117.5825	1.0074	0
#	76	7051	341	213.9759	118.6645	1.0167	1
	77	6627	318	207.4426	115.0414	0.9857	2
	80	4508	288	171.0927	94.88284	0.8130	5
	83	6631	320	207.5052	115.0761	0.9860	8
	86	6490	316	205.2872	113.8460	0.9754	11
	89	6719	322	208.8776	115.8372	0.9925	14
	92	7074	344	214.3246	118.8579	1.0184	17
	95	7486	347	220.4776	122.2702	1.0476	20
	98	7973	363	227.5362	126.1846	1.0812	23
	98	7973	363	227.5362	126.1846	1.0812	23
	101	7621	361	222.4567	123.3677	1.0570	26
	104	6853	345	210.9502	116.9865	1.0023	29
	106	6308	341	202.3883	112.2384	0.9617	31
	108	6208	340	200.7777	111.3452	0.9540	33
	110	6969	365	212.7281	117.9725	1.0108	35
	112	7780	371	224.7653	124.6480	1.0680	37

	114	7857	374	225.8749	125.2633	1.0733	39
	115	7367	358	218.7182	121.2944	1.0393	40
	117	7553	362	221.4620	122.8161	1.0523	42
	119	7107	360	214.8239	119.1348	1.0207	44
	121	6897	332	211.6263	117.3615	1.0056	46
	123	7376	343	218.8517	121.3685	1.0399	48
	125	8637	363	236.8214	131.3340	1.1253	50
	127	9997	390	254.7853	141.2962	1.2106	52
	129	11359	420	271.5874	150.6141	1.2905	54
	131	11883	438	277.7810	154.0489	1.3199	56
	133	12302	450	282.6360	156.7413	1.3430	58
	135	13160	458	292.3260	162.1151	1.3890	60
	137	12585	463	285.8684	158.5339	1.3583	62
	141	12986	474	290.3871	161.0398	1.3798	66
	143	11738	473	276.0811	153.1062	1.3118	68
	145	11689	442	275.5042	152.7863	1.3091	70
	147	12188	483	281.3234	156.0134	1.3367	72
	149	11551	450	273.8731	151.8817	1.3013	74
	151	12130	494	280.6532	155.6417	1.3335	76
	153	11822	486	277.0672	153.6530	1.3165	78
	155	11611	465	274.5835	152.2756	1.3047	80
	157	11455	476	272.7326	151.2492	1.2959	82
	159	11158	468	269.1738	149.2756	1.2790	84
	161	10849	468	265.4205	147.1941	1.2612	86
	163	9119	417	243.3398	134.9488	1.1562	88
	165	9432	432	247.4808	137.2453	1.1759	90
	167	10608	452	262.4559	145.5500	1.2471	92
	169	10912	454	266.1900	147.6209	1.2648	94
	171	10908	463	266.1412	147.5938	1.2646	96
	173	10977	456	266.9816	148.0599	1.2686	98
	175	11182	465	269.4631	149.4360	1.2804	100
	177	10955	464	266.7140	147.9114	1.2673	102
	179	11084	453	268.2797	148.7798	1.2747	104
	181	11341	465	271.3721	150.4947	1.2894	106
	183	11380	468	271.8383	150.7533	1.2917	108
	185	10672	481	263.2464	145.9885	1.2508	110
	187	10143	455	256.6391	142.3242	1.2194	112
	189	10712	456	263.7393	146.2618	1.2532	114
11	1	6341	332	202.9170	112.5316	1.0000	
	2	4450	300	169.9885	94.27048	0.8377	
	5	5693	323	192.2694	106.6267	0.9475	
	7	5751	324	193.2463	107.1685	0.9523	
	9	5381	314	186.9266	103.6638	0.9212	
	11	6472	325	205.0023	113.6880	1.0103	

	13	6512	323	205.6349	114.0388	1.0134	
	15	6536	327	206.0134	114.2488	1.0153	
	17	6597	340	206.9726	114.7807	1.0200	
	19	6675	326	208.1925	115.4572	1.0260	
	21	6552	325	206.2654	114.3885	1.0165	
	23	6606	332	207.1137	114.8589	1.0207	
	25	6450	321	204.6536	113.4947	1.0086	
	27	6443	321	204.5425	113.4331	1.0080	
	29	6507	324	205.5559	113.9950	1.0130	
	30	6608	331	207.1450	114.8763	1.0208	
	32	6285	316	202.0190	112.0336	0.9956	
	34	6372	322	203.4124	112.8063	1.0024	
	38	6562	335	206.4228	114.4758	1.0173	
	40	6591	325	206.8784	114.7285	1.0195	
*	42	6365	320	203.3006	112.7443	1.0019	
	44	6456	322	204.7488	113.5474	1.0090	
	46	6570	325	206.5486	114.5456	1.0179	
	48	6595	347	206.9412	114.7633	1.0198	
	50	6586	326	206.7999	114.6849	1.0191	
	51	6586	326	206.7999	114.6849	1.0191	0
#	52	6553	325	206.2812	114.3973	1.0166	1
	54	6541	331	206.0922	114.2925	1.0156	3
	56	6328	318	202.7089	112.4162	0.9990	5
	58	6464	321	204.8756	113.6178	1.0097	7
	60	6513	322	205.6506	114.0476	1.0135	9
	62	6728	331	209.0174	115.9147	1.0301	11
	64	7600	359	222.1500	123.1976	1.0948	13
	66	7919	382	226.7643	125.7566	1.1175	15
	68	6517	356	205.7138	114.0826	1.0138	17
	69	3427	281	149.1752	82.72805	0.7352	18
12	1	5880	328	195.4016	108.3638	1.0000	
	2	5874	291	195.3019	108.3085	0.9995	
	4	5985	304	197.1386	109.3270	1.0089	
	6	5980	294	197.0562	109.2814	1.0085	
	8	6231	304	201.1492	111.5512	1.0294	
	10	6249	316	201.4396	111.7123	1.0309	
	12	6116	303	199.2844	110.5170	1.0199	
	14	6027	303	197.8291	109.7100	1.0124	
	16	5998	307	197.3526	109.4457	1.0100	
	18	5993	295	197.2703	109.4001	1.0096	
	20	6112	306	199.2192	110.4809	1.0195	
	22	5913	297	195.9492	108.6675	1.0028	
	24	5903	294	195.7834	108.5755	1.0020	
	26	5972	298	196.9244	109.2082	1.0078	
	28	5890	297	195.5677	108.4559	1.0008	

