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THE EVOLUTION OF PREFABRICATED INTERIOR COMPONENTS FOR POST-OCCUPANCY MODIFICATION

A Thesis Submitted
to the Faculty of Graduate Studies and Research
in Partial Fulfillment of the Requirement
for the Degree of Master of Architecture

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ABSTRACT

In recent years, home modification has played an increasingly important role in the housing industry. Expenditures on renovation have consistently exceeded those spent on new home construction during the 1990s. And it has huge potential to continuously increase in the years to come. Renovators' do-it-yourself activities are efficient ways to fulfill homeowners' psychological and physical needs and save expensive labour costs.

This research investigates not only the technology evolution of ten products and the installation processes that are frequently used by renovators, but also the fundamental reasons that drive the development of these innovations. It covers the technology from the beginning of this century to the latest innovations developed by manufactures in the 1990s. Additionally, it documents recent national and Quebec renovation market trends, together with three post-occupancy studies which had been conducted in the Montreal Area.

The study reveals that many of the products and installation process have been greatly simplified and innovations in the renovation market could benefit renovators by allowing them to undertake modifications themselves. Also, the author suggests certain guidelines for increasing housing affordability and new products development.

RÉSUMÉ

Au cours des dernières années, les rénovations pratiquées dans le secteur résidentiel ont occupé un rôle majeur dans l'industrie du logement. On a noté que, pendant les années dix neuf cent quatre-vingt-dix, les investissements consacrés aux rénovations de maisons déjà existantes excédaient ceux dédiés à la construction de nouvelles maisons. Cette ascension est appelée a continuer dans les prochaines années. C'est pourquoi le type de rénovations ayant la capacité d'être exécutées par les propriétaires mêmes consistent en une manière efficace de sastisfaire les besoins physiques et psycologiques des propriétaires. Et ce, tout en leur permettant d'épargner de larges sommes d'argent qui seraient autrement destinées à la main-d'oeuvre.

Cette recherche examine non seulement l'évolution technologique de dix produits et des processus d'installation fréquemment utilisés par les rénovateurs, mais aussi les raisons fondamentales poussant le développement de ces innovations. Elle couvre la technologie datant du début du siècle jusqu'à nos jours. En supplément, elle montre les tendances récemment retrouvées dans le marché national et québécois Trois études de cas conduites dans la région de Montréal, pour lesquelles les rénovations ont pris place après l'occupation des résidences par leurs propriétaires, complémentent aussi ce travail.

L'étude révèle que de nombreux produits ainsi que leurs processus d'installation ont été grandement simplifiés. Elle démontre aussi que des innovations dans le marché de la rénovation pourraient être bénéfiques pour les rénovateurs puisqu'elles leur permettraient de prendre eux-mêmes en main les restaurations. Aussi, l'auteur suggère certaines lignes de conduites afin de rendre les maisons plus abordables et d'améliorer le développement de nouveaux produits.

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CHAPTER ONE: INTRODUCTION

Due to recent economic and socio-demographic changes, housing renovation has become increasingly important as an effective way to adapt to variations in family composition and financial situation. According to a survey by the Canadian Mortgage and Housing Corporation (CMHC), during the 1990s expenditures on renovation have constantly exceeded expenditures on new home construction (CMHC, 1996). Furthermore, CMHC predicts that the importance of renovation will continue to increase in years to come. Home modifications not only fulfill homeowner's psychological and physical needs, but can also contribute to significant savings with respect to moving costs.

Traditionally, interior modifications were the domain of professional contractors with special tools and specific knowledge to handle the complicated process. Many households had to compromise because of the high expense and complications of dealing with those contractors. Today, many innovative quality prefabricated infill components have been produced by manufacturers and, at the same time, sophisticated tools have been invented, greatly facilitating the homeowners' participation in their home renovation. In this research, the author intends to document the evolution of several interior home improvement components and technologies that facilitate user participation.

In this introductory chapter the author will present the rationale for the study, define innovation, state the research question, and the methodology used, as well as the study's scope. It will be followed by a relevant literature review in the second chapter.

1.1 DEFINITION OF INNOVATION

An innovation can be recognized as such whenever it is perceived by renovators as something new. The idea may have a long history, but still be an innovation to the renovator himself. In this regard, there are certainly still renovators who rely on contractors because they lack knowledge about the innovations mentioned in this research. Innovations take time to become well-known through the media and in society. The process of new product adoption commonly moves through five stages: awareness, interest, evaluation, trial and adoption. Successful innovation is that which is adopted and used regularly by home renovators.

Some products are adopted immediately, while others take a long time to earn acceptance. Success depends on several conditions. The first is that the innovation must have an advantage over the existing product. The greater the relative advantage renovators can perceive in using the new product, the faster the product will be adopted. For example, BOWPEX pipes offer flexibility in the arrangement of bathrooms and kitchens and it is much easier to cut and connect, therefore, this product has a high relative advantage. The second condition is that the innovation must be easy to understand and use. Complicated operating processes dissuade many renovators from taking risks. For instance, before the invention of PVC pipes, piping was the kind of work most renovators would rather hire someone to do. The third condition is that the innovation must be compatible with the lifestyle of renovators. Quebec, for example, has the highest proportion of renovators per number of households, because of the higher unemployment rate and the more leisurely pace of life, which is rooted in the local

culture. The last condition is that the innovation must have benefits which are observable and describable to others. The painting roller is easy to operate and can reach ceilings and corners without the use of ladders. This easily-explainable advantage helped this product to gain immediate popularity.

1.2 RATIONALE FOR THE STUDY

Home improvement plays an enormously important role in the housing industry and also in people's daily lives. It is an effective means to accommodate changes arising from the household's socio-economic circumstances and fluctuations in housing prices and other external influences, such as public decisions relating to land use or transportation. Society has undergone fundamental socio-demographic changes over the course of the last five decades, and the result has been a radical shift in the way people live and form households, work and enjoy their leisure, grow old and die.

Households of all types – both family and non-family undergo numerous changes in composition as they move from stage to stage in their evolving life cycles. No household is a static entity over the course of its life span. As Friedman et al. (1996) have described:

> New numbers are added through birth or a change in relationship; Children manifest shifting needs as they grow older and then eventually move out to form households of their own; members depart through separation, divorce or death; some households dissolve altogether, fragmenting to form new associations and domestic arrangements elsewhere.

In order to accommodate fluctuation in today's households as their situations change, people have to choose between moving or home improvement. Some people will choose

to alter their houses because of the high cost of moving or because they just do not want to undergo the psychological challenge of changing residence.

Even for people who stay at the same house, few will be satisfied with their dwelling over a long term. Since home builders supply mass housing projects which are designed without taking into consideration the specific priorities and personal expectations of each home owner, normally the houses do not have enough flexibility to enable homeowners to easily adapt them to their personal choices and particular requirements (Friedman, 1991).

At some point in time, a household may desire some additional or different features (e.g. ceilings, storage places, flooring or wiring) which are not provided by the current dwelling, indicating a gap between the actual and the preferred level of housing assumption (Seek, 1983). There may be several reasons for this gap. First is a change in the household's family make-up; when the composition of a household varies, the function and space of each part of the house will be different. An adjustment is therefore necessary to meet the needs of a changed household. The second reason is a change in the household's financial situation. When a homeowner has an increase in financial resources that are not adequate for moving to a new dwelling, home improvement becomes an optimum option for improving the quality of the household's life. The third reason is the household's change in taste and preferences and the last reason is outside factors, such as housing price variations or public decisions related to land use or transportation.

1.2.1 National Renovation Market

A census presenting the renovation industry in economic terms from Canada Mortgage and Housing Corporation (CMHC) and Statistics Canada shows that while in 1997 renovation spending increased 9.4 percent compared to that of 1996, renovation expenditure in 1998 will increase to $23.4 billion, which means another 6.7 percent increase compared to 1997 (Fig. 1.1). This number account for more than half of the total spending on residential construction and it is the eighth time that renovation spending surpassed new construction since 1991.

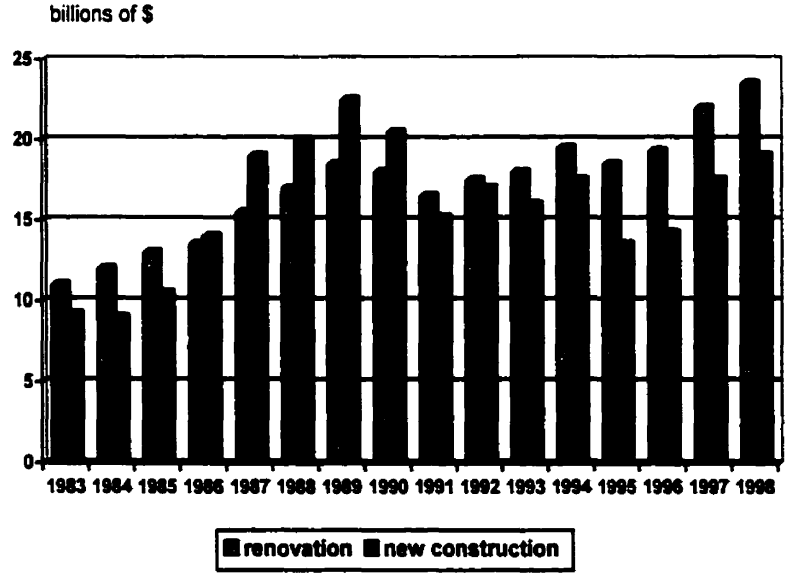


Fig. 1.1 The expenditure on renovation has been consistently higher in the 1990s than that of new construction. (Source: CMHC, 1997)

Three in four households spent money on renovation. Two thirds (12.0 billion) of the total homeowner expenditure is estimated for contracted work and other hired labor, compared with one third ($6.0 billion) for separately purchased materials (CMHC, 1996). Another Statistics Canada report, *The Size of the Underground Economy in Canada*, states that contract work could be underestimated by twenty percent and that "the underground transactions related to home renovations possibly escaping measurement in the official GDP could be up to $1695 million in 1992"(CMHC, 1996).

A 1993 study conducted by DRI Canada and McGraw-Hill states that "in 1992, real residential investment expenditures were $32.8 billion at 1986 prices, which represented 5.9 percent of real Gross Domestic Product." The study finds that "about 30 person years of employment are created for each million dollars of new residential investment, and that 1.5 million dollars of GDP (mostly in wages and profits) are also created for each million dollars of new residential spending. The residential renovation industry is growing at twice the rate of new construction and creating (dollar for dollar) jobs at more than twice the rate of new construction." In 1992, Clayton Research Associate projected that the size of the residential renovation industry would increase to more than $20 billion by the year 2001.

How do homeowners spend their renovation dollars? Homeowner renovation can be divided into five categories: renovation and alterations, structural additions, repairs and maintenance, replacement of equipment, and new installations. According to the Statistics Canada survey of recent years, renovations and alterations account for the largest category.

Renovation and alteration are defined as work done that was intended to upgrade the property, rearrange the interior space or modernize existing facilities. It includes jobs such as remodeling rooms, adding or replacing doors and windows, renovating exterior walls and upgrading insulation. Repairs, replacement and maintenance mean expenditures made on existing structures or pieces of equipment to keep them in good working condition and appearance so as to maintain them in as new a condition as possible. This category also includes repairs done to broken, damaged or malfunctioning components of the structure or equipment. New installations include the installation of equipment which did not previously exist on the property, or which was installed as an addition to the equipment on the property (CMHC, 1994). In 1994, renovation and alteration represented the largest portion of renovation expenditures (Fig. 1.2). Canada Mortgage and Housing Corporation's publication *National Renovation*

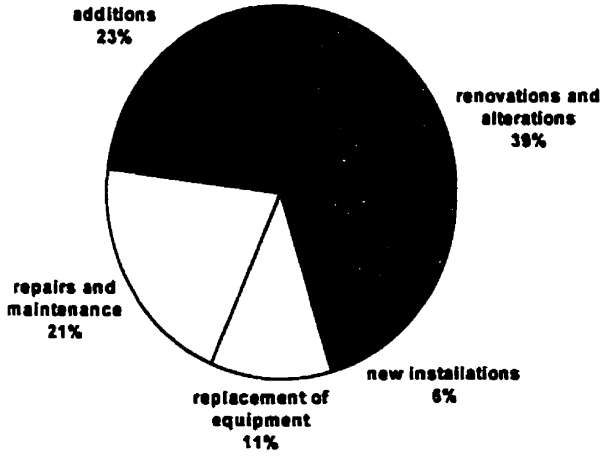


Fig. 1.2 Where the homeowner renovation dollar goes.
(Source: CMHC, 1994)

Markets 1995 has a section which reports on the top 10 renovation jobs in 1992, presented in Table 1.1.

RANK	AGGREGATE EXPENDITURE ($ MILLIONS)
Renovation—interior only	2523
Structural extensions	1433
Renovation—both exterior and interior	1376
Renovation—exterior only	998
Heating and air condition	827
Outdoor patios, fences, driveways and in-ground swimming pools	736
Roofing—complete or partial	735
Painting—interior and exterior	656
Hard surface flooring and carpeting	648
Plumbing	464

Table 1.1 Top ten renovation jobs in 1992 as listed by CMHC (Source: CMHC, 1994)

In the 1990s, the contract business (which is defined as including both material and labor) has started to drop in value in the renovation industry. The main reason for this drop is assumed to be quality prefabricated do-it-yourself materials. With the development of contemporary technology, these infill components have become extremely easy for homeowners to assemble by themselves. Tools used for renovations are relatively easy to operate compared to earlier equipment. Thus, by using do-it-yourself methods, households can not only save on renovation expenditures, but they can also obtain satisfying quality and style.

In 1991, national contract work covered two thirds of the renovation dollar while the other third was done by homeowners. But since 1994, the contractor's business has continually decreased while the do-it-yourself expenditure has increased (Fig. 1.3).

