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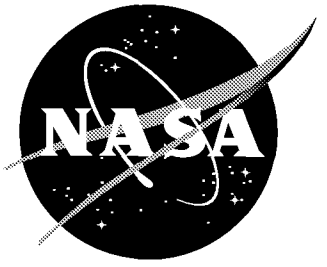

On-Line Database of Vibration-Based Damage Detection Experiments

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January 2000

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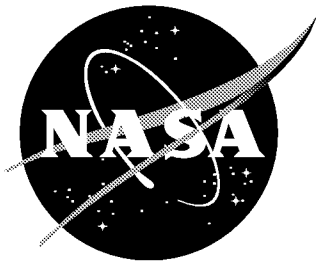

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On-Line Database of Vibration-Based Damage Detection Experiments

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ABSTRACT

This paper describes a new, on-line bibliographic database of vibration-based damage detection experiments. Publications in the database discuss experiments conducted on actual structures as well as those conducted with simulated data. The database can be searched and sorted in many ways, and it provides photographs of test structures when available. It currently contains 100 publications, which is estimated to be about 5%-10% of the number of papers written to date on this subject. Additional entries are forthcoming. This database is available for public use on the Internet at the following address: http://sdbpappa-mac.larc.nasa.gov. Click on the link named "dd_experiments.fp3" and then type "guest" as the password. No user name is required.

INTRODUCTION

Detection of structural damage using changes in vibration characteristics has received considerable research attention in recent years. This subject is part of a broader area of research and development known by various names including "structural health monitoring," "system health maintenance," and "integrated vehicle health management" [1,2]. Assessing structural integrity using vibration data has broad, potential application throughout the aerospace, civil, and mechanical engineering fields [3]. Researchers have proposed numerous ways to detect damage with vibration data (for example, by monitoring modal parameters [4,5]), but many unanswered questions remain concerning the effectiveness and usefulness of this technology.

The authors have created a new, on-line bibliographic database of vibration-based damage detection experiments to help answer the following three questions:

1. What types of experiments have been conducted to date to prove or disprove various methods?

2. Do methods that work on simple, laboratory structures also work on real, fully assembled structures?

3. Where do we go from here to move this technology to a state of readiness where it can be integrated into future structural designs?

The database is available to anyone with Internet access and a standard Web browser.

This paper explains how to access and use the database and gives an overview of its contents. To date, 100 publications have been tabulated. This number is expected to grow to over 1000 in the months ahead. Readers are encouraged to submit citations of additional publications they have written for inclusion in this public database. If possible, also send electronic photographs of the test structures used in the experiments. Submit this information by e-mail to: r.s.pappa@larc.nasa.gov.

The database uses commercial, off-the-shelf software known as FileMaker Pro [6,7]. Use of this particular brand of software is not an official endorsement or promotion of this product by the authors or the United States Government.

LOGGING IN AND GETTING HELP

To access the database, point your Web browser at the following address: http://sdbpappa-mac.larc.nasa.gov. You do not need FileMaker Pro software installed on your computer to use the database, including its searching and sorting capabilities. Figure 1 shows the welcome screen that will appear. Enter the database by clicking the link

named "dd_experiments.fp3" and then type "guest" as the password. No user name is required.

Help is available at any time by clicking the "?" icon located at the top of each page. This help information is a built-in feature of FileMaker Pro Web Companion, the Web publishing component of the FileMaker Pro software. The help text mentions that you may be able to edit, create, or delete records. You will not be able to perform these functions when you access the database using the "guest" password. When you are finished reading the help text, delete this window in your Web browser to return to the database.

TABLE VIEW

Figure 2 shows the initial database screen. This image was captured on a computer monitor with a resolution of 1024 x 768 pixels, which is the minimum resolution required to see the entire horizontal dimension of the table without scrolling. Use the vertical scroll bar to see additional rows of the table below the tenth record. (Each record in the database corresponds to one publication.) By default, you are viewing records 1 through 25, which is indicated in the "Record range" box to the upper-left of the table. To see all available records, change the "25" in the box to a large number and press Enter or click the small arrow icon adjacent to the box. You can now move through the entire database using the vertical scroll bar. There are several other ways to select the range of record numbers for viewing, which are explained in the help text.

