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ABSTRACT

A plan for a library with a storage level in the shape of a flat spiral is presented. The advantages of such a plan include: space saving, easy expansion of the building, an unbroken sequence of shelving, quick access to all books and freedom in the design of the library's other sectors. This plan is especially suited for the research library because this is where it is more important that books are preserved from damage or loss, that there is room for any increase in their numbers, that they are recorded under whatever heading they are sought, and that they are unerringly located and retrieved. Following a description of the working model is a discussion of such topics as: need for closed access, arrangement by size, undisturbed sequence, area accessibility, expandability, internal appearance, and superstructure. (NH)

University of Illinois Graduate School of Library Science

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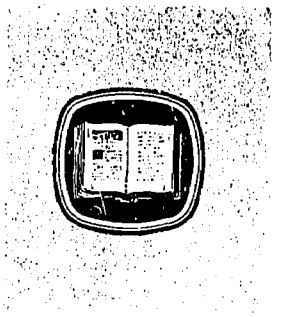

U B I B L I O T H E C A : THE SPIRAL LIBRARY

No. 98 by Guy Ottewell September 1970

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INTRODUCTION

I shall describe briefly a plan for a library with a storage level in the shape of a flat spiral, and then suggest rather more fully the advantages which may be expected from such a plan. The advantages will include a saving of space, easy expansion of the building, an unbroken sequence of shelving, quick

access to all books, and freedom in the design of the library's other sectors. The plan is not intended to be rigid, but only to be an example of what might be done. I shall be pleased if it is criticized and improved upon, for my hope is to stimulate a discussion of a constructive kind.

There are service libraries where it is important that users shall be able to browse among the books, to find them grouped roughly as they expect, to take them away freely, and in general to get pleasure from them; there are also research libraries where it is more important that books are preserved from damage or loss, that there is room for any increase in their numbers, that they are recorded under whatever heading they are sought, and that they are unerringly located and retrieved. Since I am here more interested in systematic ordering of books, I shall exclude service libraries from my scope. It is in research libraries that systematic excellence most matters. Research libraries are also typically large, and while service libraries multiply in numbers as the populations they serve increase--thus remaining roughly static in size--research libraries inexorably swell with the population of books. Flaws are thus magnified, and meditation on efficiency becomes more urgent.

In service libraries the display sector preponderates, in research libraries the storage sector preponderates. Accordingly I will be concerned first with the torage sector of the research library.

WORKING MODEL

Storage

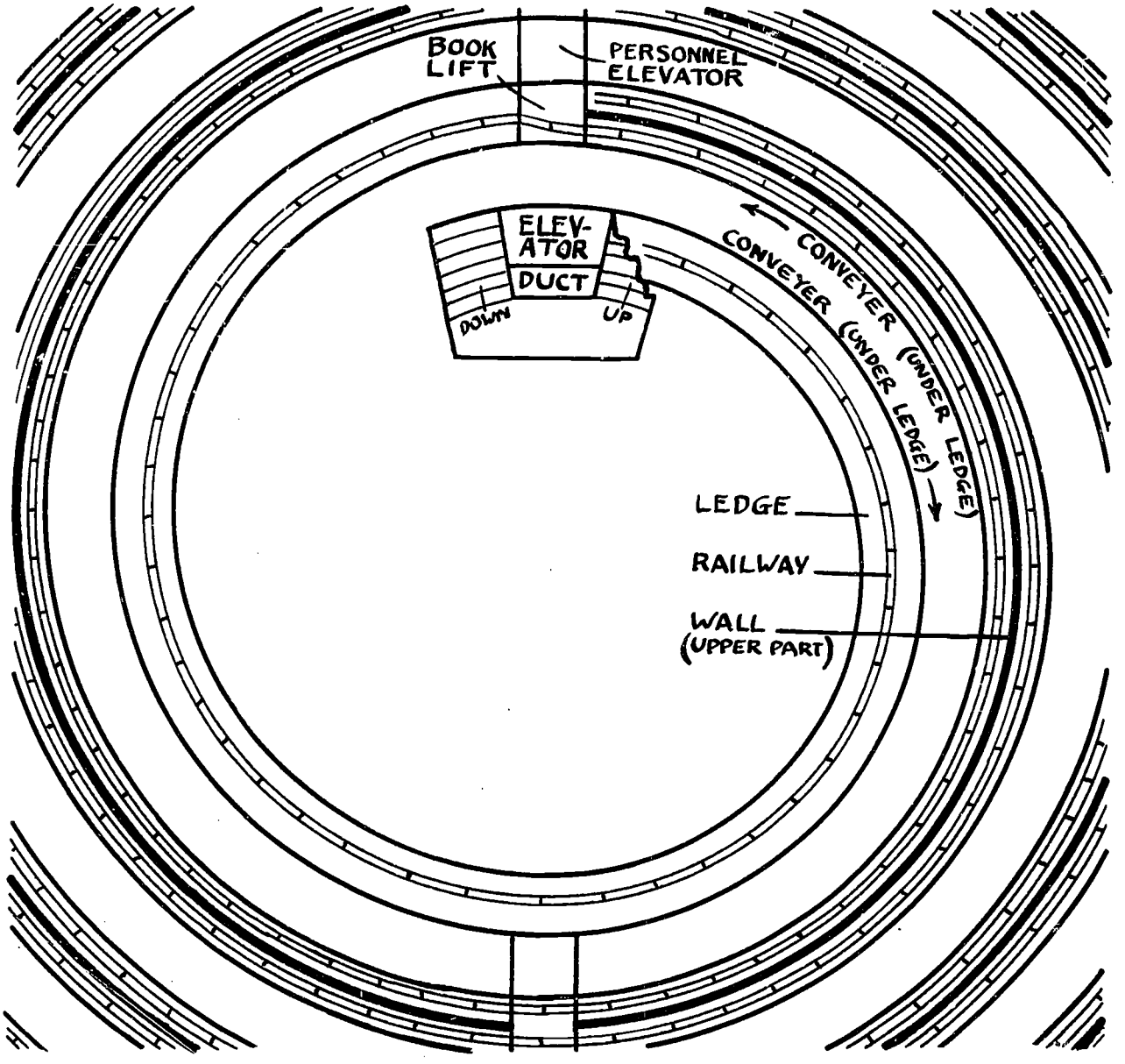
Books are stored on a single floor. This consists of a single corridor starting from a central space and moving outward horizontally in a clockwise spiral (see Figure 1). The corridor is perhaps a meter (39.4 inches) wide. On either side of it is a continuous concrete ledge, half a meter wide and at a height of half a meter from the floor. Along the center of each ledge runs a continuous pair of rails. On these two railways stands the shelving, in the form of open-fronted boxes on wheels (see Figure 2).

