

# **FilePlus**

## **Named-Component File Extensions**

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## Introduction

This document describes a Dyalog namespace that contains a set of component file management routines written in APL by Davin Church of Creative Software Design for use in APL applications. Use of this code for any purpose is hereby granted, but credit (comments left inside the code, for instance) is requested and modification is not generally recommended (to allow for later updates). Dyalog APL v17.0 or later is required.

These functions implement a simple and high-performance method of using named components in Dyalog component files. They are designed as extensions to the standard file system and may be used in conjunction with the native `ⓘF...` system functions. Both numbered and named components can coexist in the same file and operations may be performed interchangeably.

Of course, most APL programmers have written similar tools over the years, sometimes several different sets of such tools. But many of them have often had significant restrictions, inflexibility, bugs, or efficiency concerns to deal with. This set of tools does not have any significant drawbacks of this sort and are well-suited for general use for all but the most extreme application needs. These functions are being distributed in the hopes that they may satisfy any and all future named-component file needs, without any need to “reinvent the wheel” when such facilities are desired.

The mere fact that many programmers have created such tools time after time for many different purposes points to their general usefulness. The reason they are not more widely used likely has a lot to do with the bother in producing a useful and efficient system while in the midst of writing an application. With tools like these readily available they often make application coding easier in several respects, even when it isn’t otherwise important enough to build a custom system for those needs.

## Overview

The following functions are available for use:

<b>IO</b>	Read, replace, or append a named (or numbered) component.
<b>Dir</b>	Perform named-component directory management, if needed.
<b>Tie</b>	Tie and untie files. (Only needed if special functionality is desired.)
<b>Create</b>	Create a new file. (Only needed if special functionality is desired.)

The only required function for using named components is **IO**. It can accept physical component numbers as well as component names, and thus can replace **□FREAD**, **□FREPLACE**, and **□FAPPEND** any time it may be desired.

**Dir** is commonly used as well for many applications. It can provide a list of all the named components in the file, determine if a named component exists, remove named components from the file, and perform other similar file management tasks. It can also be used to mark physical component numbers as reusable so that components can be logically removed from the middle of the file. This feature is useful even when named components are not in use.

**Tie** is primarily a cover function for **□FSTIE**, but provides other options such as detecting a currently-tied file and returning its tie number. It can also accept a file name without a full path and will refer to that name as being relative to the directory where the workspace is stored. Applications that may reside in various places may find this feature useful for portability reasons. If special features such as this are not needed then **□FSTIE** can be used directly.

**Create** is a cover function for **□FCREATE**, but it also allows “reserved” component numbers to be specified for this file. These components will never be used by **IO** and will remain available for exclusive use by the application. This feature may be used when upgrading an application that uses specific component numbers by adding named components to the file without disturbing the fixed-position components. If special features such as this are not needed then **□FCREATE** can be used directly.

**IO** and **Dir** can accept the usual file tie numbers for repeated use, but they can also accept a file name (suitable for use by **Tie**) for use on a file that is not already tied. In such a case, the file will be tied, the operation performed, and the file untied. Of course, while this is convenient for single file operations, performance will suffer greatly if it is used frequently.

## General Notes

Component names (see below for more details) can be almost any APL value except for empty arrays and simple scalars. Simple character scalars are accepted but raveled before use. Component names that are simple character vectors are further processed for more convenient use but other names are used exactly as given. Therefore it is reasonable to use matrices, nested arrays, etc. of any reasonable size, shape, depth, or type as component names. (Floating point values are discouraged within a component name due to representational rounding difficulties.)

In addition, component names that are simple character vectors have been extended to allow the use of “array components”. This means that a single name may be followed by a subscript notation (in traditional APL form) to create a component that is an item of a vector (or other array of any rank). These subscripts may be integers as usual for APL, but they need not begin at `⌈IO` nor do they need to be consecutive. In addition, subscripts may themselves be names, and names and integers may be mixed within the same dimension.

Component arrays may be of any rank and any size and even extremely large component arrays are stored and accessed very efficiently with high-performance B-Tree data structures. In addition, an array and a non-array component can have the same base name, as can arrays of multiple ranks. In other words, components named `FOO`, `FOO[ ]`, `FOO[ ; ]`, `FOO[ ; ; ]`, etc., can all exist in the same file at the same time.

This system allows physical file component numbers to be released from use from the middle of the file. This can occur during internal operations or it can be performed explicitly by using the Drop Component operation of the `Dir` function (on either named components or physical component numbers). These released components are tracked and reused automatically by `IO`. A free component number may also be allocated in place of a new one when using `IO` to perform a logical file-append operation. This helps keep data files from wasting too much space.

It is a design restriction that these tools require the exclusive use of file component #1, so applications may not use that file component. All other components are dynamically assigned and `IO` will avoid all component numbers directly used by the application.