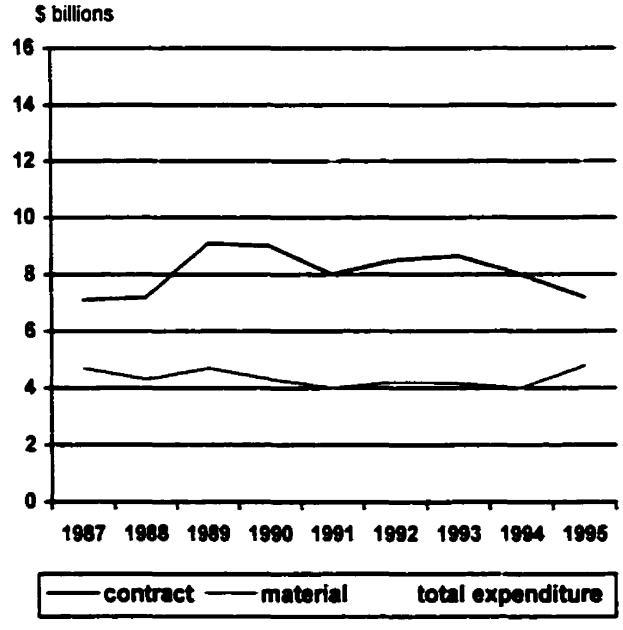


Fig. 1.3 Total expenditure on housing renovation. (Source CMHC, 1995)

CMHC's Market Analysis Center predicts that the residential renovation industry will expand with an improving economy, a recovery in housing markets and somewhat higher costs for renovation projects. The momentum of economic recovery and an improved job market will boost consumer income, confidence and spending (CMHC, 1996).

1.2.2 Quebec Renovation Market

In Quebec, renovation spending has exceeded new construction spending since 1992. In 1997 and 1998, spending on residential renovation has grown to twice the amount spent on new construction. Although residential renovation spending reached 5.5 billion in 1997, it kept on increasing to 6.0 billion in 1998 (Fig. 1.4). Over the last decade, renovation has represented between 50 and 70 percent of residential construction

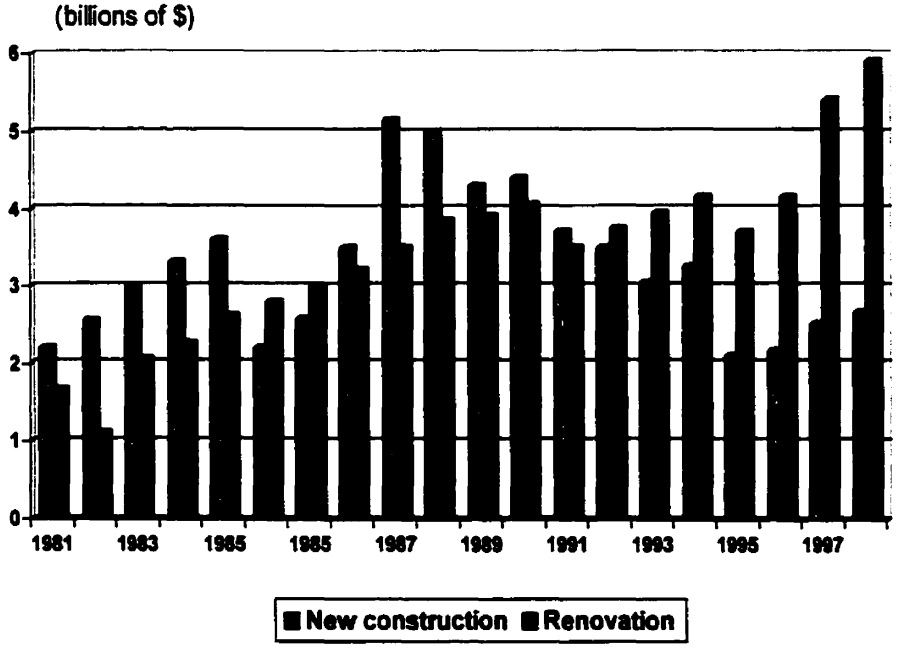


Fig. 1. 4 Renovation spending in Quebec. (Source: CMHC, 1998)

spending. Over the business cycle, renovation has shown greater stability than new construction. Consequently, the proportion of renovation work in relation to total residential activity has a strong tendency to increase (CMHC, 1998). 1.6 million households in Quebec spent 5.9 billion on renovation in 1998, which

represents 71.5 percent of the national renovation spending. Over 70 percent of households in Quebec participated in the renovation industry each year since 1990 (Fig. 1.5), while in other provinces the percentage was from 73 to 77. The average spending of these households is $3191, while the figure is $3082 in Ontario, $2455 in British Columbia, $2306 in the Atlantic region and $2199 in the Prairies. Renovations and modifications account for the largest field of expenditure in home improvement. Table 1.2 shows the renovation expenditures of Quebec renovators.

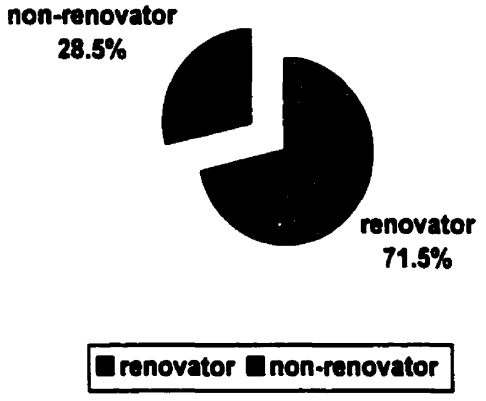


Figure 1.5 Percentage of people who renovate.
(Source: CMHC, 1998)

Addition and improvement	3000 $	30.8 %
Renovations and modification	3724 $	38.2 %
Replacing new equipment	2363 $	24.2 %
Repair and maintenance	662 $	6.8 %
average	3191 $	

Table 1.2 Average spending of renovators.
(Source: CMHC, 1998)

The contractor, however, received only one-fourth of renovation jobs in 1998 while 75 percent of the jobs were done by the users themselves (CMHC, 1998). In 1990, just 32 percent of renovators participated in the renovation work. This is a concurrent trend with the increase in renovation expenditures. The CMHC's intensive survey in 1991 (Fig. 1.6) specified Quebec's top 10 renovation jobs by order of expenditure amount.

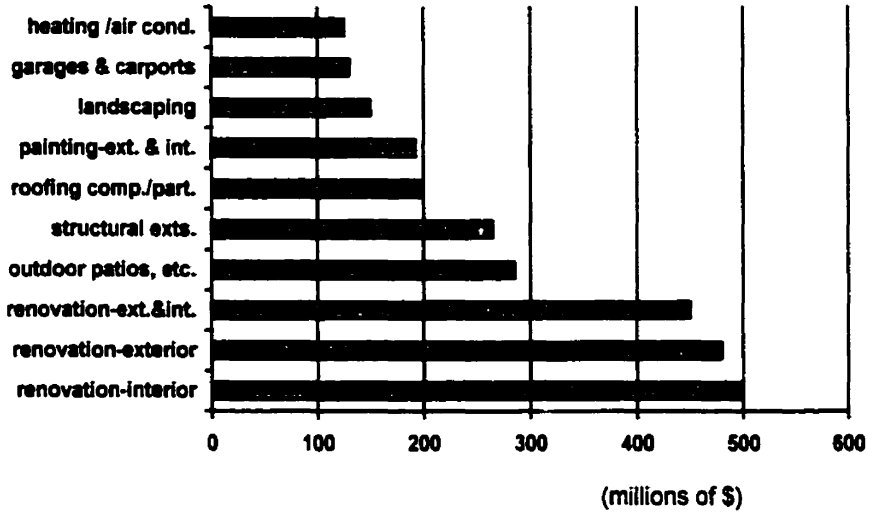


Fig. 1. 6 Top ten renovation jobs in 1990.
(Source: CMHC, 1993)

Housing market trends have been changed during the 1990s. Renovation has become the main player instead of new stock construction. Moreover, interior renovation and alteration cover the largest part of renovation activity in the statistics of both Quebec and Canada. In fact, in almost all parts of Canada, the interior is the place where households spend most of their renovation dollar. Contractors' business is being replaced

by home renovators' do-it-yourself activities. The tendency is even stronger in Quebec. Therefore, it is necessary to find components and technology improvements that homeowners can use in their post-occupancy modifications.

1.3 RESEARCH QUESTION

In order to encourage people to participate in interior housing renovation, it is important to have a better understanding of products and their technological evolution. This understanding can also inspire manufacturers and help them to find out the breakthrough point of new product development. Therefore, the central question of this research could be posed as follows:

How have the technology and installation processes of certain interior components been evolved and improved for home renovators?

1.4 OBJECTIVES

The specific objectives of the research are:

1. To examine the relevant documents and statistics related to renovation expenditures tendencies.
2. To study and understand theories, motives and practices of user's participation in home modification.
3. To document the innovations in certain interior renovation components of each period throughout the century and to determine the factors which drive these innovations.

4. To find out and document the latest technologies and products that can facilitate renovators' post-occupancy interventions.

1.5 SCOPE AND LIMITATIONS

Housing renovation is a vast and diverse field. In broad terms, it includes interior and exterior categories. Each category also contains different sub-categories. However, this research will concentrate on several interior components that will be selected by certain criteria.

The author will document the history of selected products, tools and main procedures used in interior housing modification; the latest products will be documented based on the product literature. For obvious reasons, it is beyond the scope of the present research to question the validity and authenticity of various technical statistics offered by the manufacturers. After this exposition, an analysis will be formulated concerning the main factors that drive the innovations, why and how users would benefit from do-it-yourself interventions. Due to time-budget-personnel constrains, codes which affect the technology breakthroughs, also the economic evaluation of products and their benefits are beyond the scope of this research.

1.6 METHODOLOGY

The research will be conducted in three stages:

Stage one:

The author will identify the information and statistics related to the current renovation market. The emphasis will be on the Quebec market. Through the analysis of these data, the contemporary market trends will be determined.

Stage two:

In this stage, the author will review recent post-occupancy studies in the Montreal region. The work of Pierre Teasdale and Martin Wexler in 1993, Dr. Friedman and Cammalleri's post-occupancy evaluation based on the Grow Home projects and the research of Aurea A. Rios in 1995 will be introduced. Through these direct observations of the modifications performed by the owners, the most popular types of work for home renovators will be identified.

Stage three:

According to analysis of the renovation market and post occupancy studies, the author will determine which target components of interior housing renovation renovators most like to do themselves. Then the evolving history of selected products, related tools and installation processes will be explained and analyzed. By comparing contemporary and obsolete technologies, renovators can understand to what extent these products and technologies facilitate do-it-yourself renovation.

1.7 OUTLINE OF THE THESIS

This thesis includes five chapters. Chapter one is the description of the research subject and the study rationale. At the same time, the research question, investigation scope and objective of the study are also outlined. Finally, the methodology applied to conduct research is also formulated.

The second chapter is the introduction of three recent post-occupancy studies which document different types of modifications that happen during a family's life span.

The third chapter introduces the history of product development and the factors which influence innovations, including the evolving role of the basement and innovations in housing technology. Also, this chapter contains a brief description of the development of the do-it-yourself movement in North America.

The fourth chapter is the investigation of the evolution of 10 interior products chosen by the author. As well, this chapter indicates the most important innovations and analyzes the motivating factors behind these technological improvements through the description of product development history.

The fifth chapter provides concluding observations from the investigation and outlines recommendations for ways that housing can be designed and constructed to allow for user interventions.

CHAPTER TWO: POST-OCCUPANCY ADAPTATION STUDIES

Since World War II, Canadian housing stock has undergone significant change. Much of this change came about through the introduction of new forms of housing: high-rise apartments in the 1960s and townhouse and condominium ownership in the 1970s (Bunting & Kesik-Delfgaauw, 1989). However, over the last decade the investment in renovation of the existing stock has grown rapidly.

Morris & Winter (1975) found that family norms and cultural norms are two criteria used by families to judge their housing conditions. Families evaluate their housing more or less continuously as to whether it is commensurate with cultural norms as they live their daily lives. Family norms may or may not concur with the cultural norms. Thus, the family uses a dynamic process of evaluation of the quality and quantity of its housing environment in terms of a balance between the two norms.

Whenever the family's housing deviates far enough from the norms to significantly reduce housing satisfaction, housing adjustment behaviour (characterized by Morris & Winter as the behaviour of families attempting to meet changing housing needs as they grow and decline) will tend to occur. Residential renovation that includes work intended to upgrade the property to acceptable building or living standards, to rearrange the interior space or to modernize existing facilities is one of the behavioural patterns of housing adjustments.

In order to have a thorough understanding of types of physical and functional changes renovators have made to their dwelling as an adaptation to family dynamics, three regional post-occupancy adaptation studies are reviewed. All the studies were conducted in the Montreal area. The purpose of this chapter is to determine the factors

that instigate the modifications and the types of interior alteration renovators tend to undertake most often. The observations of these reviews guide the author in selecting the products that have been studied in chapter 4.

2.1 NOTRE DAME DE GRACE

In 1993 Teasdale & Wexler studies 10 families in the Notre Dame de Grace neighborhood of Montreal, composed of teenagers and young adults, who had owned and lived in the same single-family dwelling or complex for approximately seventeen years.