This storage sector of the library is closed to the public. Therefore, while books are in it, they need not be grouped by similarities of subject, but instead they are classified by size. They are divided first according to height, then width (spine to opening edge), to the nearest centimeter. Classes of books are thus specified by marks such as 18 11, meaning 18 centimeters (7 inches) high and 11 centimeters (4.3 inches) wide.

The materials are in order of size, beginning with the largest near the center of the spiral. Each box contains materials of one size class only. The box is perhaps a meter long, but its height and width are governed by the material it contains. A box for size class 18 11 is 11.5 centimeters (4.5 inches) deep. It is divided by fixed shelves at vertical intervals of 18.5 centimeters (7.2 inches). The number of shelves depends on how many will fit under the ceiling: thus if the ceiling is about 2.3 meters (7.5 feet) high, nine will fit. In the same way the depth, height and number of shelves of each other box are determined by the size class it contains.

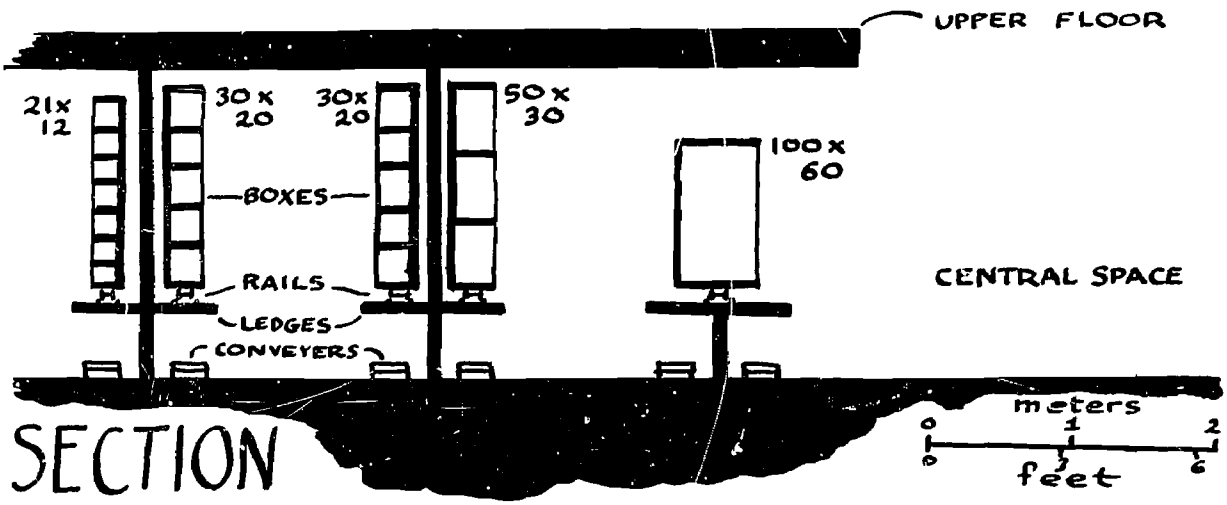
Around the first turn of the spiral there is no wall rising above the concrete ledge; instead, this ledge is a meter wide and carries only one central pair of rails. This is to provide for materials (such as maps and pictures) which might be over 45 centimeters (17.5 inches) wide.