Each record in the database has many fields of information associated with it. You are currently viewing the data in the "Table View" mode, where you see only five of these fields (Author & Date Code, Affiliation, Title, Test Structure, and Simulated Structure). These five fields were selected during database development to provide a sufficient, succinct summary of each record in a table format. All of the fields are self-explanatory except the Author & Date Code field, which contains the first author's last name appended with the year of publication and a counter index. For example, the Author & Date Code of "Kim, H. M. 1995-2" indicates that this is the second paper entered into the database that was written in 1995 by H. M. Kim.

Notice the "(P)" appearing at the end of the Test Structure field in the first record of the database (the Author & Date Code of the first record is "Abdalla, M. 1997-1"). This "(P)" indicates that a photograph of the test structure is available for viewing. You can see the photograph and additional information associated with the first data record by shifting to the "Form View" mode, discussed next.

FORM VIEW

Form View provides a more detailed look of each record in the database individually. To see the first record in Form View, do one of the following things:

- Click the "Form View" tab at the top of the window

  or

- Click the small numeral "1" to the left of the first row in the table.

Figure 3 shows the first record in Form View mode. You will probably need to use the vertical scroll bar to see the entire contents of this record. Form View displays ten fields of information associated with each record (Author & Date Code, Affiliation, Citation, Test Structure, Simulated Structure, Methodology, Photograph, Photograph Name, Date Added to Database, and Date of Last Modification). These ten fields were selected during database development to provide a useful, succinct description of each record in a list format. All of the fields are self-explanatory except the Methodology field, which contains a paraphrase of the specific vibration-based method used by the authors to detect structural damage in their experiment.

You can move to other data records in several ways. To go directly to a specific record number, type the number in the "Record" box and press Enter or click the small arrow icon adjacent to the box. To see the previous or next record, click the upper or lower page, respectively, of the small book icon. You can also skip several records at a time by sliding the tab located on the right edge of the book icon either up or down.

You may notice the same photograph appearing in more than one record of the database. To conserve disk space, each photograph is stored only once in a separate database file named "photos.fp3." The photographs in this second file are then dynamically linked to the Photograph field in the first file using the Photograph Name field as a key. The interested reader is welcome to examine the photograph database also. Access it by pressing the Home icon located at the top of each page (to the right to the "?"

icon) and then click the link named "photos.fp3." Return to the publications database when you are finished by pressing the Home icon again and then click the link named "dd_experiments.fp3"

SEARCHING THE DATABASE

Search the database to locate specific information of interest by clicking the "Search" tab located next to the Form View tab at the top of the window. You may begin in either the Table View or Form View mode. Following the search, the records satisfying your search criteria are displayed in Table View format.

Figure 4 shows the search specification page that appears when you click the "Search" tab. To begin, choose either AND or OR logic using the radio buttons at the top of the page. Most searches use AND logic, and this is the default value. Next, enter various words, phrases, dates, or other information of interest in the appropriate blank boxes. Please click the "?" at the top of the page for a full explanation of various search options and operators that are available. When you are finished reading the help text, delete this window in your Web browser to return to the database. For each search criteria you enter, select the type of search to be conducted in the pull-down menu located in each row. There are two choices for each field: "contains" the criteria or "does not contain" the criteria. Finally, begin the search by clicking the "Start search" button located at the top-left of the window.

A typical search result appears in Figure 5. This table shows all of the records in the database containing the phrase "Los Alamos" in the Affiliation field. If you switch to the Form View mode at this point, you will be working with only these eight records resulting from the search, rather than with the entire set of 100 records contained in the database. You can examine each of the eight records individually in Form View mode by clicking the upper or lower page of the small book icon to go to the previous or next record, respectively. You can return to working with the complete set of records in the database at any time by pressing the "Find all" button.

SORTING THE DATABASE

The records in the database can also be sorted in various ways to help locate specific data more quickly. By default, the database is sorted in ascending order of the Author & Date Code field. Sort the database in other ways by clicking the "Sort" button located in the top-left area of the window in both the Table View and Form View modes. Following the sorting operation, the sorted records are displayed in Table View format.