They concluded that modifications are motivated by the individual's changing needs. These needs are made up of four categories. The first is elemental need, which involves physiological and physical needs associated with shelter, health and security, such as eating, breathing, being protected from the natural elements (rain, snow, wind). The second is functional need, which includes the need to be able to engage in individual or group activities as effectively as possible, and in light of which certain characteristics of the environment should be given priority, such as the relation between the rooms, the use assigned to the rooms, and the shape of the rooms. The third is psychological need, which consists of the sensory, emotional, symbolic and cognitive levels: at the sensory level, there is the need to control the quality and quantity of immediate stimuli (noise, order); at the emotional level there is the need to experience the pleasure of being in an environment which one deems beautiful, pleasant, aesthetic and stimulating; at the symbolic level there is the need to be able to identify oneself symbolically with a place (territory) which one considers one's own and the need to be able to communicate, using

this place and the objects it contains, with the rest of society; at the cognitive level there is the need to be able to understand, to get one's bearings and to feel at home in one's environment, as well as the need to develop, learn, grow, and to actualize one's total potential in one's environment. The fourth category of need involves the need to have social contacts. The environment can exercise influence on the number and the quality of these social contacts (Teasdale & Wexler, 1993).

According to Teasdale and Wexler's point of view, renovations happened because of external and internal reasons. The external reasons for residential renovation are certain demographic changes (e.g. growth in the number of people living alone, growth in non-family households, increase in the age of the population) as well as certain economic changes (i.e. the increasingly large number of unemployed youth, the impoverishment of elderly people) that are exerting additional pressures on the dwelling.

The internal reasons come from variations inside the family (e.g. the arrival of a baby, losing a parent, the transition from childhood into adulthood, sharing the same dwelling with an adult who is not a member of the same family), which motivate individuals to become aware of new needs concerning their dwelling. These various types of needs, such as needs for privacy, for identification, to be able to personalize one's space, or to have social contacts, also exert pressure on the use of a dwelling's inside space.

As a result, the modification of the dwelling is usually the result of a repetitive process of five stages (Fig. 2.1): becoming aware of one's needs, reflection, identification of the components relevant to the situation and planning the action, action and evaluation.

One example from their case studies shows the modification of a dwelling in order to accommodate the variation of the household (Fig. 2.2). The basement was constructed while the father was unemployed to rent to visitors when his daughter and her spouse returned and lived in the basement bedroom. The following year, the daughter and her husband and child moved out to set up their own home. However, eight years later they

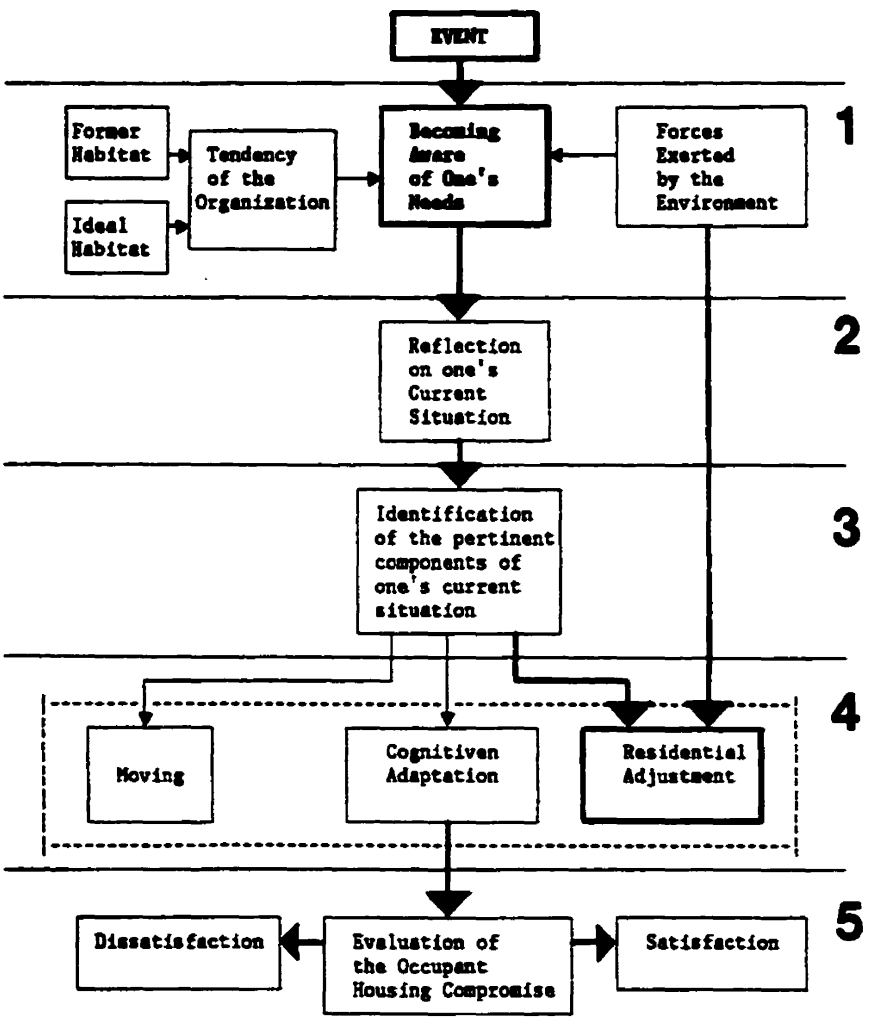


Fig. 2.1 Dynamics of the family, residential adjustments and dwelling adaptability. (Source: Teasdale & Wexler, 1993)

moved back because of financial problems. On their return, the father converted the basement to a complete adjunct apartment, adding an additional bedroom and a kitchen /dining room/living room (in other 3, Fig. 2.2). Five years later still, the daughter and son-in-law divorced, leaving the daughter and granddaughter in possession of the basement apartment.

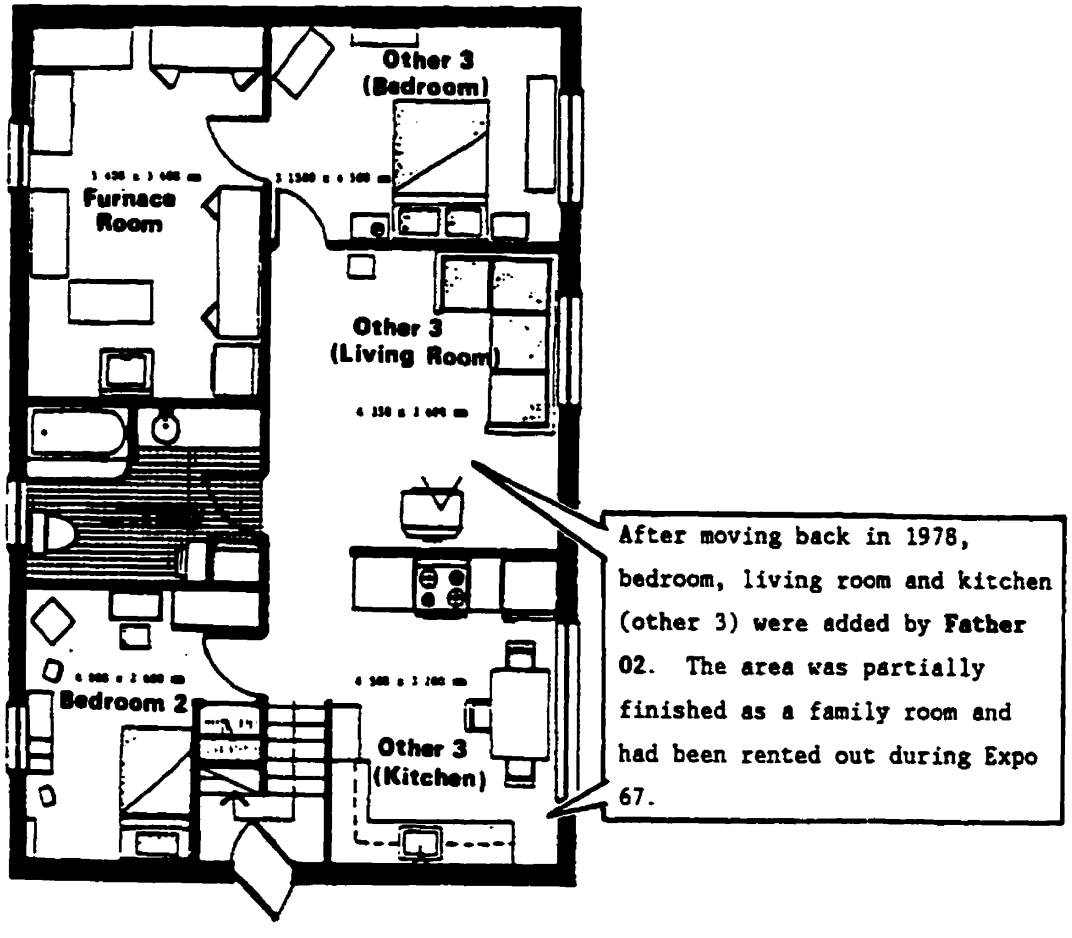


Fig. 2.2 The basement was converted into an adjunct apartment for the daughter and granddaughter. (Source: Teasdale & Wexler, 1993)

In another case (Fig. 2.3), the household expanded the common or collective space after the children had departed. In this household, the son and the eldest daughter both left their parents' home when they grew up and were going to get married. After their departure, the son's bedroom was converted into a family room, a storage area and a cold room to use the space more efficiently; the eldest daughter's bedroom was modified into a den opening onto the kitchen to create more space for the kitchen area.

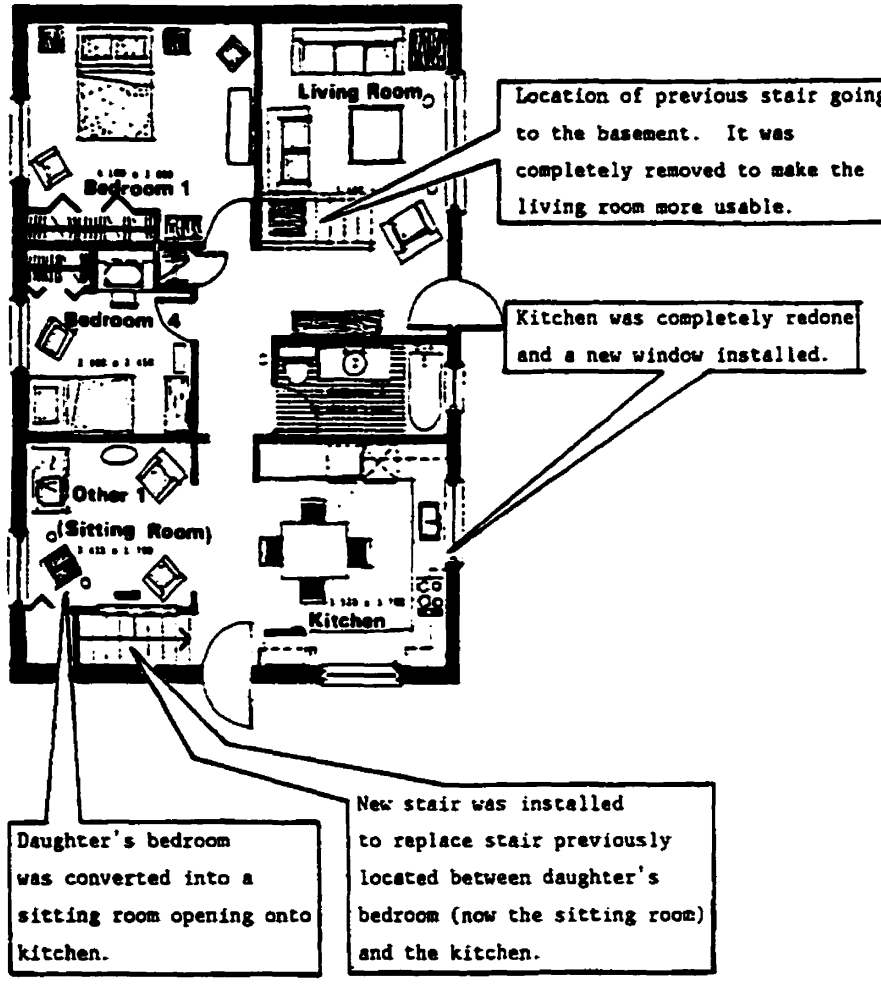


Fig. 2.3 Another example of how residents modified the dwelling. (Source: Teasdale & Wexler, 1993)

These space changes brought about many other alterations: the former stairs to the basement were demolished in order to enlarge the usable space in the living room and a new basement stair was constructed just beside the new den; the kitchen was completely renovated and even the exterior window was replaced to make the kitchen brighter. Furthermore, the departure of the children also led to multiple adjustments to acquire more or different space for the remaining children.

According to the scenarios documented in their research, the most popular modifications that people like to do are furnishing basement rooms with wood, ceramic or vinyl tiles, upgrading or modifying the kitchen, changing the location of the basement stair or its railing/balustrade, installing partitions to create another room, adding woodwork and adding storage place.

The maturing of the younger generation is one of the most important reasons behind a homeowner's modification work. In one case, the departure of grown up children may create some spare bedrooms for the household. To use the space more efficiently, renovators may modify it for other uses, for instance as part of the living room or as storage space. In another case, if the grown up children are not independent enough to live alone, the arrival of their spouse and children would create an urgent need for more livable space. The basement is logically the best place for adaptations to family variations.

2.2 NARROW-FRONT ROW HOUSING

Friedman and Cammalleri (1992) did their post-occupancy evaluation of affordable projects based on the Grow Home concept in 1992. They found that even after only a few months following the projects' construction, significant amounts of work had been done by the occupants. The study found that 39 percent of respondents' basements had already been finished and work had mainly been done in the basement. The most frequent work was drywall for the finishing of the exposed structure ceiling, partitions, electrical wiring, floor finishes, wall finishes, insulation, and rough plumbing.

Furthermore, 83.8 percent of the respondents were planning to do work, 60.8 percent of these planned modifications were to be in the basement, 23 percent on the first floor and 16.1 percent on the second. The most significant modifications planned for the units were found in the basement, where 61.5 percent of the items mentioned were related to major modifications such as an additional play room, toilet, storage place or bedroom. The type of modifications planned for the above-ground floors were quality upgrades and kitchen renovations (Friedman & Cammalleri, 1992).