		30	6174	305	200.2271	111.0398	1.0247	
		32	6168	307	200.1298	110.9859	1.0242	
		34	6219	303	200.9555	111.4438	1.0284	
		36	6212	312	200.8423	111.3810	1.0278	
		38	6194	305	200.5511	111.2196	1.0264	
		40	6060	295	198.3699	110.0099	1.0152	
		42	5976	294	196.9903	109.2448	1.0081	
		44	5940	300	196.3961	108.9153	1.0051	
		46	5909	296	195.8829	108.6307	1.0025	
		48	5832	298	194.6024	107.9206	0.9959	
		50	6061	306	198.3863	110.0190	1.0153	
		52	6004	299	197.4512	109.5004	1.0105	
		54	5937	304	196.3464	108.8878	1.0048	
		56	5977	299	197.0068	109.2540	1.0082	
		58	6052	318	198.2390	109.9373	1.0145	
*		59	5800	296	194.0678	107.6241	0.9932	
		60	6038	308	198.0095	109.8101	1.0133	
		62	6166	315	200.0973	110.9679	1.0240	
		64	5912	295	195.9326	108.6583	1.0027	
		66	6016	299	197.6485	109.6098	1.0115	
		68	6066	298	198.4681	110.0644	1.0157	0
#		69	5644	287	191.4402	106.1669	0.9797	1
		70	5906	308	195.8332	108.6031	1.0022	2
		72	5777	290	193.6826	107.4105	0.9912	4
		74	5732	291	192.9268	106.9913	0.9873	6
		76	5880	303	195.4016	108.3638	1.0000	8
		78	5916	297	195.9989	108.6950	1.0031	10
		80	6146	304	199.7725	110.7878	1.0224	12
		82	6469	323	204.9548	113.6617	1.0489	14
		84	5660	288	191.7113	106.3173	0.9811	16
		85	4937	275	179.0487	99.29498	0.9163	17
	13	1	6644	368	207.7085	115.1888	1.0000	
		2	4361	297	168.2800	93.32301	0.8102	
		4	5212	333	183.9678	102.0229	0.8857	
		6	6934	374	212.1932	117.6759	1.0216	
		8	7041	370	213.8241	118.5804	1.0294	
		10	7137	376	215.2769	119.3860	1.0364	
		12	7010	377	213.3529	118.3190	1.0272	
		14	7067	372	214.2186	118.7991	1.0313	
		15	6924	371	212.0401	117.5910	1.0209	
		17	7347	384	218.4211	121.1297	1.0516	
		19	7176	367	215.8643	119.7117	1.0393	
		21	7364	379	218.6736	121.2697	1.0528	
		23	7215	369	216.4501	120.0366	1.0421	
		25	7343	379	218.3616	121.0967	1.0513	
		27	7143	384	215.3673	119.4362	1.0369	
		29	7530	387	221.1246	122.6290	1.0646	

	31	7316	377	217.9598	120.8739	1.0494	
	33	7000	367	213.2007	118.2346	1.0264	
	35	6898	380	211.6416	117.3700	1.0189	
	37	6937	373	212.2391	117.7013	1.0218	
	39	6790	369	209.9783	116.4476	1.0109	
	41	7096	370	214.6576	119.0426	1.0335	
	43	7080	390	214.4155	118.9083	1.0323	
	45	7108	369	214.8391	119.1432	1.0343	
	47	6930	371	212.1320	117.6419	1.0213	
	49	6912	364	211.8563	117.4891	1.0200	
	51	7074	374	214.3246	118.8579	1.0319	
	53	7171	384	215.7890	119.6700	1.0389	
	55	6835	376	210.6730	116.8328	1.0143	
	57	7001	364	213.2159	118.2430	1.0265	
	59	6846	364	210.8424	116.9268	1.0151	
	61	6716	362	208.8310	115.8113	1.0054	
	63	6590	358	206.8627	114.7198	0.9959	
*	65	6847	361	210.8578	116.9353	1.0152	
	67	7111	369	214.8844	119.1683	1.0345	
	69	7039	363	213.7938	118.5635	1.0293	
	71	6975	370	212.8196	118.0233	1.0246	
	73	6874	366	211.2731	117.1657	1.0172	
	74	6953	366	212.4837	117.8370	1.0230	0
#	75	6953	366	212.4837	117.8370	1.0230	1
	77	6947	360	212.3920	117.7861	1.0225	3
	79	7019	361	213.4898	118.3950	1.0278	5
	81	6906	370	211.7643	117.4381	1.0195	7
	83	6946	373	212.3767	117.7777	1.0225	9
	85	7662	385	223.0543	123.6991	1.0739	11
	87	5233	293	184.3380	102.2282	0.8875	13
	89	3567	253	152.1917	84.40094	0.7327	15
	90	5717	298	192.6742	106.8513	0.9276	16
14	1	10525	413	261.4271	144.9795	1.0000	
	3	11138	448	268.9324	149.1417	1.0287	
	5	11680	456	275.3981	152.7274	1.0534	
	7	12362	459	283.3244	157.1231	1.0838	
	9	12506	460	284.9698	158.0356	1.0901	
	11	12430	497	284.1025	157.5546	1.0867	
	13	14338	518	305.1293	169.2154	1.1672	
	15	14379	498	305.5652	169.4572	1.1688	
	16	14261	490	304.3088	168.7604	1.1640	
	18	14309	488	304.8205	169.0442	1.1660	
	20	14320	487	304.9377	169.1092	1.1664	
	22	13934	490	300.7997	166.8144	1.1506	
	24	14172	488	303.3578	168.2330	1.1604	
	26	14875	523	310.7907	172.3551	1.1888	
	28	15142	534	313.5676	173.8951	1.1994	
	30	14665	536	308.5891	171.1341	1.1804	
	32	14239	530	304.0740	168.6302	1.1631	