The application may `⌈FAPPEND` any components it wishes to the file and those will not be disturbed by these functions. (`IO` also provides an alternative to `⌈FAPPEND` and it can re-use any free-space components that are available.) However, the application should not directly modify any other components that it has not explicitly appended or reserved or the file structure will be damaged. (Also, `Dir` may be used to determine the physical data component numbers in use by named components, which are also available for direct use.) Otherwise, all `⌈F...` functions may be used on these files as desired.

Any file operation errors caused by incorrect application use (including referencing undefined component names or numbers) are reported in the usual APL way, with a `⌈SIGNAL` that stops the code at the function call. When expected, such errors may be intercepted using `:TRAP` or `⌈TRAP` and alternative action may be taken.

File safety is always of concern when using complex facilities such as this, but these functions have been written with that in mind and no data will be lost by an APL crash while they are executing. (A system failure will still need to be protected against by the appropriate Dyalog file properties and/or explicit disk flushing with `⌈FUNTIE ⍉`.) If FilePlus files are to be shared between simultaneous users, be sure to use `⌈FHOLD` operations as usual to prevent file corruption.

## Components

### ***Component Numbers***

IO can also use conventional file component numbers and perform the same operations as `⎕FREAD` and `⎕FREPLACE` by using the same syntax as the native functions. Both IO and the system functions can be used with numbered components at the same time as IO is using component names for other components in the same file. Named and numbered components can coexist in the same file as long as the application does not use the native functions to modify components it has not created.

### ***Component Names***

Component names can be used for easy and efficient mnemonic access of file components. An application that uses component names is inherently very flexible, as new components can be added to the file without affecting any existing code that is already using that file. Component names also easily provide for widely heterogeneous data storage in a single file, whereas a component number-based file is more often used for only a single type of data. These functions provide for very flexible component naming in order to accommodate as many application designs as possible.

### ***Arbitrary Values***

A component name can be almost any non-empty APL data value. Simple scalars are reserved for special purposes, though. A scalar integer refers instead to an explicit, fixed component number, just like those used for the native `⎕F...` functions. In this way, IO can be used to directly replace `⎕FREAD` and `⎕FREPLACE` (and `⎕FAPPEND`, if 0 is used as a placeholder component number) throughout an application. A scalar character value is allowed to be given as a component name, but this value is raveled to a one-item character vector before it is used. This also simplifies use in code that may sometimes have a scalar value and sometimes have a one-item vector by treating them as the same name.

Other than that, any APL value may be used as a component name, including matrices, nested arrays, or other arbitrary structures, and those names may be of any reasonable size. Character data capitalization matters (exact matches only), but names may contain any Unicode characters. Additionally, special features are allowed in the typical case when simple character vectors are used as names (see below).

## ***Character (Text) Vectors***

The most common form of component name is probably a character vector. As noted above, character scalars are raveled into a 1 p vector before processing. For convenience, leading and trailing spaces are then stripped from the name (and it may not then be empty). Spaces may still be included as an interior part of the name, which can make component names more readable, but be wary of consecutive spaces causing readability issues. In addition, any character vector ending in text enclosed in square brackets is treated as an array component (see below).

These special character-vector-only features are not expected to cause any undue hardship to most programmers and applications, and can be quite convenient in most situations.

If character-vector component names are formatted like subscripted array names, but are not intended as arrays, little harm will be done. At worst the name will appear in the directory as an array name but I/O will be processed in exactly the same way as if it were not an array. If this is not acceptable behavior for some reason, it is also usually feasible to make slight changes to the component name so that it no longer follows the array naming conventions. For instance, extra open or close brackets could be included within the name, thus making it an illegal array name. Or the structure might be changed, perhaps enclosed or turned into a one-row vector, so that it no longer qualifies. Or perhaps an extra suffix could be added to the end of the name, such as a period or other symbol, so that it no longer ended with the closing bracket. Any of these methods would force the use of a non-array name if minor changes can be tolerated.

## ***Array Components***

As mentioned above, some component names may actually represent whole arrays of file components. Use of arrays simplifies application access to sets of related data items, just like arrays do in APL variables.

To make use of this feature, use a simple character vector as the array name and follow it by a subscript notation in square brackets (“[ ]”) in the same way as APL traditionally subscripts variables. Between the brackets are one or more subscripts (see below for a more detailed discussion), each separated by semicolons (“;”) to indicate a multi-dimensional array, in the same way that APL syntax is used to refer to array elements. Component names without such brackets are considered to be “scalar” components and are treated as any other component name rather than as arrays. Arrays may have any number of dimensions and may contain any number of elements and may be sparse (where not all consecutive elements or intersections are defined).