Rios (1995) did a post-occupancy study of two projects of affordable, single family row houses in Montreal. Approximately 140 units were surveyed and twenty-four thorough interviews were conducted in order to gain a better understanding of the households' housing attitudes and preferences and to observe the kinds of modification performed by the owners.

During the investigation, she found that 88.7 percent of the households had made their first modifications during the first year of occupancy, which indicates that the post-

occupancy adaptation began immediately. The modification happened in almost all the rooms inside the house (Fig. 2.4). One homeowner erected a wood balustrade and added a wood floor in the living room in order to separate it from the dining room (Fig. 2.5); another modernized the kitchen by changing the original closet (Fig. 2.6).

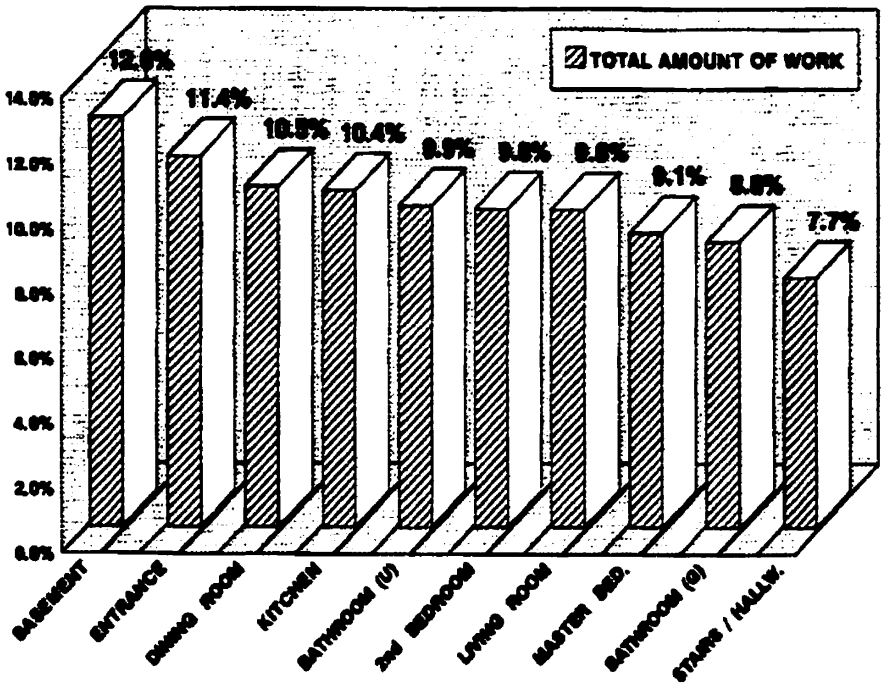


Fig. 2.4 Post-occupancy modifications, by room.
(Source: Rios, 1995)

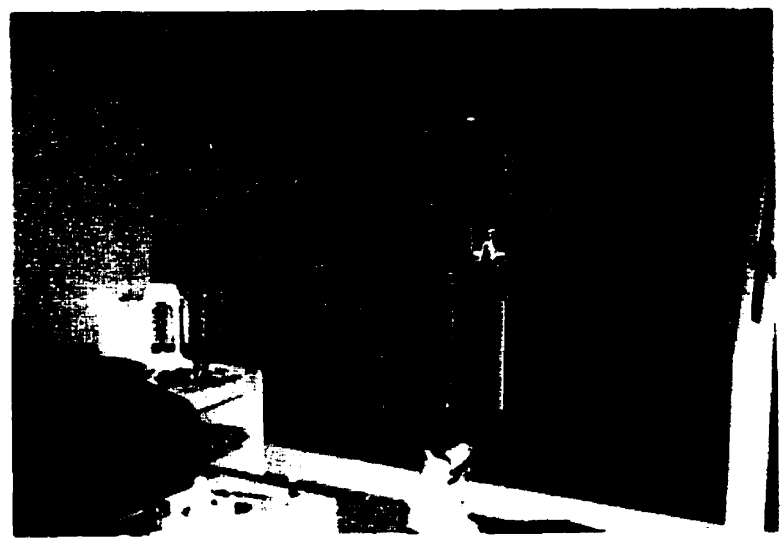


Fig. 2.5 One homeowner erected a wood balustrade and added a wood floor in the living room. (Source: Rios, 1995)

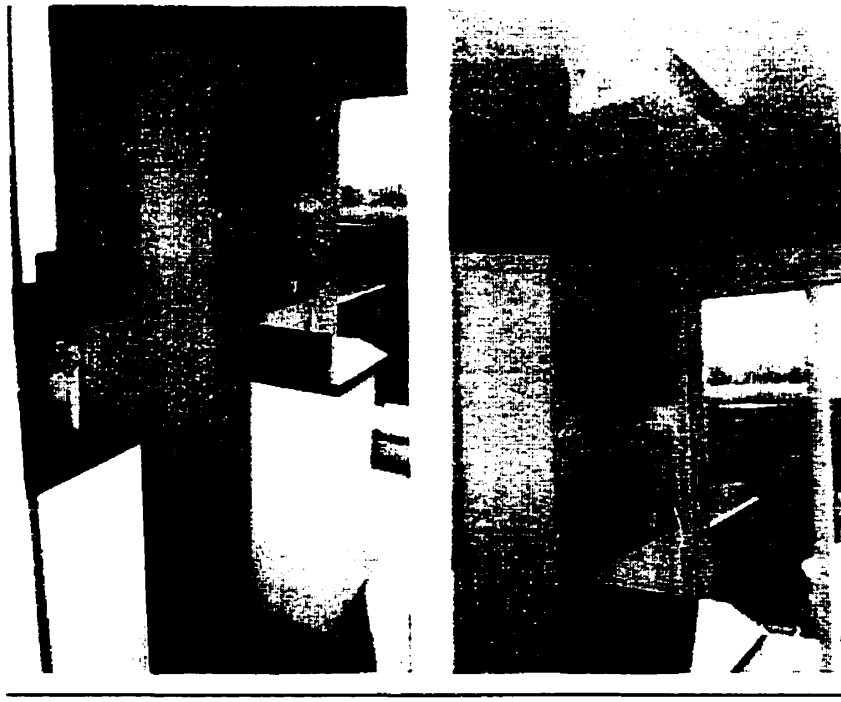


Fig. 2.6 One homeowner's modifications in the kitchen. (Source: Rios, 1995)

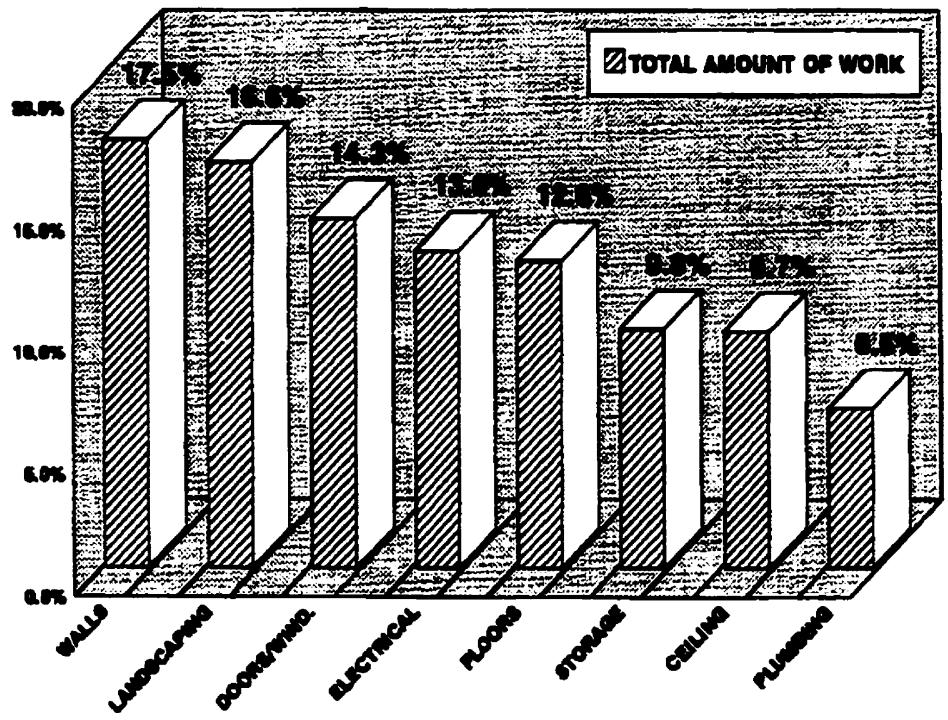


Fig. 2.7 Post-occupancy modifications, by feature.
(Source: Rios, 1995)

If the modifications are arranged by feature, painting, electrical, floors, storage, and ceilings are the most popular kinds of work that occupants like to do inside the house (Fig. 2.7). The reason is not only so that the occupants can differentiate their own house from the others and provide some kind of originality and personalization to the house, but also because the work itself can benefit their daily life. Some homeowners gave up certain modifications like changes in floors and plumbing, even if they were the planned modifications, because these were difficult features to change.

The researcher also found that the most popular place for modifications was the basement. The open, unfinished basement offered the residents sufficient flexibility to fit any kind of need that happened in different periods. Homeowners engaged in basement

modifications because of the need for space and also the need for establishing a separation between formal and informal activities, the desire to upgrade the resale value of the house, and the appearance of the area. They treat it as a way to expand their houses. 76.6 percent of the households finished and adapted the original unfinished basement with drywalling work, partitions, floor finishing, ceilings, or lighting fixtures. Fig. 2.8 illustrates some of the ceilings, flooring, partitions, and staircases that renovators have added to their basement to transform it into a livable place. Fig. 2.9 illustrates the additional storage space renovators have built.

More than half of the residents (56.7 percent) encountered difficulties in making modifications to their houses. Lack of money, lack of skill and lack of time were the typical obstacles that prevented residents from making modifications.

In her conclusion, Rios states that the high participation of residents in the modification of their houses demonstrates that people have a strong tendency to adapt their living environment. Homeowners undertake housing modifications as a way to overcome the failure of their house to fulfil their needs and expectations, and to add the signature of their own personality, providing a degree of originality to the house (Rios, 1995). On the other hand, homeowners are willing to intervene in the arrangement of their spaces because it is an affordable alternative to moving or professional contract renovation.

Rios' study clearly reveals that partition walls, electrical wiring, flooring, storage, ceiling, plumbing and kitchen cabinets are all among the most popular work that renovators like to do. Also, the basement is the place where most of the modification happens.

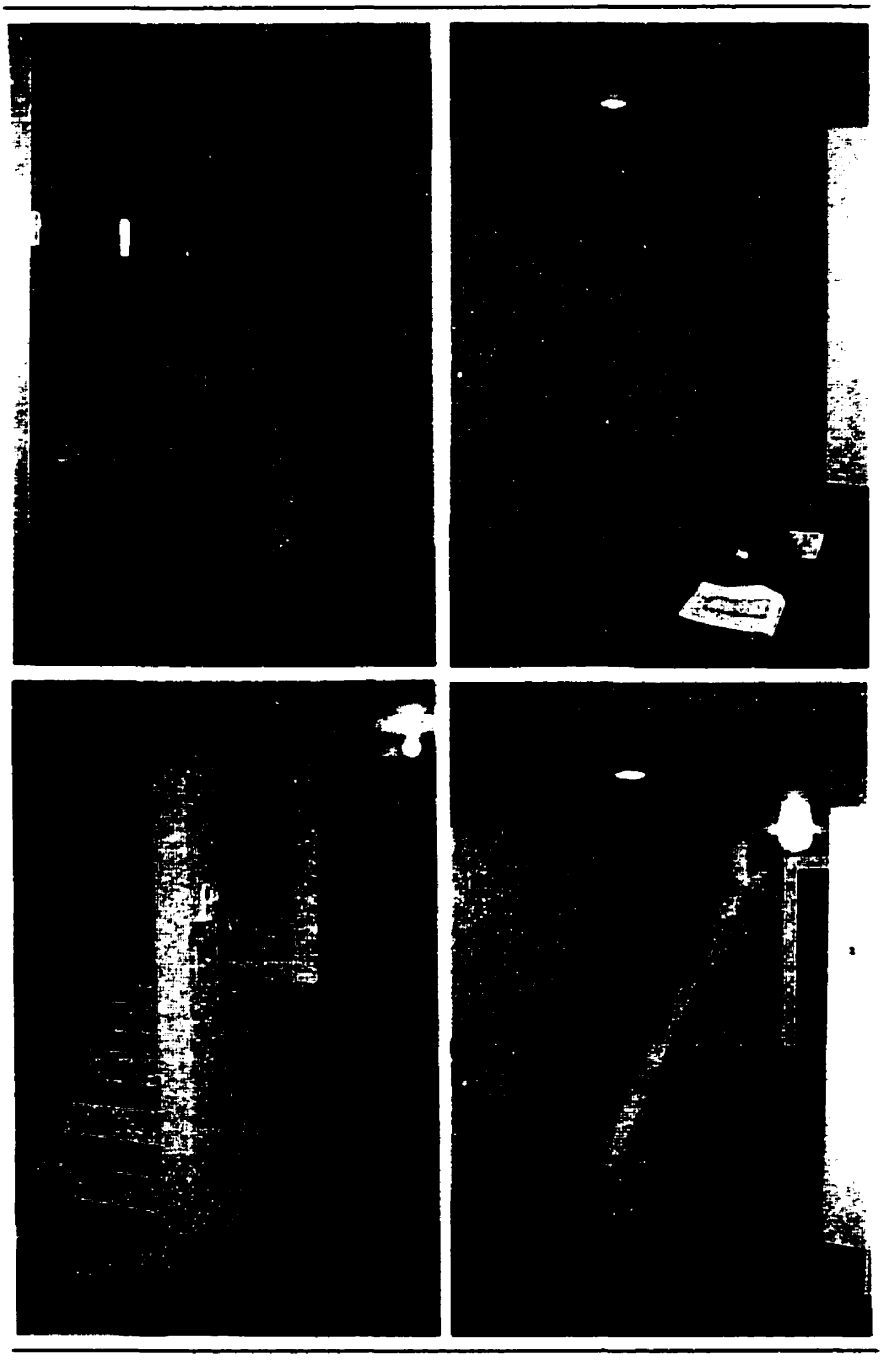


Fig. 2.8 Residents finished and adapted the originally unfinished basement with drywalling work, partitions, floor finishing, ceiling and light fixtures. These are examples of opening or demolishing the wall in the basement stairs to make the room look more spacious.
(Source: Rios, 1995)