	34	14334	519	305.0867	169.1918	1.1670
	36	14365	530	305.4164	169.3747	1.1683
	38	14659	527	308.5260	171.0991	1.1802
	40	14457	524	306.3929	169.9162	1.1720
	42	14219	505	303.8604	168.5117	1.1623
	44	14321	503	304.9483	169.1151	1.1665
	46	14144	528	303.0580	168.0667	1.1592
	48	14382	512	305.5971	169.4748	1.1690
	51	15141	531	313.5573	173.8893	1.1994
	53	12977	494	290.2864	160.9840	1.1104
	55	12799	489	288.2887	159.8761	1.1027
	57	12936	491	289.8275	160.7295	1.1086
	59	12863	493	289.0086	160.2754	1.1055
	61	13524	485	296.3413	164.3419	1.1336
	63	13345	519	294.3736	163.2506	1.1260
	65	13405	491	295.0346	163.6172	1.1286
	66	13753	499	298.8397	165.7274	1.1431
	68	13339	484	294.3074	163.2139	1.1258
	70	12631	493	286.3904	158.8234	1.0955
	72	13267	483	293.5120	162.7729	1.1227
	74	13188	480	292.6369	162.2875	1.1194
	76	12917	457	289.6146	160.6114	1.1078
	78	13029	474	290.8674	161.3062	1.1126
	80	13172	473	292.4593	162.1890	1.1187
	82	13319	486	294.0867	163.0915	1.1249
	84	12900	469	289.4239	160.5057	1.1071
	86	13826	515	299.6318	166.1667	1.1461
	88	14355	504	305.3101	169.3157	1.1679
	90	13691	514	298.1653	165.3534	1.1405
	92	13766	510	298.9809	165.8057	1.1436
	94	13698	527	298.2415	165.3957	1.1408
	96	14108	520	302.6720	167.8527	1.1578
	98	13506	501	296.1440	164.2325	1.1328
	100	13492	513	295.9905	164.1473	1.1322
	102	13594	521	297.1072	164.7666	1.1365
	104	13673	522	297.9693	165.2447	1.1398
	106	17093	635	333.1568	184.7586	1.2744
	108	16305	605	325.3868	180.4496	1.2447
	110	14465	544	306.4776	169.9632	1.1723
	112	13568	530	296.8230	164.6090	1.1354
	114	13479	515	295.8478	164.0682	1.1317
	116	13395	504	294.9245	163.5562	1.1281
	118	13495	526	296.0234	164.1656	1.1323
	120	13729	519	298.5788	165.5827	1.1421
	122	13740	511	298.6984	165.6491	1.1426
	124	13309	527	293.9763	163.0303	1.1245
	126	13551	494	296.6369	164.5058	1.1347
*	128	13545	504	296.5713	164.4694	1.1344
	130	14502	506	306.8694	170.1804	1.1738
	132	13129	469	291.9815	161.9241	1.1169
	134	13909	508	300.5298	166.6647	1.1496