FIGURE 1



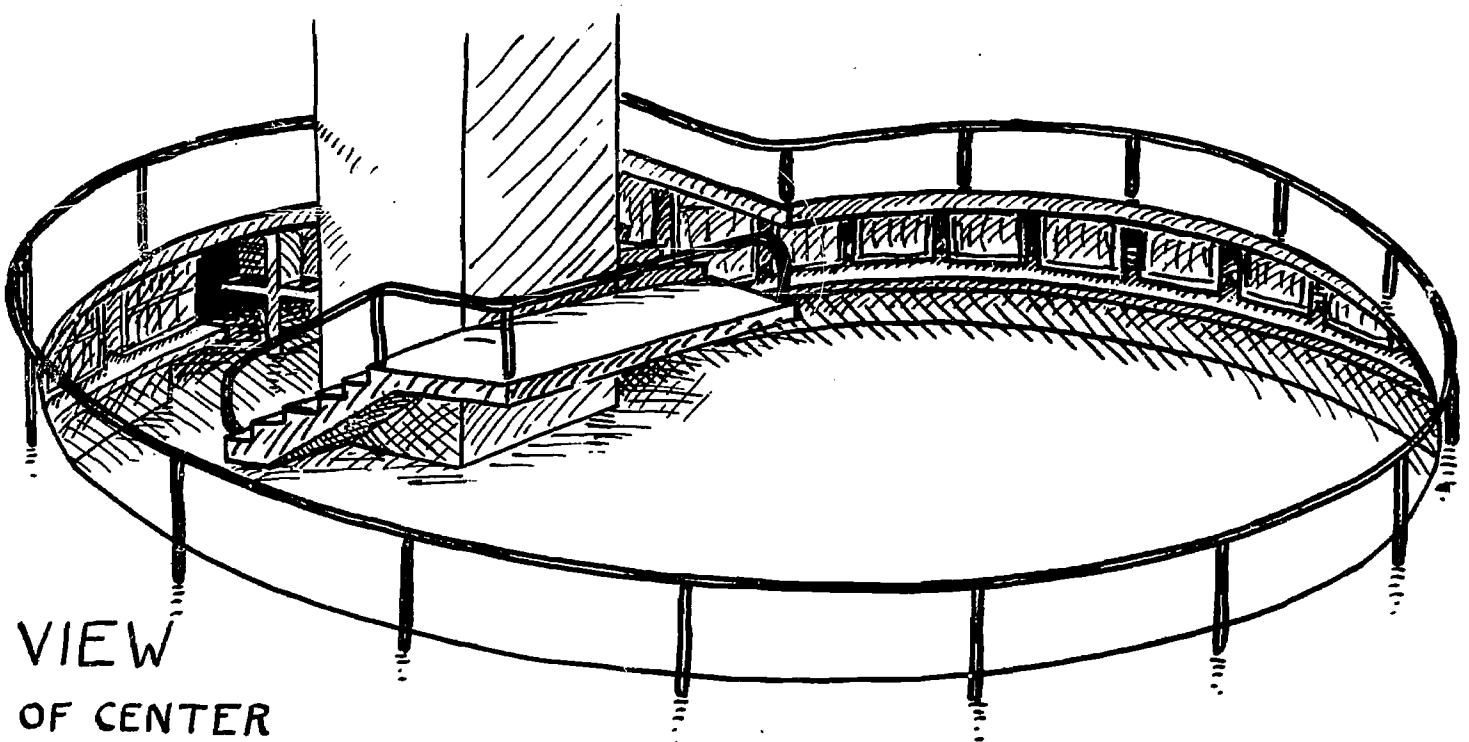
PLAN

FIGURE 2



SECTION

FIGURE 3



VIEW OF CENTER

Retrieval

Underneath the concrete ledge, on either side of the supporting wall, are two mechanical conveyers. The one on the inner side of the wall (the outer side of the corridor) carries books back to the center of the spiral; the other carries books out from the center. On the outgoing conveyer the books are placed in special trays or slots so that they stand upright. When each book reaches the region where its height class is stored, an indicator adjusted to that height strikes the top of it, bringing into operation a mechanism which deflects it from the conveyer to await shelving by an assistant.

Entrance to this storage floor is from the floor above (see Figures 1 and 3). The main point of entrance is a stair at the beginning of the spiral. The stair surrounds an elevator and a main duct for cables and pipes. Then along two opposite radii of the spiral, at every point where these radii intersect the corridor, there is another entrance. These subsidiary entrances are not stairs, but elevators, or rather rising squares of the floor. Moreover, the meter-square section of the shelf next to each of these personnel elevators is itself a book lift. When it rises, it carries its section of the rails and the two boxes on it up to the floor above. Farther out in a large library, where one turn of the spiral has become too long to be conveniently reached from only two points, there are also subsidiary entrances along other radii.

On the floor above the storage floor, a corridor runs out along each radius past the elevators. Each elevator bears a label showing the heights of books in the part of the spiral below it. Also along these radial corridors run rails to carry boxes to and from the book lifts, and conveyers to carry books directly to the center of the library at this upper level.

DISCUSSION

Need for Closed Access

Closed access to storage is not, of course, a peculiarity of the present system and I believe that to defend it is almost redundant when service libraries have been excluded. It is 1) good that users should be able to get at the books for themselves, and 2) bad if users cannot get the books they need at all because other users have lost, damaged, stolen or misplaced them.[1] In service libraries the first consideration is more important, in research libraries the second.

Not only research libraries but any institutions which propose reforms or experiments in efficiency must be able to rely on their stock to stay where it should be when not in use. An excellent catalog is a mockery if it represents what is not there; indeed, since true excellence implies revision and therefore reconsulting of the books, such a catalog is only possible if the stock is guaranteed to be undisturbed except by the staff. The researcher, too, benefits from closed access since he is forced to seek what he wants in the catalog (where it is always represented, generally under several headings) instead of browsing along the shelves (from which it might be temporarily absent).

A more corporeal argument for closed access is that the atmospheric conditions best for the health of books and of people differ. Finally, it must be remembered that we are talking only about the storage sector of the library; the display sector above it can be as large and as permissive as we wish.

Arrangement by Size

All libraries use size as one principle in arranging books, whatever other principles they add to it. Why not, therefore, use size as the only principle?[2] Being the only one which is always used, it is the only one which can be used alone. It is the only principle on which a non-composite system can be based.

The reason why all libraries use size as a principle of arrangement is that too much space would otherwise be wasted. Why not, therefore, save the maximum of space by using the finest size divisions? The wastage of vertical space is dependent on the range of variation in size expected on each shelf, since the height between shelves must be that of the highest book. The average vertical space wasted on any shelf is half the difference between the smallest and largest books, and the total wasted throughout the library is this figure multiplied by the length of shelving. In a library with no size divisions the average wasted vertical space would be about 20 centimeters (8 inches); in a library with three size divisions, the average waste would be about 5 centimeters (2 inches); in a library with divisions of 1 centimeter (.39 inches) the average waste would be only half a centimeter. If the three libraries each had a million volumes on 25 kilometers of shelving, their totals of wasted space would be respectively 5,000, 1,250 and 125 square meters (53,820, 13,463 and 1,346 square feet).

When storage by size is applied as the secondary organizing principle it greatly reduces the usefulness of whatever is the primary organizing principle. For example, when subject classes are secondarily divided into octavo, quarto and folio sequences, these usually differ widely in numbers so that they extend over different numbers of shelves; the difference accumulates until folios may be seven or eight bays away from the corresponding octavos. Indeed, they are often in a completely different part of the building. The shelflist represents the order on the shelves only as it would be if undisturbed by size groupings. The user of the library must either learn and remember the situation or miss some of the books in the class he is seeking. Again, a book may be classified and shelflisted alongside another for special reasons (for instance, a Turkish-German dictionary by Brockelmann is classified with Turkish-Arabic dictionaries and given a book number beginning with K in order to place it next to a work by Kashgari on which it is based) but the expedient fails of its effect since the two books are of different sizes and end as far apart as ever. In ways like this the principle of shelving by size is merely a nuisance; however, the more it is reduced in importance, the more of a nuisance it becomes, though no less necessary. Shelving by size and shelving by subject, if used together, interfere with each other; and shelving by size cannot be dispensed with.

Size is a wider principle than authorship, subject and others which apply to books; size applies to the whole class of physical objects, of which books are a subclass. If there were a clear distinction between books and non-books, and if libraries were guaranteed to contain only books, then it would remain satisfactory

to classify books by principles applicable only to them. But there is a continuum between books and other objects, and libraries are liable to contain more and more of the non-books, so that in the future it may well be the orthodox books which become the special case. "Library," like many other terms, must be retained for the sake of history and convenience, yet it no longer perfectly fits that which it names: the institution would be better thought of as a general storehouse than as a bookery. It has to house maps, music, ephemera, files, films, recordings, slides, microcopies, and perhaps objects which might also be found in museums; indeed, in the future it may well become impracticable to distinguish radically between libraries, museums and art galleries since the same storage might contain the undisplayed stock of all three. Already under present circumstances to regard everything other than books as marginal leads either to untidy subsystems or to mere failures to apply the central system: for instance, map rooms whose contents have all been laboriously classified and shelflisted by numbers which are no help in filing or finding them, because they have to be thrust into drawers wherever they will fit.