Figure 6 shows the sort specification page that appears when you click the "Sort" button. You can sort the contents of the database by choosing up to four field names and whether each field is to be sorted in ascending or descending order. Sorting is performed based on the first field, then the second field, etc. After selecting the field names and sorting directions, begin sorting by clicking the "Start sort" button at the top-left of the window.

Figure 7 shows typical results of a sorting operation, conducted by sorting the Title field of each record in ascending order. This sort was performed immediately after obtaining the search results shown in Figure 5, so only the eight records with "Los Alamos" in the Affiliation field are still being displayed. If you click the "Find all" button at this point, you will see all 100 records in the database sorted in ascending order of the Title field. (In other words, the "Find all" button cancels the last search operation but does not cancel the last sort operation.) You can specify a different sorting order if you wish by clicking the "Sort" button again and making other selections. To deactivate sorting, you must perform another sorting operation with no fields of information selected.

CONCLUSIONS

This paper discussed an implementation of one of the newest capabilities available on the World Wide Web, the searchable and sortable technical database. This bibliographic database of vibration-based damage detection experiments can be used by anyone having Internet access and a standard Web browser. Users can search and sort the database in a variety of ways, and the results of their requests are displayed on dynamically changing Web pages. The database currently contains 100 publications, which is estimated to be about 5%-10% of the number of papers written to date on this subject. Additional entries and capabilities will be added to the database in the months ahead.

Readers are encouraged to submit citations of other publications they have written for inclusion in this public database. If possible, also send electronic photographs of the test structures used in the experiments. Submit this information by e-mail to: r.s.pappa@larc.nasa.gov.

ACKNOWLEDGEMENTS

Thanks to everyone who contributed lists of publications or photographs for this on-line database.

REFERENCES

[1] Melvin, L. et al., "Integrated Vehicle Health Monitoring (IVHM) for Aerospace Vehicles," *Proceedings of the 1st International Workshop on Structural Health Monitoring*, Stanford University, Sept. 1997, pp. 705-714.

[2] Chang, F.-K. (editor), *Proceedings of the 2nd International Workshop on Structural Health Monitoring*, Stanford University, Sept. 1999.

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[4] Hunt, D. L. et al., "Development and Implementation of a Shuttle Modal Inspection System," *Sound and Vibration*, August 1990, pp. 34-42.

[5] Farrar, C. R. and Doebling, S. W., "An Overview of Modal-Based Damage Identification Methods," *EUROMECH 365 International Workshop: DAMAS 97, Structural Damage Assessment Using Advanced Signal Processing Procedures*, Sheffield, U.K., June 1997.

[6] Langer, M., Database Publishing with FileMaker Pro on the Web, Peachpit Press, Berkeley, CA, 1998.

[7] Feiler, J., FileMaker Pro 4 and the World Wide Web, Academic Press, San Diego, CA, 1999.