	137	13811	527	299.4692	166.0765	1.1455	0
#	138	13816	510	299.5234	166.1066	1.1457	1
	140	13800	495	299.3499	166.0103	1.1451	3
	142	13843	532	299.8159	166.2688	1.1468	5
	144	13632	543	297.5222	164.9968	1.1381	7
	146	13768	534	299.0026	165.8178	1.1437	9
	148	14081	512	302.3823	167.6920	1.1567	11
	150	15089	566	313.0184	173.5905	1.1973	13
	151	13721	477	298.4918	165.5345	1.1418	14
	152	20279	619	362.8798	201.2421	1.3881	15
	153	20825	615	367.7326	203.9333	1.4066	16
	154	22960	734	386.1229	214.1320	1.4770	17
	155	31221	880	450.2596	249.7003	1.7223	18
	156	34758	873	475.0803	263.4651	1.8173	19
	157	36221	892	484.9755	268.9527	1.8551	20
	158	40085	959	510.1884	282.9350	1.9516	21
	159	40313	1077	511.6373	283.7385	1.9571	22
	160	41181	980	517.1161	286.7769	1.9781	23
	161	38342	957	498.9729	276.7152	1.9087	24
15	1	13194	516	292.7034	162.3244	1.0000	
	3	12813	516	288.4463	159.9635	0.9855	
	5	12962	499	290.1186	160.8909	0.9912	
	7	12811	514	288.4238	159.9511	0.9854	
	9	13062	546	291.2356	161.5104	0.9950	
	11	13284	531	293.7000	162.8771	1.0034	
	13	12651	512	286.6170	158.9491	0.9792	
	15	12950	526	289.9843	160.8165	0.9907	
	17	12812	515	288.4350	159.9573	0.9854	
	19	12847	552	288.8288	160.1756	0.9868	
	20	12916	534	289.6034	160.6052	0.9894	
	22	12255	489	282.0955	156.4416	0.9638	
	24	11893	470	277.8979	154.1137	0.9494	
	26	11989	471	279.0172	154.7345	0.9532	
	28	12184	493	281.2772	155.9878	0.9610	
	30	12739	490	287.6122	159.5009	0.9826	
	32	12492	490	284.8102	157.9471	0.9730	
	34	12496	507	284.8558	157.9724	0.9732	
	36	12538	479	285.3341	158.2376	0.9748	
	38	12360	479	283.3015	157.1104	0.9679	
	40	12935	499	289.8163	160.7233	0.9901	
	42	12182	481	281.2541	155.9750	0.9609	
	44	12305	487	282.6704	156.7604	0.9657	
	46	12149	486	280.8729	155.7636	0.9596	
	48	12254	488	282.0840	156.4352	0.9637	
	50	12387	487	283.6107	157.2819	0.9689	
	52	12302	487	282.6360	156.7413	0.9656	
	54	12321	481	282.8541	156.8623	0.9664	
	56	12644	482	286.5377	158.9051	0.9789	

58	12712	488	287.3072	159.3318	0.9816
60	12706	485	287.2394	159.2942	0.9813
62	12600	494	286.0387	158.6284	0.9772
64	12526	489	285.1975	158.1619	0.9744
66	12821	495	288.5363	160.0135	0.9858
68	12585	498	285.8684	158.5339	0.9766
70	12606	485	286.1068	158.6661	0.9775
72	12553	493	285.5047	158.3322	0.9754
74	12878	493	289.1770	160.3688	0.9880
76	13012	492	290.6776	161.2010	0.9931
78	12367	480	283.3817	157.1548	0.9682
80	13395	505	294.9245	163.5562	1.0076
82	13277	505	293.6226	162.8342	1.0031
84	12805	499	288.3562	159.9136	0.9851
86	12683	495	286.9793	159.1500	0.9804
88	12804	501	288.3450	159.9074	0.9851
90	12615	494	286.2089	158.7228	0.9778
92	12545	498	285.4138	158.2818	0.9751
94	13031	498	290.8898	161.3186	0.9938
96	12838	505	288.7276	160.1195	0.9864
98	12882	500	289.2219	160.3937	0.9881
100	12576	493	285.7662	158.4772	0.9763
102	12742	477	287.6460	159.5197	0.9827
104	12757	502	287.8153	159.6136	0.9833
106	12914	500	289.5809	160.5928	0.9893
108	12767	495	287.9281	159.6761	0.9837
110	12830	513	288.6376	160.0696	0.9861
112	12792	498	288.2098	159.8324	0.9846
114	12756	490	287.8040	159.6073	0.9833
116	12271	497	282.2796	156.5437	0.9644
118	12239	500	281.9113	156.3394	0.9631
120	12002	487	279.1685	154.8183	0.9538
122	10829	479	265.1757	147.0584	0.9060
124	10506	467	261.1910	144.8486	0.8923
126	10520	482	261.3650	144.9451	0.8929
128	11072	487	268.1344	148.6992	0.9161
130	10962	464	266.7992	147.9587	0.9115
132	10415	475	260.0574	144.2199	0.8885
134	10925	465	266.3485	147.7088	0.9100
136	11268	477	270.4973	150.0096	0.9241
138	11308	478	270.9770	150.2756	0.9258
140	10912	470	266.1900	147.6209	0.9094
142	11296	464	270.8332	150.1959	0.9253
144	12054	481	279.7726	155.1534	0.9558
146	12177	494	281.1964	155.9430	0.9607
148	11963	476	278.7145	154.5666	0.9522
150	11160	475	269.1979	149.2890	0.9197
152	11400	480	272.0771	150.8857	0.9295
154	11458	471	272.7683	151.2690	0.9319
156	10925	482	266.3485	147.7088	0.9100
158	11041	467	267.7588	148.4909	0.9148