When specifying a single array element, every dimension of the array needs to contain a subscript value of some sort. This is the case with all named-component calls to **IO**. However, **Dir** can sometimes refer to entire arrays as a unit, such as when checking to see if a particular array name is defined in the file. In such cases the subscripts may be elided, although the brackets and any semicolons are still required in order to indicate the rank of the array name.

Even though **IO** supports access to arrays of components, it can still only refer to one element of the array at a time. If multiple elements need to be accessed then it must be accomplished with loops or **Each** (“”) or some similar construct.

## ***Subscripts***

### ***Numeric***

Array subscripts may be numeric, just as in APL. However, they must be provided in character form as part of the character name (as text inside the brackets). Therefore, if any provided subscript is composed entirely of digits (up to 9 digits) then it is converted internally into a number and processed that way.

Using **Dir** to search for numeric subscripts can only be done by exact match rather than the substring searching that is used for non-numeric values, for instance. In addition, numeric subscripts are **IO**-sensitive – they start with **0** or **1** as appropriate for the **IO** in use at the time. Moreover, this value changes as **IO** does, where **[5]** refers to the 5<sup>th</sup> element when **IO=1** but the 6<sup>th</sup> element when **IO=0**, both referring to the same file component in different environments, just like APL variables.

Numeric subscripts are quite convenient for keeping lists of components that have no independent identity beyond their position in the list. Unlike APL, however, numeric subscripts do not have to be contiguous and their values may be quite large (**<1E9**).

Since there are few limitations on numeric subscripts, they can also be used to look up specific data values of many sorts. For instance, Gregorian dates (in the YYYYMMDD form) can be used as subscripts to directly look up the application data to which the date is attached. Many other kinds of meaningful integers might be directly useful to the application as well.

If the array subscripts are inherently numeric, but for some reason they need to be processed as text instead of numeric values, the values might be adjusted slightly to include some non-numeric content. For instance, the number might be prefixed by an “X”, or it might be suffixed by a period, or any other kind of adjustment might be made so that it’s not composed entirely of digits.

### ***Character***

In addition to using traditional numeric subscripts, array components may also make use of names for subscripts. These names are just ordinary text of any reasonable length and character-content (except for imbedded brackets and semicolons), specified within the usual subscript notation. Spaces and other symbols of any sort are allowed, although leading and trailing spaces are removed for convenience. Any subscript text that does not qualify as a number (see above) is simply stored as character instead.



### ***Mixed Numeric and Character***

Not only is there a choice between numeric and character subscripts but they may be mixed in any combination desired. For instance, a 2-D matrix could use names for the first dimension and numbers for the second dimension. But any dimension can also be composed of both named and numeric subscripts simultaneously. Any combination within an array is possible and efficient.

## Usage Possibilities

### *Component Naming Suggestions*

Adopting a naming convention for an application's file components can enhance code readability. Some possible uses and suggestions for names to use include:

- A persistent workspace variable that is preserved in a file between executions could use the same name in the file as the name of the variable in the workspace, thus providing a clearer logical connection.
- An important workspace value that is used only occasionally in different areas of an application is often stored in a global variable. To avoid using global values for this purpose and optionally to provide persistence (as above), the value could be stored in a file component using the same name as the global would be, and it could be kept neatly localized in the few places where it was needed.
- Named components could be used to store several separate items of general application configuration or control information (in “scalar” named components) at the same time as most of the file is used for a growing collection of application-data components (optionally in one or more large array components), without explicit partitioning of the file. Then if new items need to be added (which would otherwise be inserted between fixed positions causing renumbering) then that can be accomplished by just using a new representative name without any code changes such as fixed positions would require.
- A component name of “**A**” might make a good identifier for a general file-description component (especially if it's the first component written to a new file and so physically ends up in component #2).
- A naming convention similar to “**Axyz**” might be a good place to store any documentation or other descriptive information that a component named “**xyz**” might require.
- To store a function listing or a named variable in a code-repository style of file, a prefix or suffix character of “**▼**” or “**←**” might be an appropriate convention to use.
- Component names may be given implied structure, such as using `'MyClass.MyObject.MyProperty'` or `'dir/subdir/item'` or `'first, then, more, last'` or anything else that seems appropriate. Or they may given an explicit structure (e.g. `'Top' 'Group' 'Detail'`), since nested arrays can be used as component names. Note that these components are not stored in any special way internally – they're just single names just like any other component name. Use array components if a set of values collected together into a unit is needed.
- Use naming conventions with named array subscripts, too. For instance, `Names[First;1]` and `Names[Last;1]` to store identifiable subsets of a list with mnemonic meaning.