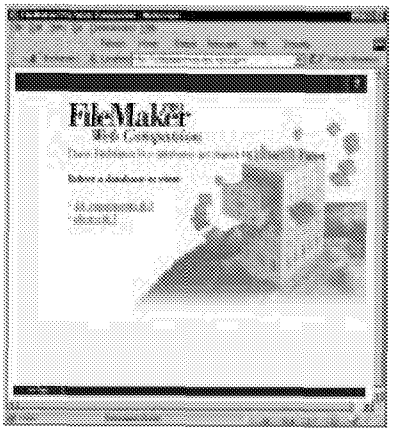


Figure 1 – Welcome Screen

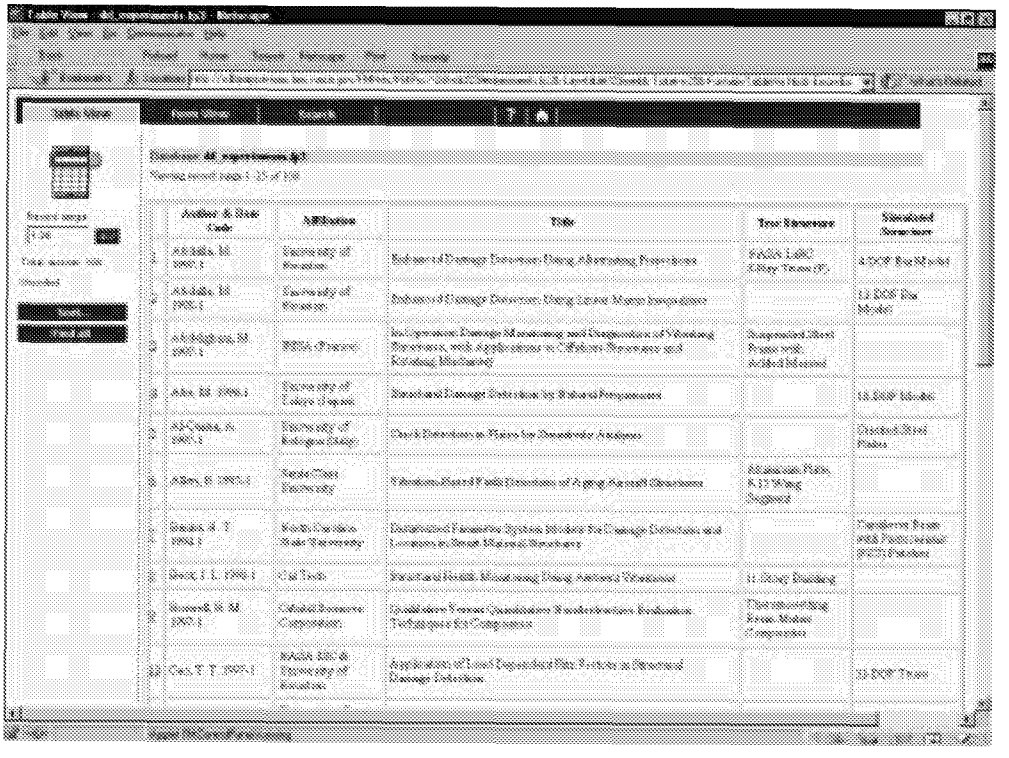


Figure 2 – Initial Database Screen (Table View)

Form View - dd_experiments.fp3 - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Stop

Bookmarks Location: http://sdbpappa-mac.larc.nasa.gov/FMRes/FMPro?-db=dd%5fexperiments.fp3&-format=formvw.htm&-lay=form%5fweb&-max=1&-t What's Related

Table View | Form View | Search | ? | 🏠

Record: 1

Total records: 100

Unsorted

Sort...

Find all

Database: **dd_experiments.fp3**

Viewing record 1 of 100

Author & Date Code
Abdalla, M. 1997-1

Affiliation
University of Houston

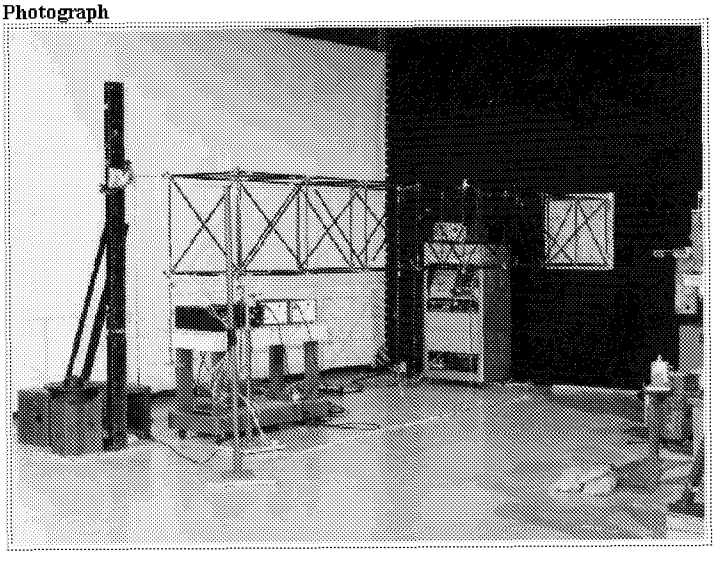
Citation
Abdalla, M., Grigoriadis, K. M., and Zimmerman, D. C., "Enhanced Damage Detection Using Alternating Projections," Proceedings of the 15th IMAC, Feb. 1997, pp. 1325-1331.

Test Structure
NASA LaRC 8-Bay Truss (P)

Simulated Structure
4-DOF Bar Model

Methodology
Identified damage-affected DOFs of the stiffness matrix using directional alternating projections with symmetry, sparsity, positive definiteness, and eigen-equation constraints.