		160	11382	476	271.8622	150.7665	0.9288	
		162	11430	466	272.4349	151.0841	0.9308	
		164	11187	472	269.5233	149.4694	0.9208	
		166	11134	487	268.8841	149.1150	0.9186	
		168	11285	495	270.7013	150.1227	0.9248	
		170	11384	472	271.8861	150.7798	0.9289	
		172	11514	491	273.4341	151.6382	0.9342	
		174	11725	471	275.9281	153.0213	0.9427	
		176	15663	595	318.9165	176.8614	1.0896	
		180	9999	424	254.8108	141.3103	0.8705	
		182	10837	457	265.2736	147.1127	0.9063	
		184	10777	437	264.5383	146.7049	0.9038	
		186	11835	459	277.2194	153.7375	0.9471	
		188	10969	479	266.8843	148.0059	0.9118	
		190	11337	462	271.3243	150.4682	0.9270	
*		192	11285	461	270.7013	150.1227	0.9248	
		194	11324	473	271.1687	150.3819	0.9264	
		196	11110	469	268.5942	148.9542	0.9176	
		198	11421	476	272.3276	151.0246	0.9304	
		201	11037	456	267.7103	148.4640	0.9146	0
#		202	11050	461	267.8679	148.5514	0.9152	1
		204	10889	460	265.9093	147.4652	0.9085	3
		206	10989	468	267.1275	148.1408	0.9126	5
		208	11330	458	271.2405	150.4217	0.9267	7
		210	11865	478	277.5706	153.9322	0.9483	9
		212	17097	556	333.1958	184.7803	1.1383	11
		214	18073	624	342.5742	189.9813	1.1704	13
		216	24195	613	396.3715	219.8156	1.3542	15
		217	21342	642	372.2692	206.4492	1.2718	16
		218	25408	703	406.1859	225.2583	1.3877	17
		220	20740	625	366.9813	203.5167	1.2538	19
		222	21815	682	376.3719	208.7244	1.2858	21
		224	19095	647	352.1271	195.2790	1.2030	23
		226	17457	598	336.6855	186.7155	1.1503	25
		228	19933	656	359.7708	199.5179	1.2291	27
		230	13842	524	299.8051	166.2628	1.0243	29
		232	17728	662	339.2887	188.1592	1.1592	31
		234	18529	679	346.8691	192.3630	1.1851	33
		236	19769	676	358.2877	198.6955	1.2241	35
		238	17826	636	340.2252	188.6786	1.1624	37
		239	17568	620	337.7542	187.3082	1.1539	38
	16	1	55913	1070	602.5540	334.1582	1.0000	
		3	56368	1056	605.0008	335.5150	1.0041	
		5	56029	1027	603.1788	334.5046	1.0010	
		7	56255	1014	604.3940	335.1786	1.0031	
		9	56512	1037	605.7730	335.9433	1.0053	
		13	47542	1795	555.6206	308.1303	0.9221	
		15	53865	1152	591.4158	327.9812	0.9815	
		17	53147	1302	587.4609	325.7880	0.9750	

	19	56141	1052	603.7813	334.8388	1.0020	
	21	44930	2325	540.1418	299.5462	0.8964	
	23	51752	2085	579.6998	321.4839	0.9621	
	25	53222	1229	587.8753	326.0178	0.9756	
	27	44977	1781	540.4243	299.7029	0.8969	
	29	53884	1204	591.5201	328.0391	0.9817	
	31	54755	1118	596.2817	330.6797	0.9896	
	33	54786	1173	596.4505	330.7733	0.9899	
	35	52422	1343	583.4403	323.5582	0.9683	
	37	46860	2156	551.6209	305.9122	0.9155	
	39	52271	1476	582.5994	323.0919	0.9669	
	41	55415	1258	599.8647	332.6667	0.9955	
	43	46502	1877	549.5098	304.7414	0.9120	
	45	43029	2314	528.5916	293.1408	0.8773	
	47	45423	1746	543.0971	301.1852	0.9013	
	49	44985	1580	540.4723	299.7295	0.8970	
	51	49886	1554	569.1529	315.6349	0.9446	
	53	55309	1039	599.2907	332.3484	0.9946	
	55	52991	1275	586.5981	325.3095	0.9735	
	57	53609	1078	590.0088	327.2009	0.9792	
	59	52593	1140	584.3911	324.0855	0.9699	
	61	52399	1143	583.3123	323.4873	0.9681	
	63	51031	1507	575.6475	319.2366	0.9553	
	65	53846	1033	591.3115	327.9234	0.9813	
	69	50679	1417	573.6587	318.1337	0.9520	
	73	53025	999	586.7863	325.4138	0.9738	
	76	53166	997	587.5659	325.8462	0.9751	
	80	52964	1035	586.4487	325.2266	0.9733	
	81	54359	1002	594.1216	329.4818	0.9860	
	82	67642	1165	662.7471	367.5394	1.0999	
	83	55942	1024	602.7103	334.2448	1.0003	
	85	54696	1011	595.9604	330.5015	0.9891	
	88	62196	1096	635.5077	352.4333	1.0547	
	91	52383	1118	583.2232	323.4379	0.9679	
	94	53103	1272	587.2177	325.6531	0.9745	
	97	53115	1181	587.2840	325.6899	0.9747	
	100	49091	1402	564.5996	313.1098	0.9370	
	104	50697	1453	573.7606	318.1902	0.9522	
	107	43684	2091	532.5996	295.3635	0.8839	
	110	40828	1856	514.8950	285.5451	0.8545	
	113	41903	1636	521.6295	289.2799	0.8657	
	117	53951	1061	591.8878	328.2430	0.9823	
	120	51825	1493	580.1085	321.7106	0.9627	
	123	48675	2006	562.2023	311.7803	0.9330	
* 2.5x	126	29837	764	676.4781	375.1542	1.1227	
	131	29691	745	674.8210	374.2352	1.1199	
	135	30220	745	680.8060	377.5543	1.1299	0
#	136	29890	749	677.0787	375.4873	1.1237	1
	140	30105	751	679.5094	376.8353	1.1277	5
	144	30670	758	685.8562	380.3550	1.1382	9
	148	34603	795	728.5059	404.0072	1.2090	13