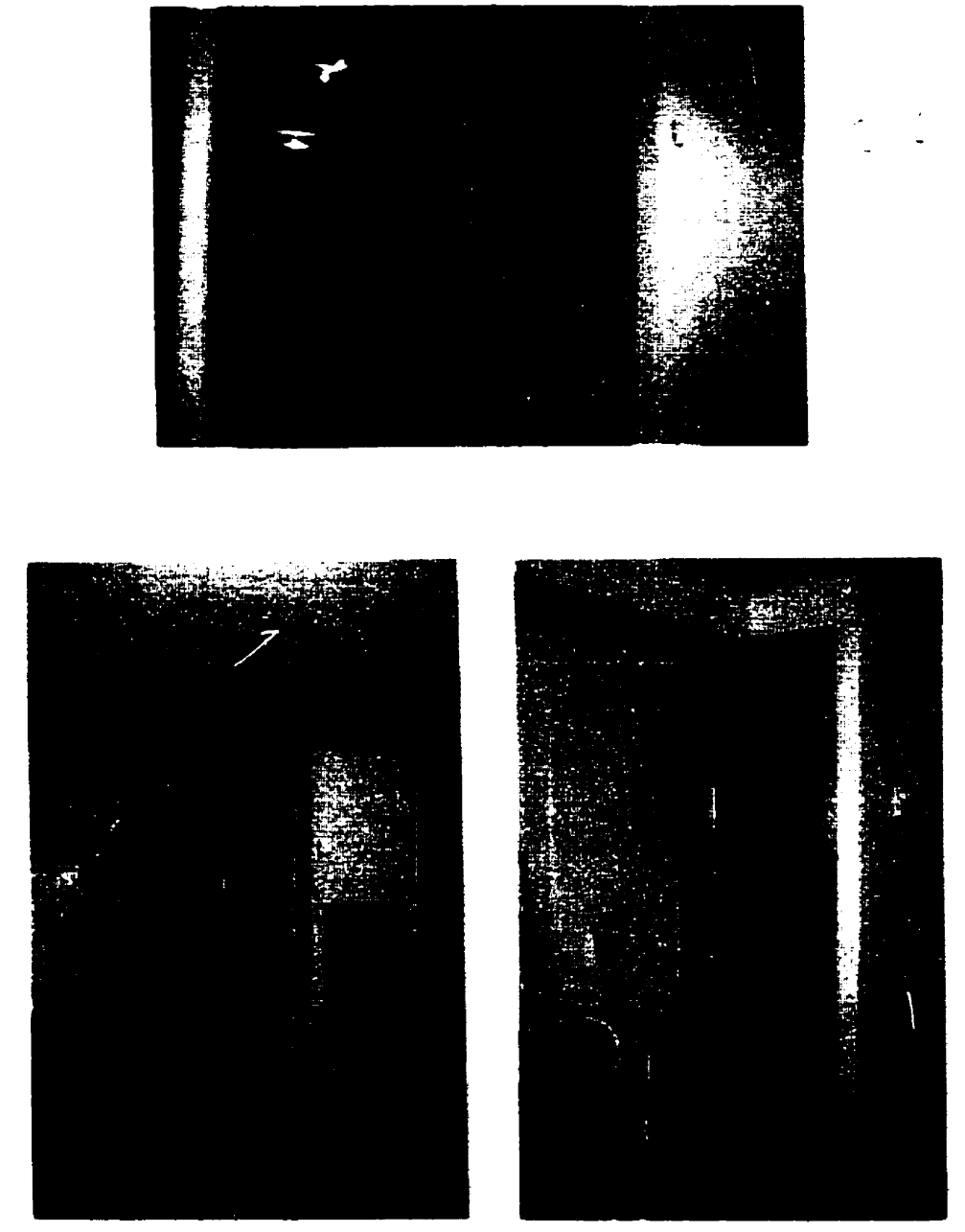


Fig. 2.9 Examples of storage spaces in the basement created by residents.
(Source: Rios, 1995)

2.3 CONCLUSIONS

The house is the largest investment that homeowners will make in their life and the place in which household members spend most of their time. Therefore they will do whatever they can to improve the quality and comfort of their dwellings. Functional and psychological needs, which drive renovators' modifications, last as long as they own the dwelling. The motivation to renovate starts even before they move in. The types of work depend on their needs and their financial situation. Certain types of modification work, like ceilings, partitions, electrical wiring, floor finishes, storage, rough plumbing, happen frequently. Furthermore, renovators have a strong will to undertake modifications even if they can not accomplish part of the work because they lack knowledge about the latest do-it-yourself products, skill or time. Their unachieved renovation goals create a huge potential market for the manufacturers of renovation products. How to develop innovative products which require less skill and time is a great challenge and opportunity for the manufacturers.

CHAPTER THREE: BACKGROUND AND FACTORS INFLUENCING PRODUCT DEVELOPMENT

3.1 INTRODUCTION

The building industry in Canada has been dominated by builders who run small firms, although some large-scale builders emerged after 1945, especially in apartment construction and in large suburban developments. The government has tried to join the industry as a developer, but these efforts have never ended with a satisfactory result (CMHC, 1994). After World War II, the nature of the industry was shaped by a number of factors that distinguished it from other industries. Buildings were constructed on site across a vast country instead of being manufactured centrally and transported to purchasers. Demand for the product varied from single family dwellings in different sizes to apartment buildings across the country. Technical innovation was unstable because of cyclical demand for the product, while the industry was highly flexible and responsive.

These characteristics shaped the way the building industry responded to technological change. Construction efficiency was important for builders because most relied on interim financing during construction, which meant that an efficient construction period would result in cost savings. Therefore innovations that brought faster completion of projects were accelerated by the market. For the same reason, developments which reduced demand for skilled labor were also welcomed.

Ideas for new products and construction techniques come from a variety of sources, but mainly from manufacturers of building materials, equipment, the Technical Research Committee of the National House Builders' Association (now Canadian Home

Builders' Association) and from the public sector: e.g. the National Research Council of Canada (CMHC, 1996).

Innovation trends in the 1990s move to the renovation market as changes in the global economy transform people's daily lives. Government budgeting for deficit reduction has lead to cut backs in social services and jobs; international trade agreements have created new sectors of employment in some countries and eradicated many jobs in others; recessions and sluggish economic growth have weakened the confidence of investors, employers and everyday consumers; the restructuring of many traditional arenas of commerce has resulted in redundancies and unemployment for many who thought they had job security (Friedman et al., 1996).

Although a lot of efforts such as unit size reduction and increasing community density have been made to improve the affordability of housing, more and more people have to depend on the modification of old houses to meet the changing needs of the growing family while adapting to the existing economic situation. The need to renew existing housing stock plays an important role. Renovation expenditure has repeatedly surpassed new construction spending in many provinces and will keep on being a main player in the industry. The do-it-yourself possibilities for home renovators are largely dependent on innovations in the products. Technological improvement can not only improve the living environment of the households, but also decrease the renovation cost by doing part of the job by themselves. In the 1990s, many innovative products have been invented and the processes of many interior post-occupancy modifications have been simplified for do-it-yourself renovators. Some of the products that have been developed in recent years will be introduced in the following chapter.

This chapter contains four sections. After this brief introduction, the second section explains the evolution of the Canadian basement as a catalyst for product innovations. The third section describes the do-it-yourself movement in North America, and the forth section introduces the main innovations in the housing industry between 1900s and 1990s.

3.2 THE DEVELOPMENT OF THE CANADIAN BASEMENT AS A CATALYST FOR PRODUCT INNOVATIONS

The basement has existed for over a century and has recently undergone an interesting transformation. Not only can it be used as a living, work and storage space, but also it is one of the most important elements in adaptation to family change. More housing modifications happen in the basement than in any other room, and many are completed by do-it-yourself home renovators. The desire for basement modification is the catalyst for product innovation. The various categories of do-it-yourself products are most often used in the basement, and the technological improvements have continued to help home renovators in their dwelling modifications.

In the early part of the century, the basement (cellar) was simply an excavation under the ground and mainly used for storing wood for the long winter months (Hawkins & Abbe, 1948). It usually had an earthen floor, and unfinished brick walls, was damp and rather dark. The furnace or heating plant were installed there and the old heating system and pipes would take up considerable space. Fig. 3.1 shows the use of a basement during this period.

Since the 1930s and 1940s, the replacement of old furnaces by more efficient heating systems offered additional space for homeowners. Basements were put to other uses, for example as a wood- or metal-working shop, photography darkroom, recreation room or laundry room. This was also brought about largely by improvements in heating units and laundry facilities, which allowed the basement to be clean, airy and pleasant. The basement of this era usually had a concrete floor, was moderately dry and well lit. The unused space was no doubt devoted to miscellaneous storage. Fig. 3.2 shows the same basement as shown in Fig. 3.1 which was remodeled in the 1940s. Fig. 3.3 shows different uses of the basement in the 1940s.

A basement is usually essential and is often built in the same size as the other floors, for several reasons. First, it provides usable space and insulation for the whole building without adding too much construction expense. Secondly, reducing the size of a basement by 30 percent does not decrease the cost of excavation accordingly. Also, any

Fig. 3.1 Traditionally, the basement was only the location of the fire-wood stockpile.
(Source: Hawkins and Abbe, 1948)

Fig. 3.2 Part of the sume basement after remodeling.
(Source: Hawkins and Abbe, 1948)

Fig. 3.3 The different uses of the basement in the 1940s.
Left: A laundry room was put in one basement.
(Source: Hawkins and Abbe, 1948)
Above: Part of the space was used as a workshop.
(Source: Dunham & Thalberg, 1945)

water pipes or drains in the unexcavated area would have to be well insulated against cold weather. If this area were enclosed with solid masonry walls and opened into the cellar, it would have the required heat, but these walls alone would be expensive.

The basement was first formally designed as a living space in the 1960s (CMHC, 1994). This was made possible by improving in the technology of heating systems. The use of small sized electrical heating plants changed the basement environment and enlarged the usable space in the basement (Fig. 3.4). In this period the basement was excavated to half the depth of the old type and the other half was built above the ground. Normally it was unfinished or simply finished, for the purpose of giving people a variety of choices. Because it was not urgent to finish this additional usable living space, more people started to make modifications by themselves, mainly to save on labor costs. In the 1980s, owning a house again became a difficult-to-attain dream. More homeowners

started to use the basement as a living space for younger generations who could not afford to buy their own houses, or as a work-place for a home business (Fig. 3.5).

In the 1990s, because of the continuing economic recession, renovation spending has surpassed expenditures on new construction. Many builders leave the basement unfinished in order to lower the selling price and to give new homeowners more flexibility to meet their different needs. Mainly because of this flexibility, basement modification accounts for the majority of home renovation work. Flooring, ceilings, additional storage space, new toilets (bathrooms), wiring, painting, and installing partitions are common projects in the basement of many households.

Fig. 3.4 The basement was used as a second living room.
(Source: Hawkins and Abbe, 1948)

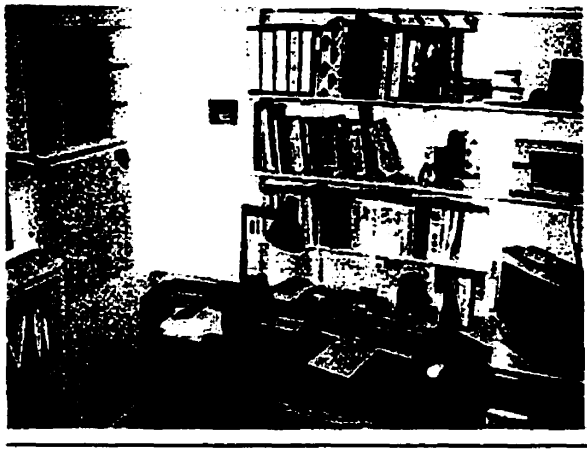


Fig. 3.5 Examples of basement use in a Grow Home Project. (Source: Rios, 1995)
Lower right: an example of a family room created by a homeowner.
Lower left: an family working-place modified by the homeowner.

3.3 THE DEVELOPMENT OF THE DO-IT-YOURSELF MOVEMENT IN NORTH AMERICA

In the early 20th century, the activity of home modification was not very popular. Most of the products were difficult to install and the processes were too complicated for the average homeowner to handle. Most homeowners relied on the skills and expertise of professional craftsmen and contractors. Interior decorative work called for the special abilities of painters, wallpaper hangers, plasterers and tile-setters. In addition to having the skills to execute remodeling projects, these craftsmen were familiar with the basic tools and requisite materials and knew where and how to purchase them. Many middle-class homeowners were more interested in the professional quality of the results than in the technical process itself. Few households assumed that they could make improvements on their own (Goldstein, 1998).