## ***Packaged Code or Data***

In the early days of APL, when workspace sizes were very limited, programmers often kept large applications in “function files”. These were most easily stored and accessed by referencing the file components by name, using the same name as the function it contained, with specialized code to manage the directory information explicitly. Of course this would obviously be easy to do with FilePlus, but while those original needs are long past variants of this idea can still be used for specific purposes.

For instance, functions might occasionally still need to be managed outside the workspace, often in “groups” or “packages”. An array name could be used to indicate a package and its subscripts could be the names of the functions themselves.

Perhaps several alternate versions of a code group may be needed in different situations, such as when running on different operating systems (or other environmental condition). The code needed for that operating system could be swapped into the workspace when the application is run. This might also be used at the namespace level to bring in alternate or additional namespaces as needed.

Or variables may need to be stored instead of functions. If several different application users are using the same system, their particular information may be stored in a named array on file and brought in for use when the user “signs in” to the application.

Dynamically-updated variables could be tracked this way as well, such as monitoring stock market prices for thousands of stocks on a daily basis.

Documentation or other support information may need to be kept close to hand in named components.

The application may allow users to create and store their own related information, such as their photos on a subject and their comments on them. Named components would be a simple and natural way for the users to keep up with their data and update it as needed.

Sometimes programmers like to keep their toolsets in a common store and have their applications refresh themselves from the store each time they run, so they’re always working with the most recent version of the code. Named component files are a natural way to manage this need.

Whole workspace contents could be kept with named references, for transfer to another application such as those used to perform documentation, analysis, comparison, versioning, or other such needs. Two-dimensional arrays could also keep additional information alongside each function, such as  $\square$ AT timestamps or sequential version numbers.

## ***Mixing Numeric and Named Components***

Named components are excellent for storing identifiable items of data, but they don't do as well when there are long lists of data where meaningful names aren't available. Sometimes it is beneficial to store both named and numbered components together in the same file.

### ***Example 1***

For an example, let's assume that a number of clients have their transaction data stored in file arrays by their name, and each name contains a list of transactions for which numeric subscripts are used (sequential numbers or dates or transaction numbers, for instance). Each transaction then becomes a file component containing a variably-sized list of products in that transaction. But the information stored for each of these products is bulky and inconsistent so that each one needs to be stored in a separate file component. Now the problem becomes how to refer to these product components.

One reasonable solution is to put each product's information in a numbered component, without a name because any names here would just be artificially-created anyway. Instead, store all the product components and keep their physical component numbers in a vector in the transaction component. That way a client name array refers to multiple transactions, but each transaction's data refers to a list of physical component numbers directly.

Now the file contains a set of named arrays, each element of which eventually points to a set of unnamed components in the same file. Since the unnamed components can be managed as easily as the named components, this is now a hybrid file structure sharing the same disk space.

### ***Example 2***

Let's assume there is an existing application that already uses ordinary component numbers from 10 to 27, but extra room should be left for possible expansion. It is convenient to convert this to a FilePlus file so that named components can be added to the file structure for better application support. (Some of those numbered components may eventually be converted to use names as programming time permits.) Create a FilePlus file and specify components numbered 10-50 as reserved components and then use the file normally with both the old-fashioned component numbers and traditional system file functions and with the new named components accessed using **IO**.

## Mini-Databases

A named-component file can operate similarly to a small database with many of the same indexing efficiencies, although accessing only one record at a time (which is reasonable for many small applications). Consider a FilePlus file that is to be used like a database table. The application data in this table could be stored as an array name (such as **Record[ ]** or **Data[ ]**) and each component could contain a database record (in any form acceptable to APL). The subscript used on the array name would be the equivalent of the table's primary (unique) key and could be used to identify a single data record in the table. By itself, this would be similar to the ancient ISAM indexing technology from mainframes, where any single record could be found directly by its key. If the data does not already have a field that would be natural to use as a unique identifier then a sequential integer may suffice. If using such a database file as if it were part of a relational database, then other tables could point to this one (a foreign key) by simply listing its primary key value within their data record.

However, a primary index on a database table is often insufficient to locate desired information. One or more secondary indexes may be needed to be able to find the appropriate records. To provide a secondary index simply create another array name (the index name) whose subscripts are the values to be indexed (names or dates or statuses, etc.) For example, **LastName[Smith]** could be an entry in the **LastName** index. When that component is read, it would contain a list of all the table's primary keys which contain data for people named "Smith". Those primary keys could then be used to read the correct data records directly from the data table.

For more complex queries multiple secondary indexes could be used at one time. For instance, looking up secondary indexes of **FirstName[Joe]** and **LastName[Smith]** would yield two primary-key vectors that could be combined together with Intersection ("∩"). The result would then be a list of primary keys of data associated with "Joe Smith". Any number of indexes may be combined in this way before ever reading the actual data from the file.