That size is the only principle used by all libraries in arranging books and that it is a wider principle than those which apply to books only suggests that, if there is any natural first principle of book classification, it is at least as likely to be size as anything else.[3] I mention this defensively because I feel that distaste for arranging books by anything so objective as size is likely to be felt on philosophical rather than practical grounds; but the matter really should be decided by practical considerations, of which there are several more.

Size is the most constant thing about a book. Knowledge about it may be revised, but once it has stopped changing hands it need never be cut to a different size. It is especially important that the feature governing the symbols to be marked on the exterior of a book should be a fixed one. When location marking is linked to subject, the result is partly a retardation or complete blockage of improvements in the scheme of classification, partly a discord between the scheme as shaped by its idealistic official revisers and as applied by the sundry libraries, partly a discord between different books in one library, and partly a physical mess on the spines of those books that people have bestirred themselves to alter, since gold leaf at least, once applied, is never completely dug out.

Materials physically similar in ways other than size will be to some extent grouped together: series in similar format, films in their spools, records in their sleeves.

It is easier to scan a group of books and to pick out a feature such as a number when the most obvious other feature, size, is not also varying.

When books are off the shelf, there are many circumstances in which it is helpful to be able to judge at a glance roughly what their location marks are, without looking closely. A marker can pick out by eye a number of books which are obviously around 25 centimeters in height and can mark the 2 on all of them, and the 5 on many of them, without putting the marking tool down. An assistant can much more rapidly put books in order for return to the shelves when they are primarily grouped by their heights.

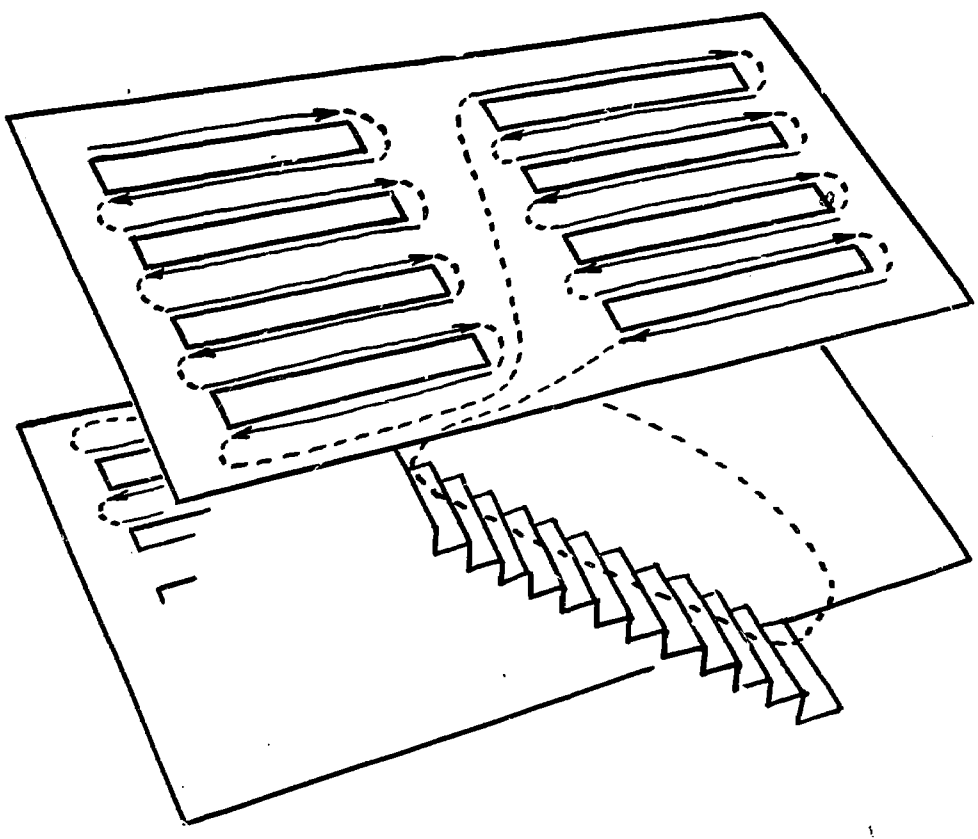
A book misplaced on the shelves is virtually lost, but when size is the principle of arrangement a book can hardly be misplaced for any length of time.

If it is put into the shelves for larger books, it will be as obvious to the eye as a soldier out of step. It simply will not fit into the shelves for smaller books. Hence when a book is missing it must be somewhere within its own strictly limited size group.

Undisturbed Sequence

Shelving arranged in rectangular rooms, on even the most rational plan, necessitates a sequence of books which is full of discontinuities (see Figure 4).

FIGURE 4



In the spiral library, it is as if all these islands of shelving were laid end to end. Incidentally, there could be no single conveyer passing all the shelves, except in a library consisting of one corridor.

Not only is the sequence single, but its order will never be disturbed. When a new box is to be inserted, for instance into size class 18 11, it is lowered into its place on one of the book lifts, and all the boxes of smaller material are simply pushed further out along the rails.