Photograph



Photograph Name
NASA LaRC 8-Bay Truss

Date Added to Database
7/12/99

Date of Last Modification
9/20/99

Applet FMControlPanel running

Figure 3 – Typical Record (Form View)

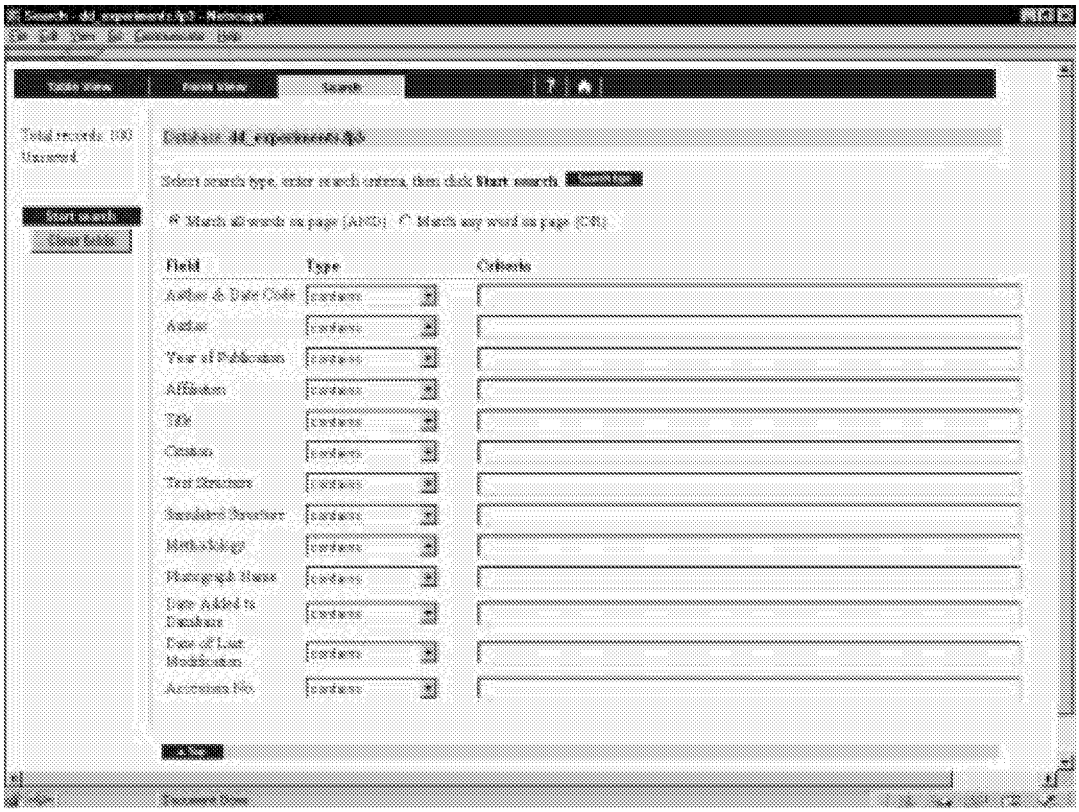


Figure 4 – Search Specification Page