	152	34533	762	727.7686	403.5984	1.2078	17
	156	33593	749	717.7952	398.0674	1.1913	21
	160	34513	748	727.5578	403.4815	1.2075	25
	164	35975	749	742.8080	411.9388	1.2328	29
	168	34529	736	727.7265	403.5750	1.2077	33
	172	32911	703	710.4716	394.0060	1.1791	37
	176	32589	710	706.9874	392.0737	1.1733	41
	180	34464	734	727.0412	403.1950	1.2066	45
	184	35006	733	732.7358	406.3530	1.2160	49
	186	35263	732	735.4206	407.8419	1.2205	51
17	1	36976	882	490.0039	271.7413	1.0000	
	4	19958	786	359.9963	199.6430	0.7347	
	7	19603	1286	356.7803	197.8595	0.7281	
	10	12880	608	289.1995	160.3812	0.5902	
	13	13291	758	293.7774	162.9200	0.5995	
	16	15763	889	319.9330	177.4251	0.6529	
	19	31449	953	451.9007	250.6104	0.9222	
	22	18460	1483	346.2226	192.0045	0.7066	
	25	29258	1240	435.8749	241.7230	0.8895	
	26	31413	978	451.6420	250.4669	0.9217	
	29	34554	807	473.6840	262.6908	0.9667	
	32	26290	1389	413.1758	229.1347	0.8432	
	35	23180	1604	387.9684	215.1555	0.7918	
	38	24946	1889	402.4761	223.2010	0.8214	
	41	16139	910	323.7262	179.5287	0.6607	
	44	18782	1619	349.2292	193.6719	0.7127	
	47	31906	891	455.1722	252.4247	0.9289	
	50	32428	898	458.8806	254.4812	0.9365	
	51	32997	840	462.8890	256.7041	0.9447	
	54	33362	797	465.4421	258.1200	0.9499	
	57	34612	794	474.0814	262.9112	0.9675	
	60	33436	908	465.9580	258.4061	0.9509	
	63	32760	921	461.2236	255.7806	0.9413	
	66	32811	980	461.5825	255.9796	0.9420	
	69	33987	817	469.7816	260.5266	0.9587	
	72	31457	931	451.9582	250.6423	0.9224	
	75	32651	1036	460.4557	255.3547	0.9397	
	78	34601	791	474.0061	262.8694	0.9674	
	81	34973	867	476.5473	264.2787	0.9725	
	84	34722	846	474.8342	263.3286	0.9690	
	87	35270	837	478.5665	265.3985	0.9767	
	90	34527	977	473.4989	262.5881	0.9663	
	93	35316	918	478.8785	265.5715	0.9773	
	96	35153	834	477.7721	264.9579	0.9750	
	99	34959	965	476.4519	264.2258	0.9723	
	105	37223	853	491.6378	272.6474	1.0033	
	108	38668	846	501.0897	277.8891	1.0226	

	111	38545	838	500.2921	277.4468	1.0210	
	114	36706	851	488.2116	270.7473	0.9963	
	117	35902	942	482.8352	267.7657	0.9854	
	120	36508	847	486.8931	270.0161	0.9937	
	123	36395	837	486.1390	269.5979	0.9921	
	126	37014	811	490.2556	271.8809	1.0005	
	129	36677	834	488.0187	270.6404	0.9959	
	132	37568	866	493.9109	273.9080	1.0080	
	135	38559	853	500.3829	277.4972	1.0212	
	138	37999	822	496.7361	275.4747	1.0137	
	141	38364	825	499.1161	276.7946	1.0186	
	144	36187	805	484.7478	268.8264	0.9893	
	147	37018	827	490.2821	271.8956	1.0006	
	150	35112	975	477.4934	264.8033	0.9745	
	153	35382	946	479.3258	265.8195	0.9782	
	155	36124	814	484.3257	268.5923	0.9884	
	158	37378	833	492.6604	273.2145	1.0054	
	161	38333	823	498.9144	276.6827	1.0182	
	165	35718	801	481.5963	267.0787	0.9828	
	169	36334	809	485.7314	269.3719	0.9913	
	173	35319	793	478.8988	265.5827	0.9773	
	177	36175	807	484.6675	268.7818	0.9891	
	181	35892	821	482.7679	267.7284	0.9852	
	185	34275	782	471.7678	261.6281	0.9628	
	189	34189	797	471.1756	261.2997	0.9616	
* 2.5x	192	18632	608	534.5716	296.4572	1.0910	
	197	18967	641	539.3560	299.1104	1.1007	
	201	18149	585	527.5972	292.5894	1.0767	0
#	202	18429	574	531.6515	294.8378	1.0850	1
	206	18488	594	532.5019	295.3093	1.0867	5
	210	19580	580	548.0025	303.9055	1.1184	9
	214	20636	585	562.5860	311.9931	1.1481	13
	218	20407	579	559.4558	310.2572	1.1417	17
	222	24243	640	609.7746	338.1625	1.2444	21
	226	28327	687	659.1382	365.5380	1.3452	25
	230	33955	760	721.6524	400.2065	1.4727	29
	234	38318	853	766.6155	425.1417	1.5645	33
	234	38318	853	766.6155	425.1417	1.5645	33
	238	39664	873	779.9638	432.5442	1.5917	37
	242	39811	843	781.4078	433.3450	1.5947	41
	367	26089	716	632.5646	350.8011	1.2909	166
	371	24674	682	615.1711	341.1552	1.2554	170
	375	22943	688	593.2002	328.9708	1.2106	174
	379	20000	637	553.8487	307.1477	1.1303	178
	381	18247	590	529.0198	293.3783	1.0796	180
	385	18000	570	525.4270	291.3859	1.0723	184
	389	18308	597	529.9033	293.8683	1.0814	188
	393	17996	576	525.3686	291.3535	1.0722	192
	397	17138	567	512.6916	284.3232	1.0463	196
	401	18780	592	536.6906	297.6323	1.0953	200
	405	21036	609	568.0123	315.0024	1.1592	204