Consider the situation in a library of classified books in a building made of rooms. There is a theoretically continuous spectrum from the 0s to the 9s.[4] But the building probably does not consist of ten parts, nor, if it did, would the ten main classes be of equal size, and some of them are akin to classes not numerically adjacent to them. Thus begins a process of adjustment to which there are no limits, and of which only a few examples can be given. Suppose the building has a trunk and two wings, then these three parts may be assigned respectively to 5 and 6 (science), 3 (social studies) and the rest ("arts"). Then 8 (literature) is distributed alongside 4 (language)--82 alongside 42, 83 alongside 43, 891.66 alongside 491.66 and so on. 61 is removed to a special medical library, and 69 and 72 to a special architectural library. 57 (anthropology) and 65 (business) are taken out of the science wing and put among social studies, except that 571 (prehistoric archaeology) goes with 913 (archaeology),which goes with 47, 48, 87, 88, 937 and 938 and 949.5 to form an enclave of classical and archaeological studies. 7 (art) seems appropriate on the floor next to this. By similar processes of association 2 (religion) attracts on the one side Near Eastern studies (491.5, 492-493, 494.3, 891.5 etc., 953-956) and on the other side 1 (philosophy and psychology), with the sequence altered so that 13 and 15 (branches of psychology) can be next to each other. 91 (geography) is removed from the middle of 9 (history) and put next to the map room. 0 (generalia), being less used, is put in the basement. 27-28 (ecclesiastical history) and 355-359 (military history) are taken from their places to be put with 9 (general history). Every group is now divided into three sequences--octavos, quartos and folios. Then the periodicals are taken out of each group (using "group" to cover such uncoordinate entities as 7, 371.92, and 42-plus-81-plus-82) and placed at the end of the group, in alphabetical instead of classified order. Then, with expansion, pressure has to be relieved at some points, so 98 (South America) is removed to some spare shelves between 350-354 (administration) and 39 (folklore); the education periodicals are moved a floor down, and the music folios more than 12 inches high are moved a floor up. And then all over the building are segregations of other kinds: parliamentary papers, British record office calendars, Rolls series, United Nations documents, county histories, Loeb editions of the classics, uncataloged books, old periodicals, theses, reserved books, duplicates of popular texts, valuable books, erotica, bequests, books of local interest, manuscripts, phonograph records, etc. Some of these are in classified order, some alphabetical, and some by date; some are scattered throughout the building, some in rooms of their own, some grouped in each reading room, some along the side walls of stacks, some in boxes, some on top of the catalog, some behind the counter, some in glass cases, some in the librarian's cupboard. This situation is far simpler than many a reality: once a system is laid open to exceptions, exceptions are conceived almost weekly. And this highly complex structure of documents has to be fitted to the equally complex topography of a static building. Consider by contrast the situation in a spiral library. There is one sequence of documents, from the largest to the smallest, running along the two sides of a single corridor.

Area

The first objection to the spiral plan occurring to the reader's mind may have been that a single floor would have to spread far too wide in order to contain all the books which another building would contain on seven or eight floors. Space, however, is saved in many ways.

Since new boxes can be inserted at any point, in principle no gaps need be left between boxes anywhere. In practice gaps would be left at intervals for the easier

shifting of groups of boxes. Also a box would not be stationed half on a book lift. These two requirements could be combined by leaving all book lifts normally free. But in a library with static shelves, vacant shelves for expansion must be left after every section.

For the same reason, few gaps need be left even within boxes, except in the last box of a particular size. This is because the consequences of having to move books along are not great: never more than the moving of all books in one of the fine size divisions, or the insertion of a new box. In a conventional library, not only must a great many shelves be left unused, but almost all used shelves must be incompletely filled (incidentally entailing the use of thousands of bookends). The use of shelving length in such a library can hardly be much over 50 percent on the average, and can never approach 100 percent. By the time it reaches 80 percent or much less, some sections will already be so full that not another book can be put in them; in other words, the library is by that time unusable. The use of shelving length in an unclassified library with shelves on a continuous railway would approach 100 percent, not just toward the end of the library's life, but right from the beginning. Where space for expansion must be scattered throughout a library, it is impossible to scatter it in the proportions which will prove correct, because no one can predict exact rates of expansion in each class of literature; but in the spiral library there is no need to worry about any such thing, because all the space for expansion is concentrated at one place, the end.

The spiral plan itself saves floor space. In the storage sector of the library there will be only the shelves and the meter-wide corridor between them. This density is like the density of a block of shelving in the stacks of a conventional library. But since in such a library there is not one corridor but many, they must be reached by many transverse corridors, usually of greater width (see again Figure 4). Also, one floor of a conventional library contains so many other features that perhaps not half of it is occupied by stacks. The storage floor of the spiral library, however, contains no other feature except the central room.

The cutting of wasted vertical space by about 90 percent by shelving books strictly according to size has already been mentioned. (Part of this saved vertical space is used for the conveyers underneath the shelves.)

In combination, all these factors render the spiral library quite unexpectedly compact, as will now be shown.

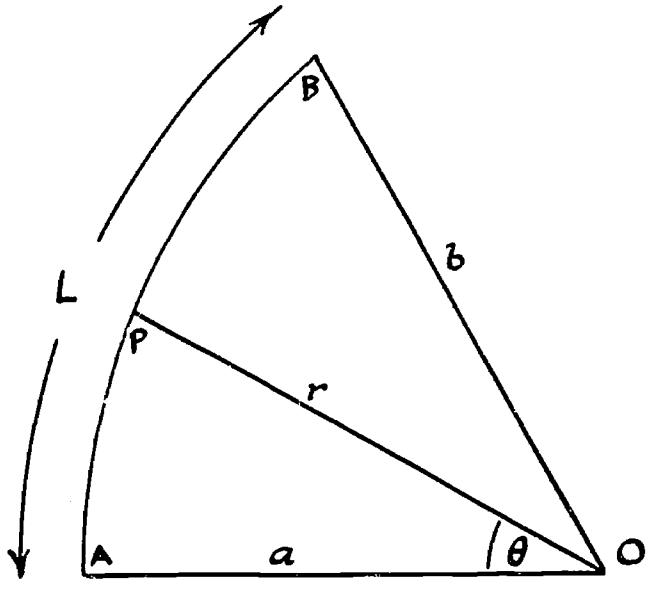
Shelves a meter long each should hold on the average forty books, and boxes should contain an average of six shelves. (The first estimate may be high, not allowing for gaps, but the second is more certainly low: 18 by 11 centimeters (7 by 4.3 inches), giving nine shelves per box, is perhaps the commonest size of books, and will be more so when paperbacks become the rule; and the outer end of the library with its masses of microtexts will account for much more than the individually huge items at the inner end.) Each box, then, contains an average of 240 items; and each meter of the corridor with shelving along either side represents 480.

The equation for this type of Archimedean spiral[5] in polar coordinates is

$$r = a + k\theta$$

where a is the length of the initial radius OA, r is the length of the radius from O to a general point P, θ is the angle turned through from the initial radius to the

FIGURE 5



radius OP, and k is a constant defining the rate of expansion of the spiral (see Figure 5). The length of the arc AB of the spiral, when radii OA and OB are of lengths a and b respectively, is then

$$L = \frac{b\sqrt{b^2+k^2} - a\sqrt{a^2+k^2}}{2k} + \frac{1}{2}k \log_e \left(\frac{b+\sqrt{b^2+k^2}}{a+\sqrt{a^2+k^2}} \right)$$

For readier calculation there are these simplifications of the formula: when k is small compared with a and b--i.e., in all but the smallest spirals--then roughly

$$L \simeq \frac{b^2 - a^2}{2k}$$

so that

$$b \simeq \sqrt{(2kL + a^2)}$$

When b is large compared with a and k--i.e., in the very largest libraries--then roughly

$$L \simeq \frac{b^2}{2k}$$

so that

$$b \simeq \sqrt{2kL}$$

In the present case, $k = \frac{1}{17}$ and $a = 5$.