In addition, another named component could be present in the file that contains a list and description of secondary indexes that are defined for this table. This list could be accessed automatically by a generic subroutine whenever data records are written and it could automatically update all the table's indexes upon every write of a data record. This would keep all the indexes synchronized together much like a database system would do implicitly.

In a more unusual situation, a table may have a multi-part primary key but any individual portion of that key may need to be used independently. If the array were stored with multiple dimensions, one dimension per portion of the key, then **Dir** could be used to find full subscripts that match any combination of sub-keys and thus the actual records to which they refer. For instance, **Data[name;date;sequence]** might provide a structure for such an array.

Of course, this type of architecture would not provide all the facilities of an actual database system, but it's not an unreasonable way to keep track of simple data for a small, self-contained application that doesn't have a significant need for a separate database facility.

## ***Alternative Names***

Since component names and array component subscripts are case-sensitive, it may occasionally arise that the exact capitalization of a component or array subscript may not be easily available. For example, an array may be subscripted with the value “Davin” but it needs to be referenced as “DAVIN”. This can be accomplished in a roundabout way by creating another component array where the subscripts are stored in all capital letters and the contents of that array element tell how to capitalize the primary array subscript. Multiple variations on this theme are possible, including translation to multiple capitalizations at once or removal of spacing and punctuation for easier reference. Possibilities also exist for translation of non-array components, with some additional effort.

This mechanism can also be used in conjunction with the database-style storage mentioned above, to provide case-insensitive indexes or similar transformations.

## ***Releasing (Dropping) Unnamed Components***

Whether named components are needed in a particular file or not, the ability to make use of dynamic component numbers can be beneficial in itself. Many programmers during their careers have created methods to release unneeded component numbers from the middle of a file and reuse them again later when a new component is needed. FilePlus files can handle this directly without writing any extra management code.

## Quick Reference

The FilePlus system provides four public functions for use, each of which has multiple syntax choices. When combined with the standard system file functions they provide all the tools needed for working with file components referenced by either names or numbers.

<i>filetie</i> ← [reserved] <b>Create</b> <i>filename</i>	□FCREATE a FilePlus file.
[result] ← <i>function</i> <b>Dir</b> <i>file</i> [ <i>component</i> ]	Perform file directory management.
<i>data</i> ← <b>IO</b> <i>file component</i>	Read a file component.
<i>data</i> <b>IO</b> <i>file component</i>	Add or replace a file component.
<i>number</i> ← <i>data</i> <b>IO</b> <i>file</i> 0	Append a file component by number.
<i>filetie</i> ← [options] <b>Tie</b> <i>filename</i>	□FSTIE a file.
<b>Tie</b> <i>filetie</i>	□FUNTIE a file.

### Major Parameters

<i>file</i>	May be either a file tie number or a full or relative file name.
<i>component</i>	May be a physical component number or a component name. Component names may be almost any APL value, as described in detail above, but are often just character vectors (with or without subscript notations).
<i>function</i>	<p>A mnemonic character scalar or vector that specifies the directory operation to perform, selected from the following list:</p> <ul style="list-style-type: none"> <li>? Return a list of all existing component names.</li> <li>€ Determine whether the component (or array) exists.</li> <li>ι Return the physical file component number for the component name.</li> <li>[?] Return a list of all defined subscripts for a given array.</li> <li>[ι] Return a list of all physical component numbers for the named array.</li> <li>[&gt;] Return the next array subscript immediately following the one given.</li> <li>[&lt;] Return the previous array subscript immediately preceding the one given.</li> <li>[+] Return a list of defined subscripts beginning with the prefix given.</li> <li>↓ Drop a named or numbered component and free the space it used.</li> <li>≠ Return a list of all user-reserved physical component numbers.</li> <li>⊖ Return a list of all free-space physical component numbers.</li> <li>⌘ Validate the file's directory structure and return a list of the application-created physical component numbers.</li> </ul>

## Syntax and Descriptions

### Create

Create a new FilePlus file:

*filetie* ← [reserved] **Create** *filename*

**FCREATE** a new file, initialize it as a FilePlus file, and return the file's tie number. Unlike **Tie**, the file is left exclusively tied.

The filename argument may omit a full directory path (no root directory specified) to indicate that the file is to be created relative to the current workspace's (**WSID**) directory.

If **FCREATE** is used instead, the internal FilePlus directory will be automatically initialized upon its first use by **IO** or **Dir**. So that this automatic initialization can be performed, leave the file empty before this first use, or append file component #1 as a ' '. File component #1 is always required for internal use by the FilePlus system.

#### *Optional use*

Use of this function is not required unless an optional list of pre-reserved component numbers is specified during creation or a relative-path file name is being supplied.