18	1	52537	897	584.0799	323.9129	1.0000	
	2	52537	897	584.0799	323.9129	1.0000	
	6	52652	895	584.7188	324.2673	1.0011	
	10	52349	896	583.0339	323.3329	0.9982	
	14	51407	899	577.7643	320.4105	0.9892	
	18	51584	888	578.7581	320.9617	0.9909	
	22	51655	896	579.1563	321.1825	0.9916	
	26	52621	901	584.5466	324.1718	1.0008	
	30	52349	919	583.0339	323.3329	0.9982	
	34	52647	921	584.6910	324.2519	1.0010	
	38	53097	939	587.1845	325.6347	1.0053	
	42	53970	945	591.9920	328.3008	1.0135	
	46	53804	915	591.0808	327.7955	1.0120	
	50	54851	946	596.8042	330.9695	1.0218	
	54	53794	944	591.0259	327.7650	1.0119	
	58	53239	945	587.9692	326.0698	1.0067	
	62	52457	945	583.6350	323.6662	0.9992	
	66	52975	929	586.5095	325.2604	1.0042	
	70	53432	950	589.0339	326.6603	1.0085	
	74	53999	931	592.1510	328.3889	1.0138	
	78	53503	931	589.4252	326.8773	1.0092	
	82	53505	921	589.4362	326.8834	1.0092	
	86	54055	946	592.4580	328.5592	1.0143	
	90	53706	946	590.5423	327.4968	1.0111	
	94	52946	926	586.3490	325.1713	1.0039	
	97	53133	960	587.3835	325.7451	1.0057	
	102	52969	931	586.4763	325.2420	1.0041	
	106	52674	927	584.8409	324.3350	1.0013	
	110	52261	915	582.5436	323.0610	0.9974	
	114	52082	900	581.5451	322.5073	0.9957	
	118	51375	890	577.5845	320.3108	0.9889	
	122	53361	913	588.6425	326.4432	1.0078	
	126	53296	924	588.2838	326.2443	1.0072	
	130	45876	829	545.7985	302.6833	0.9345	
	134	51367	894	577.5395	320.2859	0.9888	
	138	51180	886	576.4873	319.7023	0.9870	
	142	52821	899	585.6564	324.7873	1.0027	
	145	55624	948	600.9948	333.2935	1.0290	
	149	50716	890	573.8681	318.2498	0.9825	
	153	50202	896	570.9527	316.6330	0.9775	
* 2.5x	154	27232	654	646.2729	358.4033	1.1065	
	159	27094	646	644.6333	357.4940	1.1037	
	163	27064	643	644.2763	357.2961	1.1031	0
#	164	27420	641	648.4999	359.6383	1.1103	1
	169	27293	636	646.9963	358.8045	1.1077	6
	174	28698	659	663.4405	367.9240	1.1359	11
	179	41949	815	802.1156	444.8290	1.3733	16
	184	36137	898	744.4786	412.8652	1.2746	21
	189	57017	1072	935.1437	518.6023	1.6011	26
	194	48066	1021	858.6085	476.1582	1.4700	31
	199	55419	1052	921.9461	511.2833	1.5785	36

	204	54101	990	910.9170	505.1669	1.5596	41
	209	54812	1064	916.8832	508.4756	1.5698	46
	214	57826	1135	941.7546	522.2685	1.6124	51
	219	55231	1073	920.3810	510.4153	1.5758	56
	224	61606	1124	972.0479	539.0683	1.6642	61
	229	61836	1130	973.8608	540.0736	1.6673	66
	234	59494	1121	955.2406	529.7474	1.6355	71
19	1	45346	893	542.6366	300.9298	1.0000	
	5	43445	960	531.1406	294.5544	0.9788	
	9	42918	877	527.9093	292.7625	0.9729	
	13	44065	929	534.9171	296.6488	0.9858	
	17	43748	914	532.9896	295.5798	0.9822	
	21	43937	949	534.1396	296.2176	0.9843	
	25	44624	928	538.2993	298.5245	0.9920	
	29	44025	889	534.6743	296.5141	0.9853	
	33	44612	918	538.2270	298.4843	0.9919	
	37	44802	929	539.3719	299.1193	0.9940	
	41	44631	924	538.3416	298.5479	0.9921	
	45	45005	900	540.5925	299.7962	0.9962	
	49	44815	933	539.4501	299.1626	0.9941	
	53	43596	884	532.0628	295.0659	0.9805	
	57	46107	912	547.1710	303.4444	1.0084	
	61	46334	936	548.5162	304.1904	1.0108	
	65	44859	907	539.7149	299.3095	0.9946	
	69	45105	901	541.1927	300.1290	0.9973	
	73	45797	930	545.3284	302.4226	1.0050	
	77	45803	922	545.3641	302.4424	1.0050	
	81	45881	933	545.8283	302.6998	1.0059	
	85	46298	915	548.3031	304.0722	1.0104	
	89	46104	926	547.1531	303.4345	1.0083	
	93	45520	892	543.6767	301.5066	1.0019	
	97	45968	925	546.3455	302.9866	1.0068	
	101	46446	914	549.1788	304.5579	1.0121	
	105	46368	906	548.7175	304.3020	1.0112	
	109	46315	911	548.4038	304.1281	1.0106	
	113	46449	923	549.1965	304.5677	1.0121	
	117	46784	915	551.1734	305.6640	1.0157	
	121	45405	883	542.9895	301.1255	1.0007	
	125	48670	911	562.1734	311.7643	1.0360	
	129	48422	948	560.7393	310.9690	1.0334	
	133	46949	909	552.1445	306.2026	1.0175	
	137	46581	923	549.9763	305.0002	1.0135	
* 2.5x	139	24679	659	615.2335	341.1898	1.1338	
	144	25012	668	619.3703	343.4840	1.1414	
	148	23891	642	605.3316	335.6985	1.1155	0
#	149	25033	661	619.6303	343.6281	1.1419	1
	154	24529	647	613.3609	340.1513	1.1303	6