The invention of prefabricated Gypsum wallboard eliminated the traditional steps used by carpenters and plasterers to create smooth wall surfaces (Jester, 1995). Bathrooms and kitchens became the standard-bearer of modernization in many homes. The appearance of porcelain and ceramic fixtures, toilets, bathtubs, floor, and wall tiles encouraged homeowners to transform their bathrooms into idealized havens of sanitation and cleanliness. Manufacturers of gas and electric appliances presented kitchens as models of efficient workspace, promoting built-in cabinets and standardized appearance (Cowan, 1995).

World War II and its socio-economic effects accelerated the growth of a home improvement infrastructure and helped to bring about innovations in materials and

construction techniques. Manufacturers of building materials, appliances and home fittings gradually provided improved products to consumers, offering them new possibilities for transforming their home. More and more manufacturers started to advertise their products such as floor coverings or decorative finishes. Many magazines also began to provide more information about home remodeling and improvement. All of these factors combined to create a home improvement infrastructure that changed the way people viewed their homes, sowing the seeds of the do-it-yourself ethic. Some homeowners started to show a great interest in handicrafts and workshops. Dreams of improved housing and a fulfilling family life, along with a growing market of materials and power tools, increased the will to have a better living environment. At the same time, war-time experience predisposed home owners to undertaking renovation on their own by providing them with skills and confidence needed to make their "American Dream" into a reality. War experience gave servicemen not only the ability but also the desire to improve their surroundings (Wright, 1992). Home improvement began to assume a self-conscious character and to have a place in Canadian culture. Although many manufacturers and dealers had already begun to develop tools and materials for do-it-yourselfers before the war, the technology was greatly developed only in the postwar period. Many manufacturers started to convert their wartime manufacturing facilities to peacetime uses, while many wartime industries redesigned and repackaged their products to meet the needs of home renovators. This transformation greatly increased the possibilities for do-it-yourself projects. Traditionally, the hardware industry produced facilities for professionals and specialists, but in order to seek a larger market for their

goods, producers started to provide products and kits that greatly simplified jobs for the do-it-yourselfer.

In the 1960s and 1970s, home owning men were keeping on learning from easy-to-follow instruction manuals, how-to magazines and even tips from neighbors or hardware salesmen. Manufacturers began to promote a wide range of products. They also encouraged women to get involved in remodeling tasks. By suggesting that "even a women can do it," advertisements sometimes meant to show users that the renovation would be an easy job. Due to the feminist movement in the early 1970s, new kinds of instruction manuals appeared on the market, aimed especially at female do-it-yourselfers (Webb & Houseman, 1973).

In the 1980s, when the number of buildings being constructed started to decline, many manufacturers replaced their warehouse-type stores with layouts resembling supermarkets. Some companies even added home-decorating products. A number of small restoration-orientated businesses were also established.

In the 1990s, the renovation industry plays a major role in the housing industry. Home improvement depots, on various scales, are full of sophisticated tools and wide varieties of products. For example, detail-sanding power tools enable quick achievement of period effects. With accessories such as scraper attachments, they allow for careful and accurate paint removal on items such as furniture. For the less-skilled individual, a variety of ready-made and kit restoration products have made it easier in the 1990s to achieve even classical and Victorian Decorate effects. Pre-cut wooden moldings make it possible to recreate and install old-fashioned fittings without special woodworking know-

how or tools, while imitation moldings and ornamental "plasterwork" made of polyurethane and plastic offer the look of something old, but require little time or effort.

Many stores have emerged selling many kinds of restoration products. At the same time, ordinary hardware stores, home centers and home warehouses have expanded to include many restoration-related goods among their general home improvement supplies.

Another advantage for the do-it-yourselfer in the 1990s is that the media is joining in promoting the trend. Starting from 1973, a monthly newsletter *The Old-House Journal: Restoration and Maintenance Techniques for the Antique House* began to provide regular articles about home renovation (Jester, 1995). Starting in 1979, *This Old House* from PBS, provided a weekly program to introduce renovation processes. Using detailed step by step explanations, this program continues to show the public old and new techniques, materials and effects.

3.4 THE EVOLUTION OF HOUSING CONSTRUCTION TECHNOLOGY DEVELOPMENT

Although the infrastructure of Canada's housing industry was formed during this period, it is hard to find any impressive construction innovations before World War II. The industry developed very slowly and builders were satisfied with the balloon-frame with plank sheathing. The basement was only used for coal or as a root cellar. Walls were usually uninsulated and attics were, insulated at best with 2 inches of mineral wool or lime-treated wood shavings. There was little awareness of air/vapor barriers. Ceilings

were finished with lath and plaster. Kitchens were built with few appliances and cabinets like dressers were built on site with a painted finish. The bathroom was always furnished with three pieces. Siding was often clapboard, applied, trimmed and painted on-site using scaffolding. Gravity hot-air furnaces heated most homes. Brick and stucco dominated in many areas. But there were still some technology improvements. By the beginning of the 1940s, the horse-drawn scraper was totally replaced by bulldozers. Basement concrete blocks gave way to site-mixed pure concrete, with site-built board formwork. The boards were then reused as wall and roof sheathing. And the first transit-mix and the first oiled-plywood forms were already being used by a few industry leaders. Tilt-up, precutting and "stationary assembly line" processes also gradually came into use (CMHC, 1994).

World War II and its aftermath affected the housing industry in a dramatic way. Primary because of the ongoing transformation of the Canadian economy from a resource base to a service and information base, a large segment of the population shifted from rural areas to major cities. On the other hand, newer immigrants rushed to cities for employment opportunities in contrast to the pre-War waves of immigration to the rural area for farming land. This growth led to a massive expansion of Canadian suburbs and created large demand for new housing (CMHC, 1994).

The "baby boom" generation began to enter the housing market in the late 1960s and 1970s, initially as singles desiring their own apartments and increasingly through the 1970s and 1980s as young families seeking a first home. This led to successive peaks in apartment construction and suburban development. After steady growth in the first two decades after the War, the mid-60s to 80s experienced a roller coaster economy.

Global economic trends intruded on the housing markets unexpectedly in the 1970s. The OPEC energy crisis, initiated in 1973, led to temporary shortages of certain products, a rapid shift in fuel use from oil to natural gas and electricity, and a switch to energy-efficient construction practices.

The post-war era was not only a booming period for the housing industry, but it was also a fruitful period for innovations. Many industries that once produced materials for the war turned to consumer goods. For this reason, many factory-based innovations came about and the efficiency of industrialized tract building operations was greatly improved.

A number of new ideas about housing technology were developed and major changes took place in the way in which housing was built. Pre-finished aluminum and PVC siding was widely accepted in a very short time after its invention. Its easy installation, reasonable price and low maintenance were much appreciated by builders and homeowners because before the beginning of 1950s, options for house cladding were limited to masonry veneer, stucco, or site-painted wood siding. All of them were labor-intensive and builders had to pay more to hire professionals. The advent of aluminum windows changed the convention that homeowners needed to paint the windows every few years. The manufactured wood window of the period tended to swell easily and stick, and often became discolored or rotted after a few years because of exposure to cold weather. Windows were no longer high maintenance items. The window with aluminum dressing was further diversified in a range of new styles and designs to decorate houses.

Gypsum board was another revolutionary innovation in this period. It was invented in the early 1960s and soon become widely used in interior partitions. It can be

installed once the interior partitions are in place. The joints between the sheets are taped and plastered to provide a smooth surface. This revolutionary invention totally changes the way the interior walls are built: wet plastering used to be highly skilled and labour intensive work. In 1955 plasterers made up about 7 percent of the total cost of on-site labour, whereas today this has dropped to less than 1 percent.

Winter construction developed in the 1960s and from then on builders could work through the whole winter: concrete with special formulae could be poured in cold weather and the working area was kept warm by polyethylene sheeting and space heaters. This is also considered very innovative because Canada's climate had previously prevented year-round construction. The whole industry had to come to a standstill for almost half the year.

Until the 1960s, most innovations were breakthroughs in housing technology that reduced construction time, decreased the amount of materials necessary and improved efficiency, while enhancing the performance and quality of the finished product. The housing industry was challenged by the energy crisis starting in the 1970s, and energy efficiency had continued to be a central issue affecting building practice during the economical instability of the 1980s. As a result, affordability became a major issue. Most inventions were the result of energy saving efforts. Walls, windows, doors and mechanical equipment underwent significant change before the end of the decade. Energy, Mines and Resources Canada developed the experimental "Mars Houses" series which concentrated on the technology of energy efficiency. Another experimental house design, the R-2000 Super Energy Efficient housing (SEEH) program, showed the latest technology to be used in reducing energy consumption. For the sake of energy

conservation, builders reduced site size and increased the density of housing projects. This practice gave us a prototype that may one day become our standard building.

Plastic Weeping Tile is one of the housing construction innovations of this period. Normally builders used clay-weeping tiles around the perimeter of a house. These clay tiles were very heavy and awkward to install. This difficulty was alleviated in the 1970s by lightweight plastic tiles in long rolls, which were very easy and quick to install.

In order to make houses more energy efficient, walls were now commonly framed using 2"x6" studs to allow for additional insulation. Roofs trusses were redesigned to provide more space for insulation. These new insulation practices provided benefits for both the homeowner and the environment. At the same time, the move towards airtight homes with effective vapor barriers meant that indoor air was no longer naturally exchanged through leaks and cracks. Certainly the air quality would be decreased. This concern about indoor air quality and condensation led to the invention of the Heat Recovery Ventilator, which used the heat of out-going air to warm incoming outside air. Ground Source Heat Pump's method of tapping into the earth's thermal energy provided an environmentally friendly form of heating and cooling, while using electricity to a degree of efficiency never before achieved with other systems.

More efficient insulation material also became available in this period. Canadians have always tried to insulate their dwellings against the cold, since the 1940s. Before the 1960s ceilings were usually insulated with vermiculate, treated shavings or loose mineral wool. Walls used mineral wool batting, although shavings poured between the studs were also commonly used. Glass fiber, a product that had superior performance over mineral wool was developed in the 1950s and rapidly became the standard insulating material in

Canada. During the energy crisis, its quality and efficiency continued to improve and it played an important role in the housing industry.

3.5 CONCLUSIONS

The development of innovative building construction technologies and the evolving use of the basement were two of the most important factors which influenced product development. The increased use of the basement as a living or working space generated a constant market demand of new products for homeowner's post-occupancy modifications. Many new construction technologies were absorbed directly or indirectly by the renovation industry. New products such as PVC pipe and the Gypsum board not only provided construction efficiency for the professionals but also offered installation convenience for home renovators. The emergence of the factory-based assembly line made possible the development of prefabricated low-cost products for renovators.

CHAPTER FOUR: THE EVOLUTION OF PRODUCTS AND INSTALLATION PROCESSES

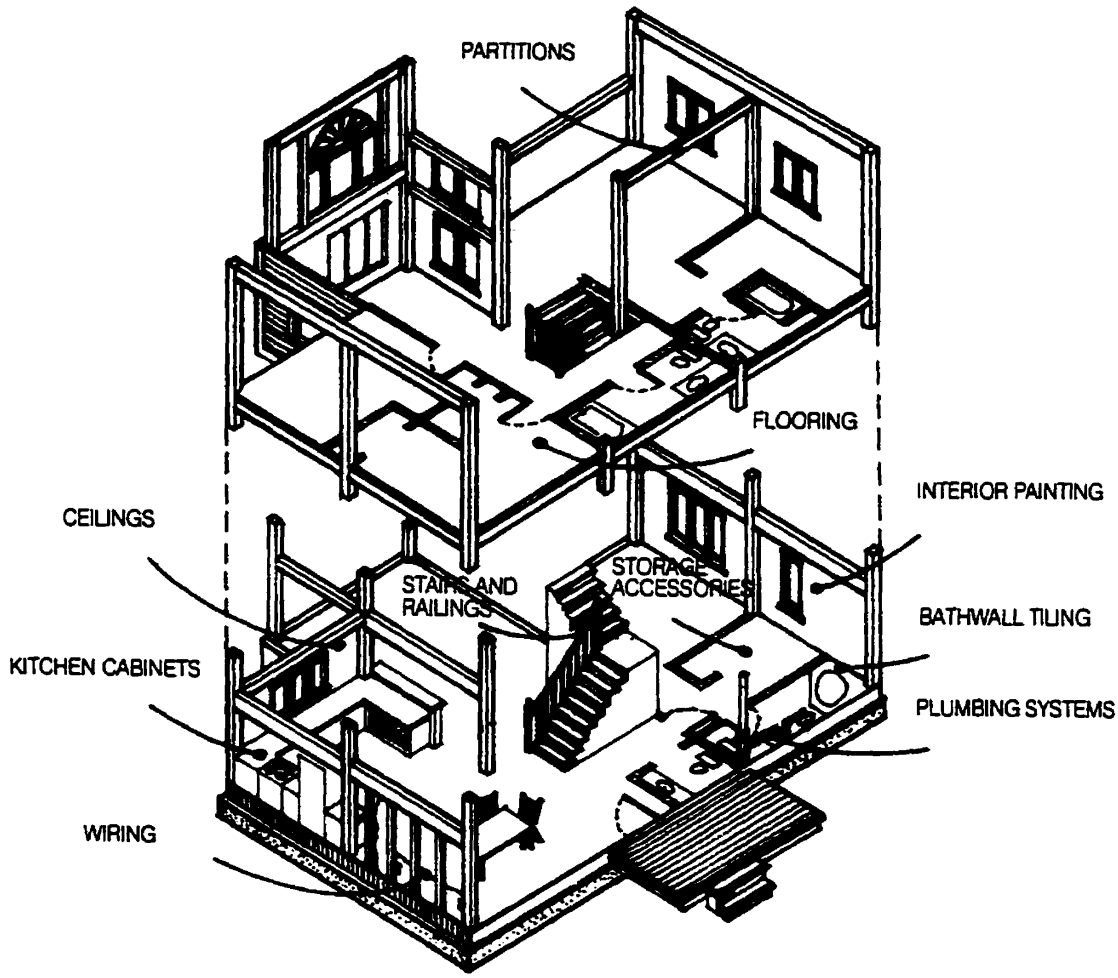
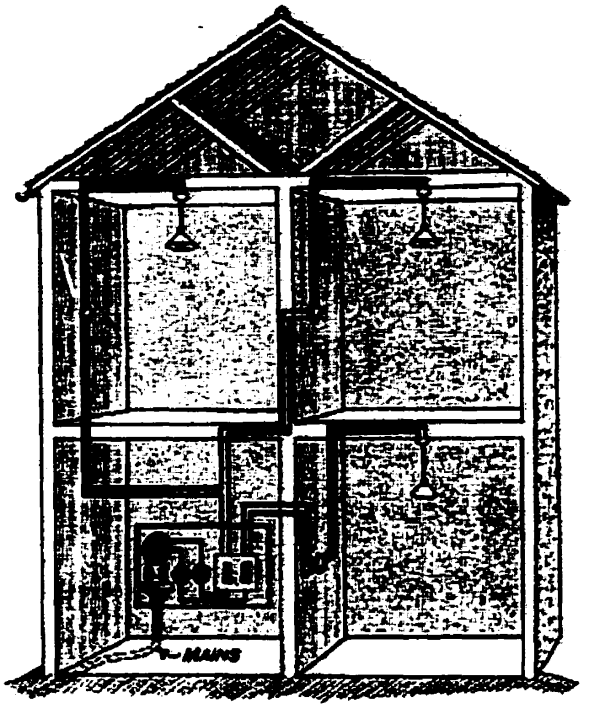