As a result the first turn of the spiral would be 37.75 meters long and hold 9,060 books in a single row, or 18,120 in a double row. A million books would require sixteen turns of the spiral, with a radius of 37 meters. Fifteen million would require sixty-eight turns, with a radius of 140 meters.

Here is a comparison of some representative existing libraries with spiral libraries of the same capacity.[6] (See chart on page 13.)

The essence of the comparison is in the second and third columns of figures. The amount of space a building uses is not just the area it covers but the area it makes unavailable for other use, which is, generally, the rectangle enclosing it. A visual comparison could be made by superimposing the rectangle which encloses the conventional library on the square which encloses the spiral library of equivalent capacity.

In the cases of Shoreditch and Cambridge libraries the spiral library would be smaller than its existing counterpart in all dimensions. Cambridge is a diffuse, long-limbed library. Shoreditch has less capacity than the first turn of the spiral, on the assumption of two rows of boxes in that turn, though if the first turn had only a single row of boxes its capacity would be 9,060, marginally less than that of Shoreditch.

In the cases of Leeds and Maryland the spiral is greater in one dimension than its counterpart and smaller in the other. Leeds would be smaller in area than the spiral, Maryland greater. Leeds is a circular library (though with projections). In the case of Manchester (also circular) the conventional building would be smaller in both dimensions than the spiral. In the case of the Library of Congress, the largest library of them all, there is no direct comparability because the conventional library is in two buildings. If we imagine them placed against each other with their longest sides touching, the spiral library would completely enclose them. Then, however, they would be one building: the area between them, now made unavailable for other buildings, should be considered as part of them.

Library	Number of volumes (capacity)*	Dimensions of a rectangle enclosing the library	Diameter of a spiral library of the same capacity	Maximum radius of the spiral	Length of the spiral	Length of outermost turn of the spiral	Number of turns of the spiral
		in meters					
Shoreditch (branch public)	10,000	18 x 15	11.36	6.18	20.83		.59
[spiral library of one turn]	18,120	—	13	7	37.75		1
Leeds (university)	700,000	70 x 49	60.8	30.9	1,458	188	12.9
Maryland (university)	1,000,000	74 x 36	72.6	36.8	2,083	225	15.9
Manchester (central public)	1,125,000	68 x 64	76.8	38.9	2,344	238	16.9
Cambridge (university)	2,000,000	168 x 112	102.4	51.7	4,167	319	23.3
Library of Congress	5,000,000	142 x 103	281.2	141.1	31,250	880	68
Library of Congress Annex	10,000,000	131 x 77					

* I have assumed that the first turn of the spiral has a double row of boxes like all the rest, not a single row; this is for the sake of simplicity and in order to make the figures for the small sizes comparable with the rest.

The spiral library, in short, a storage space on one floor, consumes roughly the same horizontal space as some and rather more than others of its conventional counterparts, which are buildings on many floors. The capacity of the spiral library may really be much greater since a proportion of its books will be in the display sector above it. Incidentally the compactness of the spiral would take effect increasingly in the very largest sizes, larger than any library today, because at such sizes the addition of an extra turn (more than half a mile long) would house more than half a million books and yet would add only two meters to the radius.

It should be remembered that compactness in a library is desirable not only, or even not so much, for the sake of saving land as for the accessibility of books. Compactness does not serve this purpose directly: to compress the library beyond a certain point may make the books less accessible. (An obvious example is when shelves have to be swung out to get at others behind them. Manchester Central Library, the most compact in the list above, has very low accessibility.) If we balance the requirements 1) that as little horizontal space should be used as possible and 2) that books should be as accessible as possible, we might then assign them weight in the proportion of about 40:60. This is probably satisfied by the spiral library. It is not the most compact: it is merely compact enough. On the other hand, it may be the most accessible.

Accessibility

Since the storage library is either below the surface of the ground or on a level with it, users and staff would enter and move about the building on the floor above. From this floor the staff can descend into the plane below wherever they need to. The spiral corridor is like the spiral groove of a phonograph record, onto which the needle can descend at any point, whereas a point on a recording tape can be reached only by traversing all of the spiral before it.

To get a book asked for by a user, an assistant travels along a radius of the library (a straight line), descends seven feet in an elevator, and walks along part of the curving corridor. To get to the furthest book in a library of even 15 million volumes the distance along the radius would be, as we have seen, not more than 140 meters, and the distance along the corridor perhaps 20 meters; in comparison, 160 meters is a common enough distance to walk in a conventional library of only 1 million volumes. The journey in the spiral library compares favorably not only in distance but also in simplicity with those which the assistant would make in a rambling library on many floors, where corners must be turned, steps climbed, doors opened or even unlocked, readers competed with, and (in certain libraries) bookcases pulled out on hinges or rails.

In practice, of course, books would be called for by speaking tube, telephone or closed-circuit television; they would be sent along the spiral conveyer or, if needed immediately, by compressed air tube across the upper floor. Such devices of communication would be very simple to fit into a radial plan (the upper floor of the spiral library is radial) and would all travel along straight lines.

This high accessibility of the spiral library would be almost evenly spread, without peaks of accessibility (shelves at the fingertips) or troughs of obscurity (locked cubbyholes devious miles away). In fact a map could easily be drawn showing contours of accessibility in minutes from the central counter, and would show them falling off evenly but slowly from the center and from the other points of entrance.

(Such a map could be useful for answering users' questions as to how long they must wait for books. It would be less possible to draw for a library with storage on more floors than one.) If gaps for expansion are left between boxes, they can be left in the parts of each turn of the spiral furthest from these points of entrance.

In the spiral sector below, radial corridors could be opened at any moment by pressing a button which raises all the book lifts, or they could be left open all the time by leaving the book lifts at ceiling level until they are needed below.

Boxes, etc.