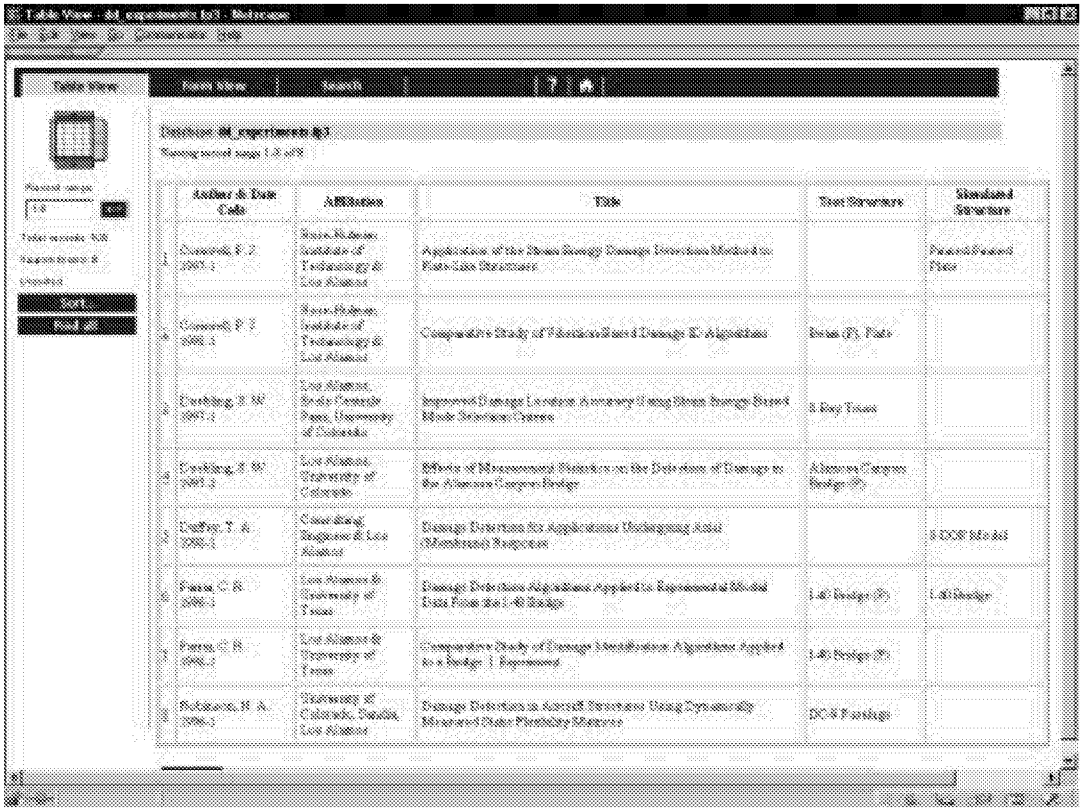


Figure 5 – Typical Search Results (Affiliation = “Los Alamos”)

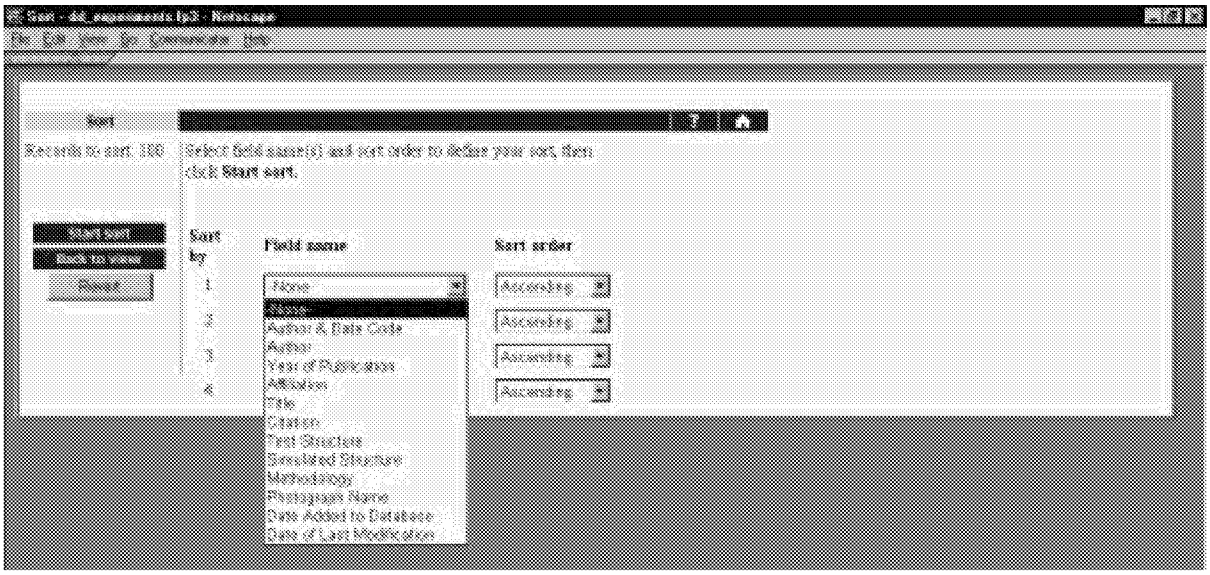


Figure 6 – Sort Specification Page

Figure 7 – Typical Sorted Results (Figure 5 Sorted by Title)

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