		159	24982	664	618.9987	343.2779	1.1407	11
		164	33135	782	712.8853	395.3445	1.3137	16
		169	45031	893	831.0592	460.8802	1.5315	21
		171	39633	854	779.6589	432.3752	1.4368	23
		174	41692	840	799.6548	443.4643	1.4736	26
		176	47596	958	854.4003	473.8245	1.5745	28
		179	50860	985	883.2108	489.8019	1.6276	31
2.5x								
	20	1	29481	722	672.4303	372.9094	1.0000	
		5	31641	735	696.6286	386.3290	1.0360	
*		8	29959	751	677.8597	375.9204	1.0081	
		13	28868	749	665.4026	369.0121	0.9895	
		17	28833	734	664.9991	368.7883	0.9889	0
#		18	28998	763	666.8992	369.8420	0.9918	1
		23	28631	741	662.6656	367.4942	0.9855	6
		28	34070	812	722.8734	400.8836	1.0750	11
		30	37571	849	759.1062	420.9773	1.1289	13
		32	41594	872	798.7144	442.9428	1.1878	15
		35	44087	957	822.3022	456.0238	1.2229	18
		38	44704	984	828.0363	459.2038	1.2314	21
		41	41730	932	800.0191	443.6663	1.1897	24
		44	40797	906	791.0251	438.6785	1.1764	27
		47	41990	917	802.5075	445.0463	1.1934	30
		50	42618	937	808.4864	448.3620	1.2023	33
		53	42782	980	810.0405	449.2238	1.2046	36
		56	43529	1042	817.0818	453.1287	1.2151	39
		59	43088	1035	812.9322	450.8275	1.2089	42
		62	45261	1059	833.1789	462.0557	1.2391	45
	21	1	42635	857	526.1659	291.7956	1.0000	
		5	42516	893	525.4311	291.3881	0.9986	
		9	42722	894	526.7025	292.0932	1.0010	
		13	42170	894	523.2888	290.2000	0.9945	
		17	42616	920	526.0487	291.7306	0.9998	
		21	40433	905	512.3982	284.1605	0.9738	
		25	41238	926	517.4738	286.9753	0.9835	
		29	42256	920	523.8221	290.4958	0.9955	
		33	42713	909	526.6470	292.0624	1.0009	
		37	42730	908	526.7518	292.1206	1.0011	
		41	42672	934	526.3942	291.9222	1.0004	
		45	42129	908	523.0343	290.0589	0.9940	
		49	42121	883	522.9846	290.0314	0.9940	
		53	41577	879	519.5964	288.1524	0.9875	
		57	42314	903	524.1814	290.6951	0.9962	
		61	42560	879	525.7029	291.5389	0.9991	

	65	41673	903	520.1960	288.4849	0.9887	
	69	42075	900	522.6990	289.8730	0.9934	
	73	42334	895	524.3053	290.7638	0.9965	
	77	41868	882	521.4116	289.1590	0.9910	
	81	41126	852	516.7706	286.5853	0.9821	
	85	41600	882	519.7401	288.2321	0.9878	
	89	41682	885	520.2521	288.5160	0.9888	
	92	41571	869	519.5590	288.1316	0.9874	
	93	57409	1064	610.5618	338.5990	1.1604	
	94	42885	871	527.7063	292.6499	1.0029	
	98	57044	1016	608.6177	337.5209	1.1567	
	102	41416	866	518.5894	287.5939	0.9856	
	106	41981	889	522.1148	289.5490	0.9923	
	110	41364	870	518.2638	287.4133	0.9850	
	114	43627	889	532.2520	295.1708	1.0116	
	118	42652	872	526.2708	291.8538	1.0002	
	122	41862	846	521.3743	289.1383	0.9909	
	126	43229	903	529.8186	293.8213	1.0069	
	131	43062	906	528.7942	293.2532	1.0050	
	136	43601	912	532.0933	295.0828	1.0113	
* 2.5x	139	22772	632	384.5388	213.2535	0.7308	
	144	22866	657	385.3317	213.6932	0.7323	
	148	21919	637	289.9055	160.7728	0.5510	0
#	149	22345	633	292.7092	162.3276	0.5563	1
	154	22631	661	294.5764	163.3631	0.5599	6
	159	25112	689	310.3036	172.0849	0.5897	11
	164	24996	627	309.5861	171.6870	0.5884	16
	169	24450	677	306.1862	169.8015	0.5819	21
	174	40811	821	395.5804	219.3769	0.7518	26
	179	38174	818	382.5868	212.1710	0.7271	31
	184	32523	742	353.1356	195.8382	0.6711	36
	189	26955	680	321.4888	178.2879	0.6110	41
	194	21662	626	288.2009	159.8275	0.5477	46
	204	20563	575	280.7950	155.7204	0.5337	56
	209	18670	578	267.5582	148.3796	0.5085	61
	214	19904	600	276.2589	153.2048	0.5250	66
	219	20855	609	282.7817	156.8221	0.5374	71
	224	20927	597	283.2694	157.0926	0.5384	76
	239	27794	710	326.4538	181.0413	0.6204	91
	244	27791	691	326.4361	181.0316	0.6204	96
	249	30200	683	340.2903	188.7147	0.6467	101

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