#### *Examples*

```
tn←Create 'C:\App\Data.dpf'
tn←Create 'Data.dpf'
tn←2 3 4 5 Create 'C:\App\Data.dpf'
```



## **Dir**

Perform various FilePlus directory-management functions:

*[result] ← function Dir file [component]*

The *file* parameter may be a **Tie**/**FTIE** file number or a file name suitable for passing to the **Tie** function. Use of a file name (that is not already tied) will tie and untie that file with each use. Use of pre-tied numbers is most efficient for multiple calls. See the **Tie** function for more details on using a *file* name.

### **Functions**

*Functions* are specified as character codes as the left argument of **Dir**. Choices are as follows:

#### ? — List Components

Return a list of all component names in the file. Array names in the list are suffixed with empty subscript notations (they include the brackets and semicolons but no subscripts) in order to indicate the rank of the array. Names are returned in sorted (**⌈**) order.

The *component* name in the right argument is optional, but may be included to specify a partial component name on which to search. If present, only component names containing (**⌈**) that partial name are returned in the result.

#### ⌈ — Does Component Exist

Return a Boolean indicating whether or not that component is defined in the file. A *component* name is required in the right argument.

If the argument specifies an array name, it must include the brackets and semicolon to indicate the rank of the array. It may optionally contain a specific subscript of that array. If a subscript is specified then the existence of that element is checked. If the subscript is empty then the whole array (of the indicated rank) is checked to see if the array exists at all. Partial subscripts are not accepted as input for this function.

#### ⌊ — Physical Component Number

Return the physical component number in use for the *component* name specified in the right argument. A full component name must be specified, although it may be a specific element of an array. Array names without subscripts are not accepted.

This is useful when the application needs direct access to the physical file component, such as when **FRDCI** needs to obtain component information.

### [ ? ] — List Array Subscripts

This is only used on a component array. It returns a list of all the defined subscripts on that array in sorted ( $\blacktriangle$ ) order. The *component* name in the right argument must be an array name and it must include brackets and semicolons to indicate the desired rank of the array.

The array *component* name may optionally include partial subscript items within the brackets. If it does so, then only subscripts that contain ( $\underline{\epsilon}$ ) that text within the subscript (each dimension must match separately) will be included in the result. (Numeric subscripts require an exact match.) For example, requesting `FOO[ 7 ; ]` will return all the defined subscripts on row 7 of that component matrix.

The shape of the result changes depending upon the rank of the requested array. If the array is a vector, then the result is a vector of simple subscripts (numbers and/or character vectors). If the array has multiple dimensions then the result is an  $n$ -column matrix for an  $n$ -dimensional array.

### [ ι ] — Physical Array Component Numbers

This is only used on a component array. It returns a list of all the physical component numbers used by all the elements of an array, in the same order as the “[ ? ]” function would return them when given the same argument. The *component* name in the right argument must be an array name and it must include brackets and semicolons to indicate the desired rank of the array.

This is useful when the application needs direct access to the physical file component, such as when `□FRDCI` needs to obtain component information.

The array *component* name may optionally include partial subscript items within the brackets. If it does so, then only subscripts that contain ( $\underline{\epsilon}$ ) that text within the subscript (each dimension must match separately) will be included in the result. (Numeric subscripts require an exact match.) For example, requesting `FOO[ 7 ; ]` will return a vector of all the component numbers used by the defined elements on row 7 of that component matrix.

### [ > ] — Next Array Subscript

This is only used on a component array. It returns the succeeding defined subscript, in sorted ( $\blacktriangle$ ) order, in use by that array. The *component* name in the right argument must be an array name and it must at least include brackets and semicolons to indicate the desired rank of the array.

If a specific subscript is named in *component*, whether it exists or not, then the succeeding subscript in order is returned as the result. If the entire subscript is left empty (e.g. `[ ; ]`) then the first ordered subscript is returned. Partial subscripts are not accepted as input for this function.

The shape of the result changes depending upon the rank of the requested array. If the array is a vector, then the result is simple (a number or a single character vector). If the array has multiple dimensions then the result is a vector with one item per dimension. If there is no succeeding subscript, the returned result is  $\emptyset$ .

### [ < ] — Previous Array Subscript

This is only used on a component array. It returns the preceding defined subscript, in sorted (▲) order, in use by that array. The *component* name in the right argument must be an array name and it must at least include brackets and semicolons to indicate the desired rank of the array.

If a specific subscript is named in *component*, whether it exists or not, then the preceding subscript in order is returned as the result. If the entire subscript is left empty (e.g. [ ; ]) then the last ordered subscript is returned. Partial subscripts are not accepted as input for this function.

The shape of the result changes depending upon the rank of the requested array. If the array is a vector, then the result is simple (a number or a single character vector). If the array has multiple dimensions then the result is a vector with one item per dimension. If there is no preceding subscript, the returned result is  $\emptyset$ .