If the library's materials have to be sent elsewhere, each box has only to be fitted with a front to become a packing case (with or without wheels, as is convenient in the different stages of transport). All books inside it fit it to within one centimeter.

Since books are in boxes which are exactly the right depth for them, their fronts are automatically aligned. There are no spaces behind them which could collect dust or into which books could fall. Similarly there is no space above them--or never more than 9 millimeters--to allow dust to settle on their tops.

Incidentally dust, heat, damp and other sources of harm that enter through windows and outside walls are kept to a minimum. There are no windows to the storage floor, and the outside wall is of almost minimum length in proportion to the area (the absolute minimum, a perfect circle, being 2 meters shorter).

When a library with fixed shelves is being repainted the top two shelves of any range that approaches the ceiling and all the shelves of any range that is against a wall must be cleared. The contents of these shelves must be temporarily absorbed elsewhere. The contents of the other shelves must be laboriously dust-sheeted, and yet never escape a few splashes of paint. This disruption, however rarely it occurs, is sufficiently fearful to be worth special measures. In a spiral library, each box will simply be rolled aside while the surfaces it obstructs are painted.

As there are no books below the concrete ledge, all books are within reach of a person standing; he does not need to stoop. Nevertheless, the meter allowed for the corridor is greater than the usual width of corridors between shelving.

Each box, since it contains books of only one size class, can be permanently labeled with a size mark. In early libraries, each press (vertical division of the shelving) had its painted title such as "XVI--Sacred History," and then the press mark XVI was stamped on each book supposed to be in that press. This was an inflexible system, as people found when they wanted to move a book to press XVII. Location marks came to refer to subject classes, and to be dissociated from physical locations, so that books marked 398.2 were spread over shelves or groups of shelves numbered on a quite different system or not numbered at all. But in the spiral library location marks are divorced from subject and can again, as in the old press and press mark system, be associated with permanent physical places, so that a box marked 18 11 contains books also marked 18 11.

Boxes of the narrower sizes may need to be made more stable by means of a widened base. Since books fill the vertical space between shelves, each shelf

will have to be cut back a centimeter or so to allow access for the finger extracting a book. Though there will be far fewer incompletely filled shelves than in a conventional library, some bookends or springs based on the right hand wall of each shelf will still be needed. A general solution to this problem of holding books in the position best for their storage could be to make the shelves slope upward from left to right. (It is already customary to stand current periodicals on a slope, though in another direction and only one deep.) This solution, however, does not arise specially from the nature of the spiral library--unless the spiral were an upward helix.

Machinery for automatically filing books on the shelves and fetching them therefrom, such as that suggested by Stanley Humenuk,[7] would perhaps fit still better into the spiral library than into the cubic one which Humenuk envisages. In his plan the books must be transported in three directions: upward to the right floor, along to the right range, and along the range to the right position. These would be reduced to a movement along the single range which is the spiral library.

Expandability

A spiral building can be built indefinitely outward as it fills.

Articles on library design regularly contain a statement that space should be allowed for thirty years' intake, or that space has (in the particular example) been allowed for twenty years' intake--only the figures vary. Yet everyone knows that after twenty, thirty or any other number of years the books are not going to stop coming; in fact, they are going to come faster. The output of literature is doubling every twenty or fifteen years (faster than world population, which is currently estimated to be doubling every thirty-five years).

It was said in 1964 that libraries ought to double their capacity by 1970,[8] but obviously they have not. What they have done up to now is to reproduce. When it was completed in 1897, the Library of Congress was the largest library building in the world; but by 1928, an annex of twice the capacity had to be begun. Such a story cannot have an end. Conventional libraries can add bits to themselves, up to a point; if there is space, a new block can be built nearby; if they are trapped in the centers of large cities, as most major libraries are, they must eventually acquire storage extensions many miles away, like those of the Bibliothèque Nationale at Versailles and the London University Library at Egham. All of these are great upheavals; the results of all are awkward and the gains temporary.

The only real answer is an expandable building. But to be expandable a building either must consist of movable parts or must possess, like the chambered nautilus, a structure which remains the same when added to. So far neither kind of library building exists. Buildings of modular plan contain movable internal parts, but have immovable perimeters. The only structures of the second kind I can think of are the straight line, the indefinitely high tower, the pillared hall or grid of indefinite expanse without any bounding wall, the concentric circles or semicircles or other concentric outlines, and the spiral.[9]

It is interesting to notice that a circular building, though at first glance diverging little from the spiral and though also a very compact shape, is at the opposite extreme from the spiral in this matter of expandability. Whereas the

spiral has a perpetually open end, the circle is absolutely closed, so that any addition is a glaring detraction from its shape. A circle could be expanded (retaining its shape) only by having another shell of the same shape thrown around it; but this is impossible because the absolutely closed nature of the circle is usually expressed architecturally in a very final outer crust. The circular building stands typically on an island site in a city and is built to fill it once and for all; the spiral would be most suitably begun in an American desert, or at any rate, like the British National Lending Library, in open country.

A trial library on a spiral plan can be built to a small scale. One turn, for example, would form a small one-room library with a side door, and would like Shoreditch Branch Public Library contain about 10,000 books. If it proves workable, it can then be expanded until it grows at last great enough to house a World Deposit Library. Among the lesser items of expense saved by an expandable building is its own scale model!

Adding a length of corridor, short or long, would be a simple operation that would involve extending one wall of the corridor, and extending the roof across to it--the other wall will already be in place. Even the slightest need will justify adding a length because even the shortest section will be easy and cheap to build in proportion to its shortness. This operation is not comparable to the convulsion of adding a new wing, floor or basement to a conventional building. It is more like adding a small lean-to. In fact the spiral building is a kind of total lean-to, perpetually leaning against itself.

One reason for having a wall rather than a line of pillars is that each stretch of wall may have to begin its life as the outer wall of the building--although an outer skin wall could be added and moved--but other reasons are that pillars would be more expensive than a wall of brick and, if alterations are ever planned, they could not be moved, whereas a wall can be pierced at any point. Pillars might, however, be used in all the inner turns of the spiral built in the first stage.

The spiral, incidentally, could be a false spiral consisting not of a constantly expanding curve but of a series of linked semicircles of increasing radius based on alternate centers; or it could be a "square spiral" consisting of a series of straight lines of increasing length joined at right angles, though the corners would have to be rounded if the bookcases were to move on rails. Either shape would simplify the calculations and the drawings and laying out of the building (Figure 1 above actually shows the false spiral).