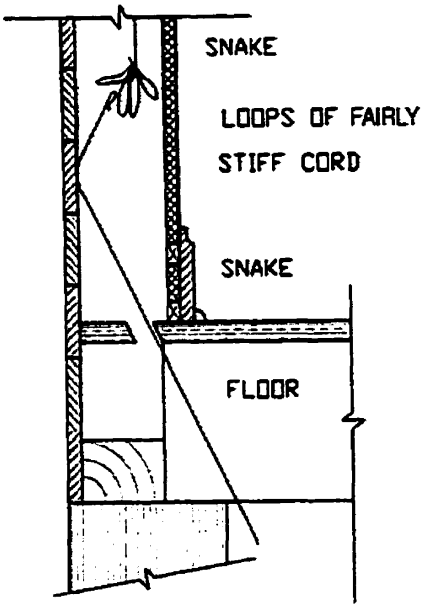
Fig. 4.1 Illustration of ten selected products. (Author)

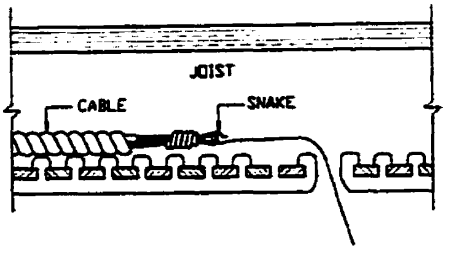
In Chapter Two, it was pointed out that spending on interior modification accounts for the greatest part of total renovation expenditure. In addition, market information and post-occupancy studies have shown that the installations of certain interior components are the most popular modifications among home renovators. Using these criteria, 10 products were chosen as the target of this research (Fig. 4.1). The time span is from the beginning of this century till the 1990s. Since product development accelerated mainly after World War II, the description of technological improvements will concentrate on the period after the 1940s.

4.1 WIRING

Before the 1940s, there were not many home electrical appliances and wiring in new construction was relatively simple. Fig. 4.2 illustrates the simple wiring system of this period. For home renovators, installing new wiring or repairing an old connection was definitely not an easy job. As shown in Fig. 4.2, wiring in a house was normally along the ceilings, floors or vertical walls. To add a new wiring line, the renovator first needed to have a "road map" of the house in order to find the nearest electrical fixture. Then the new wires needed to follow these three tracks or traverse the "secret passages" that existed in the house: the pipe chases, vents or crawl spaces (Hawkins & Abbe, 1948).







Left: Fig. 4.2 House wiring system in the 1930s. (Source: Molloy, E, 193-?)

Right: Fig. 4.3 Sections showing the way of adding wiring through walls and ceiling. (Source: Hawkins and Abbe, 1948)

To run wires through partitions, under floors, behind walls and above ceilings required an intimate knownledge of the structure of the house. The most important tools for running wires in finished a house were not wire cutters but rather plaster chisel and fish wire which would result in increased wiring costs. Fig. 4.3 shows how wiring was added through ceilings and walls. Often the homeowner needed to open the partition at that point. Another hour or more had to be spent to patch a hole after solving the problem, or trying to force a fish over an obstacle just would not yield (Labine &

Flaherty, 1980). The work was difficult even for the professionals, let alone for homeowners.

The other way to add wiring was to connect the wire from the ceiling (or floor) and install the wire along channels in the plaster. First a channel needed to be cut in the plaster for the tube of the wires that went to the switches in the various rooms. These channels all needed to be cemented up afterwards. Then the switch was screwed into a little square box which had first to be cemented in the wall. Fig. 4.4 shows a renovator cutting a groove in the plaster with a chisel and a hammer to install the "concealed" wire for a new light switch.

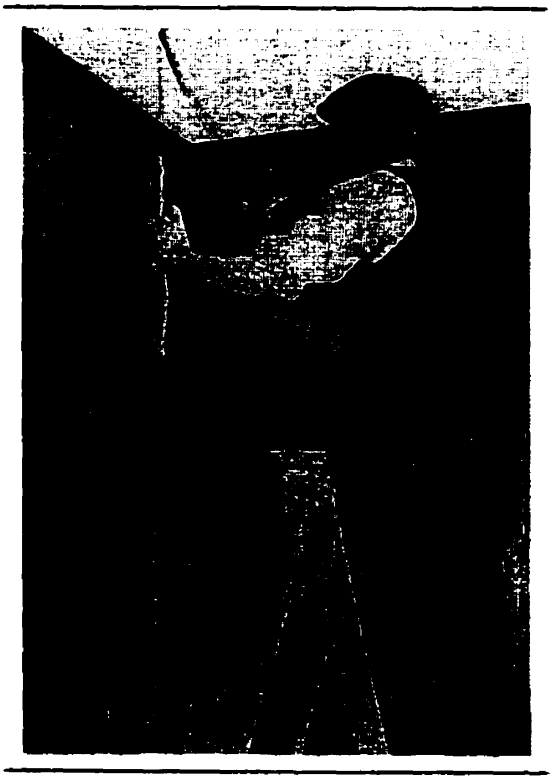
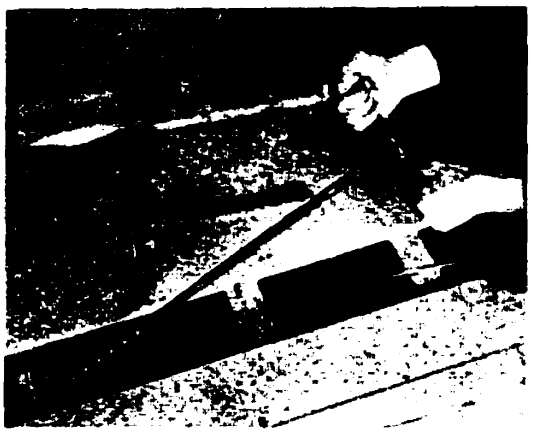


Fig. 4.4 A renovator cutting a groove in the plaster to install "concealed" wiring. (Source: Molloy, 193-?)

On the other hand, renovators who wanted the wiring to go through the floors often needed to remove one or two floor boards and then cut notches in the joists where the floor boards had been taken up for the pipe or conduit to fit in (Fig. 4.5). Sometimes it was necessary to carry the conduit deeper in the joist than was possible with a notch. In such cases a hole was bored through the joist (Fig. 4.6). In some cases, renovators would find that wires could not be run between certain points, or that too much ornate plasterwork would have to be chiseled away. In this circumstance, running exposed surface wiring was the only choice to accomplish the job.



Left: Fig. 4.5 A renovator cutting notches to carry the conduits. (Source: Molloy, 193-?)

Right: Fig. 4.6 Another method of laying conduits. (Source: Molloy, 193-?)

With the proliferation of home electrical appliances and the use of electrical heating systems in the years from the 1940s to the 1990s, wiring systems in house became more complicated than before. Fig. 4.7 illustrates the expanded wiring system in

this period. Wires and outlet boxes were mounted through wall studs and through the floor joists. This means of organization made the wiring more efficient than before. But once the frame was enclosed, running extra wires for homeowners was still difficult. Wiring a timber-frame house was further complicated by the many details involved in the installation. For exterior walls, the wiring systems most widely used went through the studs behind finished walls. If homeowners wanted to add wires, they would have to open the wall finish and use a snake in the traditional way.

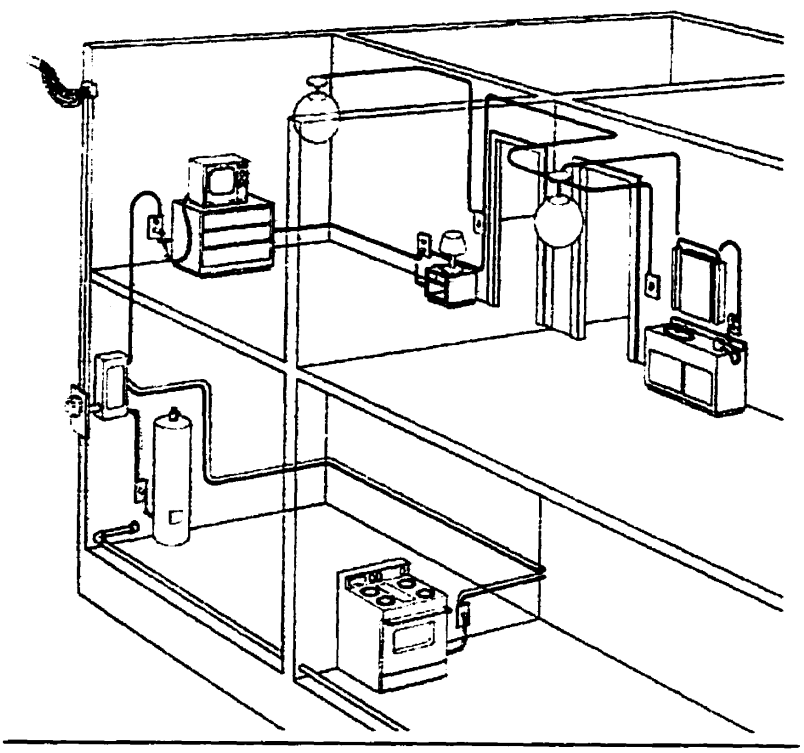


Fig.4.7 The expanded wiring system. (Source: Time-Life Books, 1977)

The improvement during this period was that home renovators could choose to use the extended-baseboard wire chase inside exterior walls as illustrated in Fig. 4.8 (Benson, 1997). Although opening and cutting the wall could be avoided, it still took a long time to build the wire chase and install the outlet. For partition walls, the wires and

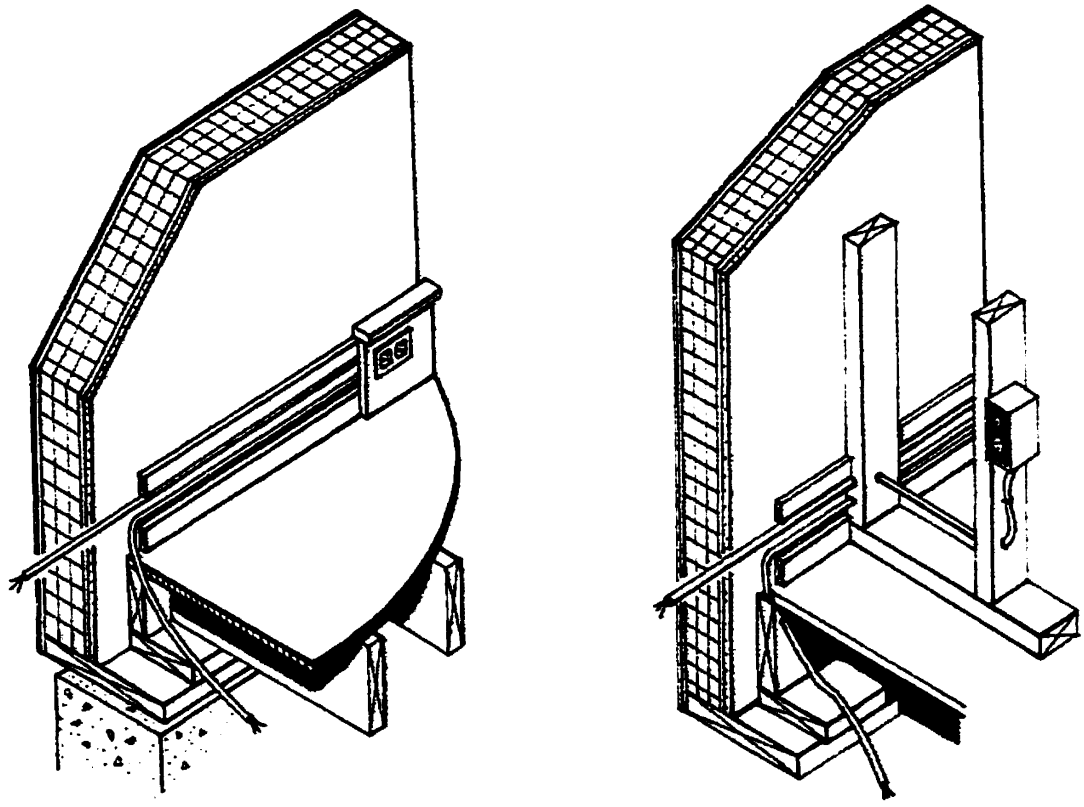


Fig. 4.8 Although the extended-baseboard wire chase obviated cutting the wall, it still required a lot of work to construct the chase. Left: wires hidden in a wood chase built on site. Right: wiring where the chase meets with a partition. (Author)

boxes were mostly installed in the conventional way. However, the holes in the studs helped to not only systemize the wiring route but also to save space. Fig. 4.9 illustrates

wiring going through holes in the studs of interior partition walls. When partitions intersected with exterior walls, the wires could be passed into the partition from the extended-baseboard chase, the openings in the exterior wall or the floor system. If renovators had to bring a wire to an interior partition wall that did not intersect with an exterior wall, the only way was to connect with the floor system by drilling from the basement, crawlspace or from partition of the other floor.