### [ + ] — List Array Subscripts With Prefix

This is only used on a component array. It returns a list of all the defined subscripts on that array in sorted (▲) order. The *component* name in the right argument must be an array name and it must include brackets and semicolons to indicate the desired rank of the array.

The array *component* name usually includes partial subscript items within the brackets. If it does so, then only subscripts that begin with ( $\supseteq$ ) that text within the subscript (each dimension must match separately) will be included in the result. (Numeric subscripts require an exact match.) For example, requesting `FOO[My ]` will return all the defined subscripts beginning with the text “My” in that component vector, such as “MyName”, “MyAddress”, and “MyPhone”.

The shape of the result changes depending upon the rank of the requested array. If the array is a vector, then the result is a vector of simple subscripts (numbers and/or character vectors). If the array has multiple dimensions then the result is an  $n$ -column matrix for an  $n$ -dimensional array.

### ↓ — Drop Component

Delete the named or numbered component from the file and mark it as available for re-use by IO.

If a physical component number is provided, it must be one that the application has previously created with `IO...0` or `□FAPPEND`. That component is released from use and is now explicitly available for future allocation by either named or unnamed components. This feature may be used for dynamic component management even if named components are not in use.

If a component name is provided, it should be a full component name. If it names an array then it must at least include brackets and semicolons to indicate the rank of the array. If it further includes an exact subscript naming an element of that array, then only that one element is removed. If the subscript notation is empty (e.g. `FOO[ ; ]`), then the **entire** array (of that rank) is deleted as a single unit (the array name and all its elements). Partial subscripts are not accepted as input for this function.

If the final remaining element of a named array is deleted then the array name is also removed from the file.

#### ≠ — List Reserved Components

Return a list of all the physical component numbers that were reserved by the application during file creation (with `Create`). No *component* argument is permitted with this function.

#### ⊖ — List Free Components

Return a list of all the physical component numbers that have been marked as deleted and reusable.

Deleted components are simply abandoned in place (for performance reasons) so they will continue to contain arbitrary data until reused. If many deleted components remain unused then they may take up a noticeable amount of file space. On the rare occasion that excessive wasted space should be removed, this list provides a map of unused components that may be specifically emptied of data (with `IO` or `⊖FREPLACE`) prior to a file data compression with `⊖FRESIZE`. No *component* argument is permitted with this function.

#### ⊞ — Validate Structure

This function performs a detailed analysis of the file's internal named-component structure to make sure that no logical errors or idiosyncrasies are detected anywhere. No *component* argument is permitted with this function.

In addition, it returns as its result a list of all component numbers that have been explicitly created by the application without names (using `IO...0` or `⊖FAPPEND`) and are thus not included in the directory trees.

## *Examples*

List of component names *containing* the string “name”:

```
'?' Dir 'data.dpf' 'name'
```

Does a component exist with the name “First name”?

```
'ε' Dir 123 'First name'
```

Does a component exist with the subscripted name “Name[First]”?

```
'ε' Dir 123 'Name[First]'
```

List all subscripts in component vector “Names[]”:

```
'?' Dir 123 'Names[]'
```

What is the physical file location of the component named “First name”?

```
'ι' Dir 123 'First name'
```

Remove component “First name” from the file:

```
'↓' Dir 123 'First name'
```

Remove subscript “First” from component vector “Name”:

```
'↓' Dir 123 'Name[First]'
```

What is the next subscript (in order) in the vector “dictionary” after the one named “water”:

```
'[>]' Dir 123 'dictionary[water]'
```

What are all the subscripts in the vector “dictionary” which begin with “wa”:

```
'[+]' Dir 123 'dictionary[wa]'
```

Return the list of user-reserved component numbers (defined during **Create**):

```
'≠' Dir 123
```

Return the list of all internally-unused component numbers (only useful diagnostically):

```
'θ' Dir 123
```

Validate file consistency and return numbered-only (e.g. **APPENDED**) components:

```
'⊞' Dir 123
```

## **IO**

Read a named (or numbered) file component (that must exist):

*data* ← IO *file component*

Write (create or replace) a named (or numbered) file component:

*data* IO *file component*

Write an unnamed file component and return its physical component number (□FAPPEND):

*number* ← *data* IO *file* 0

The **IO** function reads and writes named or numbered file components.

The *file* argument may be a tied file number or a file name suitable for passing to the **Tie** function. Use of a file name (that is not already tied) will tie and untie that file with each use. Use of pre-tied numbers is most efficient for multiple calls. See the **Tie** function for more details on using a *file* name.

The *component* argument is a component name or a physical component number; see the full description under “Components” on page 6.

- Reading a non-existent component results in an APL error.
- Writing to a new component name adds the data to the file.
- Writing to an existing component name replaces the existing component.
- Writing directly to a non-existing component number succeeds by extending the file as necessary.
- Writing a new unnamed component (with a 0) does not use a name and returns the physical component number assigned.