The spiral library directly expresses its own capacity. Conventional buildings of all miscellaneous shapes may appear large when their capacity is small and vice versa (the Library of Congress annex covers a smaller area than the main building yet has twice the capacity); in fact there are so many variables that the capacity is just not something that can be judged by eye or expressed by simple dimensions. The extreme example is perhaps the British Museum Library, an institution so complex and so intertwined with its surroundings that there is really no way of stating either its size or its capacity. The capacity of a spiral library, however, is stated when one of its dimensions--radius, diameter, length, or number of turns--has been stated: all 6-turn libraries, for example, are equivalent. The actual fullness of a conventional library is also very tedious to assess: some parts look dense while others are sparse, because space for expansion is scattered irregularly throughout the rooms and floors. In a spiral library all the room for expansion is at the end, so that the degree of

fulness of the library and the actual quantity of materials is stated when the length filled is stated. Spiral libraries would be directly comparable with each other in all these statistics; conventional buildings would not, even if they were all of the same non-spiral shape.

Internal Appearance

The appearance of the space at the heart of the spiral will not be unimpressive. Variations are possible. For instance the main point of entrance could be at the spiral's center instead of its start, the elevator if hydraulically operated could be circular, and the staircase around it could be a double spiral so that the second stair on the same shaft would lead the public to cloakrooms in a basement without their being able to set foot on the storage floor. However, with the form originally suggested, the central space is open to the upper floor (see Figure 3). Either the counter surrounds this pool-like feature, or the public can come to a railing and look down into it. It is on average 11 meters (36 feet) across; it could be larger and could be used for display or as a lecture theatre, perhaps with the mid-landing of the stairs as rostrum. Stairs and elevator debouch in the first reach of the corridor, next to the terminus of the conveyers and in front of the first booklift (or transverse corridor).

As a visitor descends the open stair he sees ranged all around the walls the largest items in the library's possession--maps, pictures, genealogies, as well as the more lavish books. They amount to as much stock as there is in a small public library. On closer view it is seen that the wall is not a wall, since there are some glimpses past the books into a surrounding corridor. The room is apparently circular, but at one point the line of books disappears behind itself. This is the beginning of the sole corridor of which the rest of the library consists--whether the building is fifteen meters across or three hundred. Underneath the books on the ledge is a line of books coming in along the conveyer and accumulating around the skirts of the room. Just visible at the beginning of the corridor is the other conveyer, on which books are put to be ferried away into the outer parts of the library.

Imaginatively this room might feel somewhat like a clearing in the midpoint of a mysterious forest of books--mysterious because the spiral is a geometric form that never quite comes to seem axiomatic; the mind does not master it securely enough not to have to ponder it again. Thus at each visit one might be struck by the fact that, although the farthest point of the building is only 140 meters away, the corridor which sets out to reach it takes 31 1/4 kilometers to do so, passing behind one's back sixty-eight times on its way.

This spiral motif, by imposing such thorough unity on the library and by making it so strikingly different from other buildings, entails what seems to be a drawback; even if it were the best possible building, people might be loath to build it twice. A tour de force without room for followers becomes an isolated experiment, a freak, instead of an addition to the continuing stock of possible solutions. But this is to forget that the spiral element is not the whole building. It is only the one-story pedestal to the rest--an element so low and dull to the external view that the building as a whole need not appear spiral at all.

Superstructure

The spiral storage library is a low flat disc. Any sort of superstructure can be set on top of it.

The superstructure need not occupy as much area as the disc beneath. The disc could be a basement, so that the part of its ceiling extending beyond the superstructure would be a pavement flush with the surrounding soil; or the disc could be the ground floor, so that its extending fringe appears from outside as a terrace sweeping all around the superstructure's base. One set of steps from the terrrace would close the present end of the corridor beneath and would be moved forward as the corridor is extended. Elsewhere bridges would carry the exits from the radial avenues of the floor above the spiral. The ledge already in place around the outer wall of the building, half a meter wide and high, would form a capacious outdoor bench--with a roof cantilevered over it, since the concrete slabs roofing the corridor would probably have to be centered over the supporting walls rather than resting between them.

The flat disc-shaped ceiling of the windowless storage library, flush with ground level or at most seven feet above it, could be a thick and bombproof layer. It is as safe to discount future warlike explosions as to ignore the information explosion; and the largest reservoirs of human knowledge should be higher on the list of priorities for protection than at least some other inanimate things.

On a disc-shaped platform supported by a maze of walls at two-meter invervals, a superstructure of any plan could be imposed. But I imagine that an architect would welcome the novel and fruitful exercise of incorporating some of the spiral curves of the substructure into his designs above. If the building were based on the false spiral of widening semicircles, then the range of patterns derived from two sets of concentric circles with slightly different centers would be available.

The administrative floor immediately above the spiral substructure might contain no internal walls, but only pillars standing over points of the spiral below, so that the view sweeps over the surface of the spiral realm below and its accessibility at all points is dramatized. The distances between pillars on adjacent turns of the spiral would all be 2 meters, so that movable modular components--screens, desks, sections of tubes and other conveyers--would fit between them. The non-modular distances along the spiral would not be closed, thus leaving the radial avenues open. Rails and conveyers serving the lift shafts, and pathways for the public, would be laid along these radial avenues. The public, following their segregated routes, would still be able to watch the operations of the library taking place in all parts of the hypostyle hall--no storage shelves in sight, yet books emerging from the openings which punctuate the floor and being carried here and there mechanically.

The superstructure need not contain only the non-storage sectors of the library; they could be merely a fraction of it. There could be room in the building for restaurants, theatres, researchers' rooms, and even squash courts (which I have often felt are much needed by the sessile and cerebral inmates of libraries); on the terrace outside there could be gardens. The public displays of museum, art gallery and library could merge above while their storage is merged below, as already suggested. Commercial and other buildings could incorporate their own libraries in disc-like basements--an arrangement symbolic (in a trite sort of way) of the basal relation of knowledge to other enterprises. If the library were a World Deposit Library, there would be nothing inappropriate in its supporting United Nations buildings.

In summary, by solving the requirements of the storage library in strict isolation we begin to be rewarded both with strong clues as to how other sectors could be added to it, and with great freedom in the design of those sectors.

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