Since **IO** can be used with physical component numbers, using it in place of □FREAD, □FREPLACE, and □FAPPEND throughout an application provides additional consistency and readability to application code. Also, **IO** can be used to write to an explicitly-reserved component number for the first time (before the component exists in the file), which cannot be done with □FREPLACE.

Writing an unnamed component (using either **IO...0** or □FAPPEND) implicitly reserves that component for use by the application as a numbered component (optionally via □FREAD or □FREPLACE) and it is thereafter avoided by these functions. Using **IO...0** logically does the same thing as □FAPPEND, except that it may instead assign an existing component number that’s no longer in use if one is available. Be sure to have the application keep track of any returned component numbers assigned in either of these ways because there’s no reliable way to identify them later.

An unnamed component that is no longer needed, even one in the middle of the file, can be released back to the “free component pool” (i.e. made available for re-use) by using `Dir`’s Drop Component (“↓”) function on that component number. When combined with `IO`’s Append Component feature, this provides an easy way to manage dynamic component allocations without using named components at all.

### *Examples*

Writing and reading with relative file name:

```
'Davin' IO 'Data.dpf' 'First name'  
fname←IO 'Data.dpf' 'First name'
```

Writing with file tie number:

```
'Church' IO tn 'Last name'
```

Reading with absolute Windows file name:

```
lname←IO 'C:\App\Data.dpf' 'Last name'
```

Appending an unnamed component:

```
newcmp←directdata IO tn 0
```

Writing a component with a nested name value:

```
xyzy IO 'Data.dpf' ('weird' (2 3p16) ('cmp' 'name'))
```

Subscripted names are efficient and don’t have to be contiguous:

```
'Davin' IO 123 'First name[1]'  
'Church' IO 123 'Last name[777]'
```

A numbered matrix of people’s names:

```
'Davin' IO 123 'Names[1;1]'  
'Church' IO 123 'Names[1;2]'
```

A named vector of a person’s names:

```
'Davin' IO 123 'Name[First]'  
'Church' IO 123 'Name[Last]'
```

Mixing named and numbered subscripts in separate dimensions:

```
'Davin' IO 123 'Names[1;First]'  
'Church' IO 123 'Names[1;Last]'
```

## ***Tie***

Tie a standard or FilePlus file:

*filetie* ← [*tienumber* [*exclusive* [*writable*]]] **Tie** *filename*

Untie a standard or FilePlus file:

**Tie** *filetie*

**␣FSTIE** or **␣FUNTIE** an APL component file. If a file name is provided this will tie the file to the next available file tie number. If one or more numeric file tie numbers are provided, this will untie them.

### ***Tying a file***

When providing a file name, it will be share-tied to the next available tie number, which is then returned as the result.

The filename argument may omit a full directory path (no root directory specified) to indicate that the file to be tied is relative to the current workspace's (**␣WSID**) directory.

If the named file is already tied then the existing tie number will be returned (rather than creating a new one), after turning it into a negative value. To use this negative number with the native **␣F...** functions, first negate it or take its absolute value. The fact that it's negative can later be used to determine if the file was previously tied so that utility-style code may avoid untying it when it finishes.

### ***Advanced tying***

If an explicit tie number is needed, or the file should be exclusively tied, or confirmation is needed that the file is not in a read-only state, an optional left argument of one to three positional values may be supplied, as follows:

- [1] Normally, the file is tied to the next available number (which is returned). But if this parameter is provided with a valid file tie number and the file is not already tied, an attempt will be made to tie it explicitly to the given *tienumber*. [0=default]
- [2] If true (1), indicates that the file should be exclusive-tied instead of share-tied (0, the default). If the file is already tied, no changes will be made.
- [3] If true (1), indicates that read/write access to the file is mandatory. An error will be signaled if the file is read-only on disk. If false (0, the default), no checking is done.



### ***Optional use***

This function is only needed for tying if:

- A relative file name is being supplied
- Detection of an already-tied file is desired
- Detection of a read-write file is needed

...otherwise a simple `□FSTIE` (or `□FTIE`) is sufficient.

However, since the above features do not imply the use of `IO`, `Tie` may be used on standard component files without any use of named components. This allows the above features (relative naming, etc.) to be used on otherwise normal files.

### ***Untying a file***

To untie a file, simply provide one or more file tie numbers in the argument. These are simply passed to `□FUNTIE` after quietly ignoring any illegal or not-tied numbers.

### ***Examples***

```
tn ← Tie 'C:\APP\Data.dpf'
tn ← Tie 'Data.dpf'
tn ←|17 1 0 Tie 'C:\APP\Data.dpf'
Tie tn
```