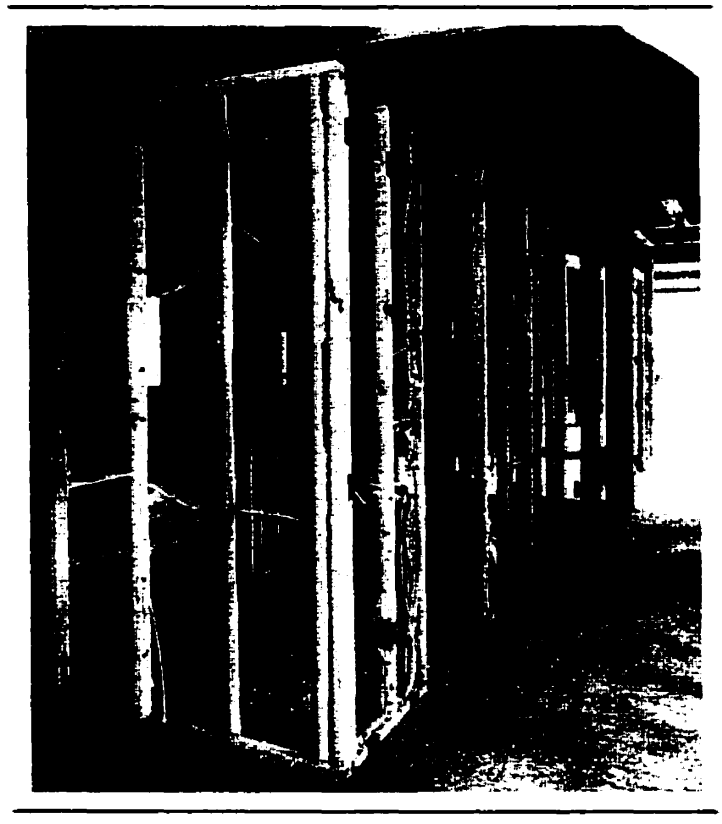


Fig.4.9 Wiring goes through holes in the studs of interior partition walls.
(Source: Benson, 1997)

In the 1990s, home telecommunication and computerization technologies have been improving at an unprecedented speed. Updating wiring systems, adding wiring to accommodate more appliances or changing power distribution are frequently necessary in many households. Most families require wiring that is easy to change and update.

Homeowners need to do much more wiring than before. But traditional wiring offers neither flexibility nor expansibility to keep pace. The innovative Wiremould wiring management system (Fig. 4.10) for residential use has greatly simplified wiring modification. It is easy to install, flexible and attractively fits the room décor. Also, it allows the location of the outlets to be changed. Homeowners can choose from different types according to their different needs. For example, Wiremold Access 5000 raceway is sleek while greatly simplifying running power lines as well as low-voltage cable. Its two-channel design is ideal for AC power, computer, telecommunication, video and security system cabling. Modular outlets and jacks make for easy installation and upgrades. And home renovators can choose from a large variety of finishes: from standard white, black, and gray to real wood veneers. 5400 nonmetallic raceway provides all of the advantages of the 5500 line but is specifically designed for those requiring less cable fill.

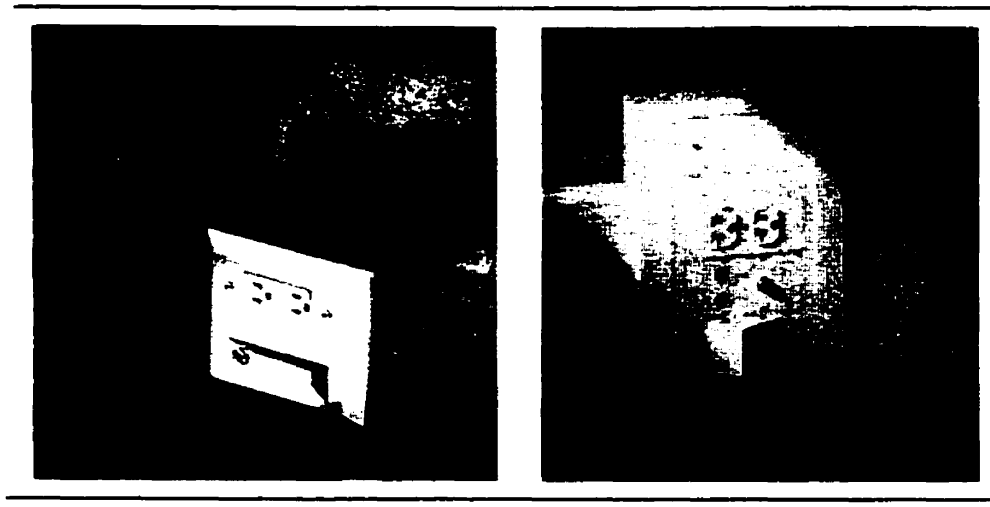


Fig. 4.10 Wiremold wiring management system combines communication and power plugs and is very easy to install. (Source: Wiremold, 1999)

Another advantageous development is that the open-web flooring construction offers ample open space for home renovators' wiring modifications. Wires can be hidden and pass through the joists without any interruption. Also, more sophisticated suspended ceiling systems give the renovator the ability to run wires in the ceiling much more easily than before.

In summary, wiring has traditionally been one of the most complicated jobs for home renovators. In the old days, manual woodworking tools were crude and not widely available in the market. Opening and finishing wet plaster walls was so difficult that homeowners were not likely to be able to do it themselves. Much of the work was difficult even for the professionals. Technological improvements in housing construction after World War II made wiring much more systematic and efficient. Moreover, the popular usage of gypsum board facilitated openings in the walls and ceiling. Also, the use of power tools simplified the cutting job. The opportunity for home renovators to add wiring by themselves has only been greatly enhanced recently. Mainly driven by the need to accommodate the soaring market needs, the modular prefabricated raceway and multi-plug system was invented and offers homeowners a way around troublesome wiring work. Without special tools or professional knowledge, home renovators can finish the work in a short time and they will also have the flexibility to face future change.

4.2 PLUMBING SYSTEMS

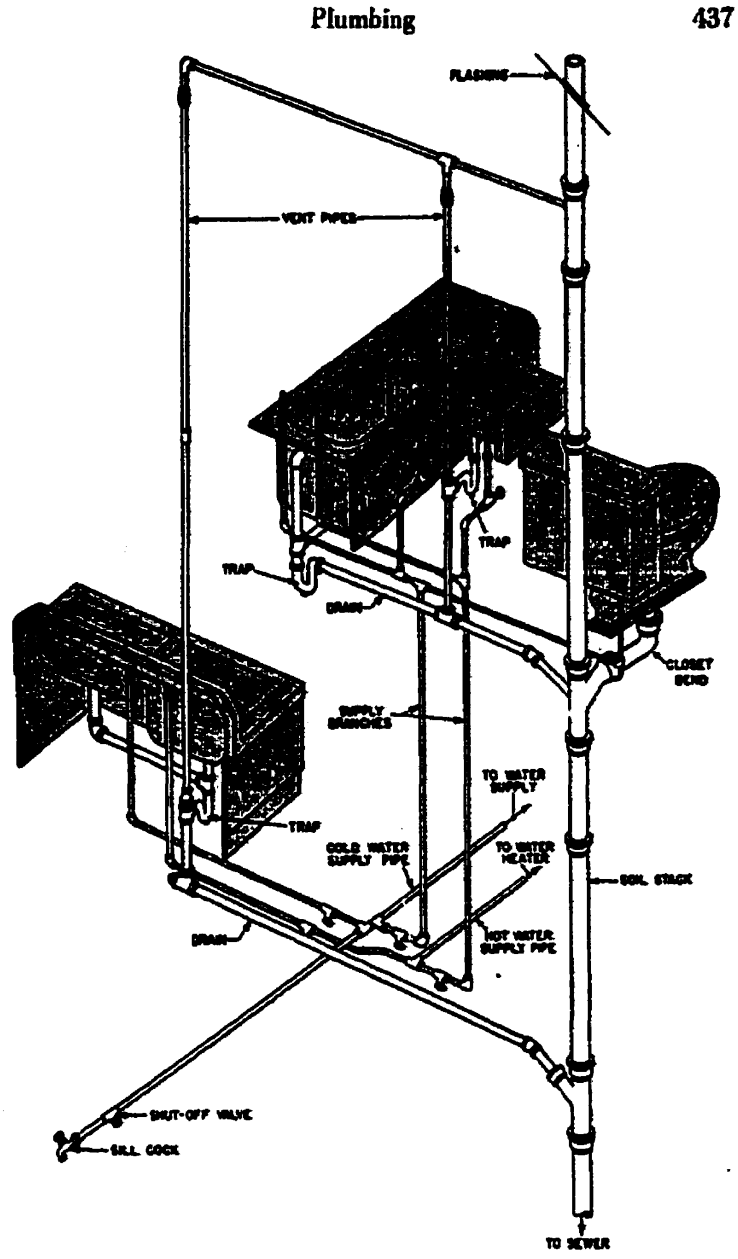


Fig. 4.11 House plumbing system in the beginning of this century. (Source: Hawkins & Abbe, 1948)

At the turn of this century, a different house plumbing system (Fig. 4.11) was invented and quickly became widely used. The main installation principle of this system was to expose the pipes as much as possible (Hawkins & Abbe, 1948). Fig. 4.12 shows the use of exposed pipes in the bathroom and Fig. 4.13 shows the use of them in the kitchen. In Fig. 4.13 the pipes are also used as supports for the work-table. The fixtures were cumbersome, inconvenient and in most cases boxed in with wood paneling. The idea in the new system was to place the skeleton of pipes and the fixtures in such a way that adjacent space could be kept clean and every part of the system could be accessible to home renovators. This was made possible to a large extent by the use of nickel-plated piping and enameled iron, porcelain, and vitrified fixtures.

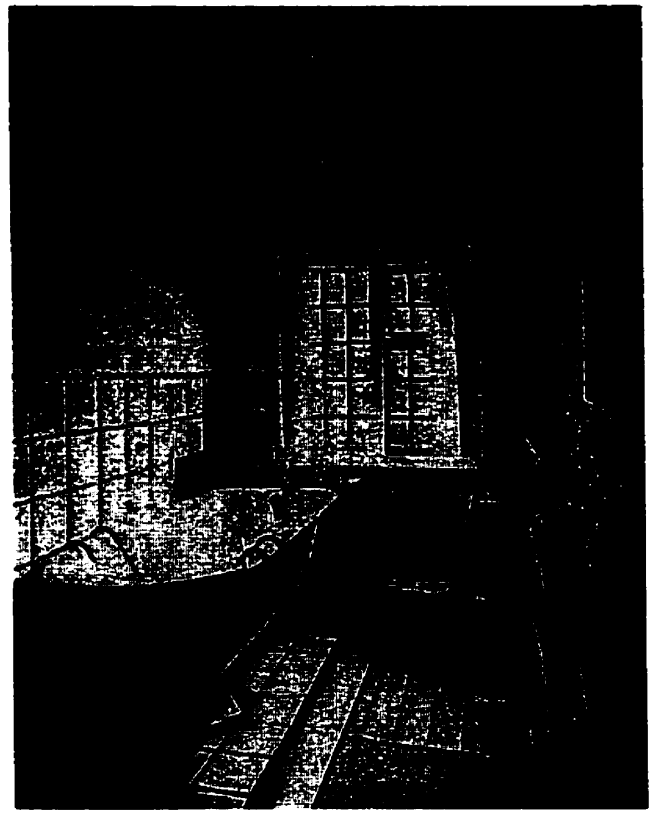


Fig. 4.12 The use of exposed pipes in the bathroom. (Source: Hawkins & Abbe, 1948)

Fig. 4.13 The use of exposed pipes in the kitchen. (Source: Desmond & Frohne, 1908)

In this period, water-supply pipes were mainly made of lead or galvanized iron even though they could be made of brass, or "durometal"-an alloy of nickel and brass. The size was usually ¾ inch or 1 inch, depending on the water pressure. Although lead pipe was not advisable because certain chemical consistency would dissolve lead and it was more expensive, it was widely used because it lasted longer than iron pipe even when the latter was galvanized. A tin-lined pipe was used which combined the durability of lead and purity of tin and to prevent poisoning. Later these materials were replaced by galvanized steel pipe and copper tubing (Labine & Flaherty, 1980). Galvanized steel pipe was relatively inexpensive, but was subjected to rust and to eventual stoppage.

All these materials had their shortcomings. Galvanic action often caused joints-corrode between dissimilar metals. It was very common to have a drop in pressure from scaled-up pipes if the joints were corroded. This meant increasing difficulty for renovators in order to make the renovation work last longer. Rigid copper was too hard to install while making pipe connections and it was too expensive for the average

homeowners. All these materials were extremely difficult to cut, fit and join and tools in this period were crude and not easy to control. Most of the tools were manual and the industry only provided a few prefabricated fittings for the renovators; even threads were often hand made. Fig. 4.14 illustrates some of the tools in this period.

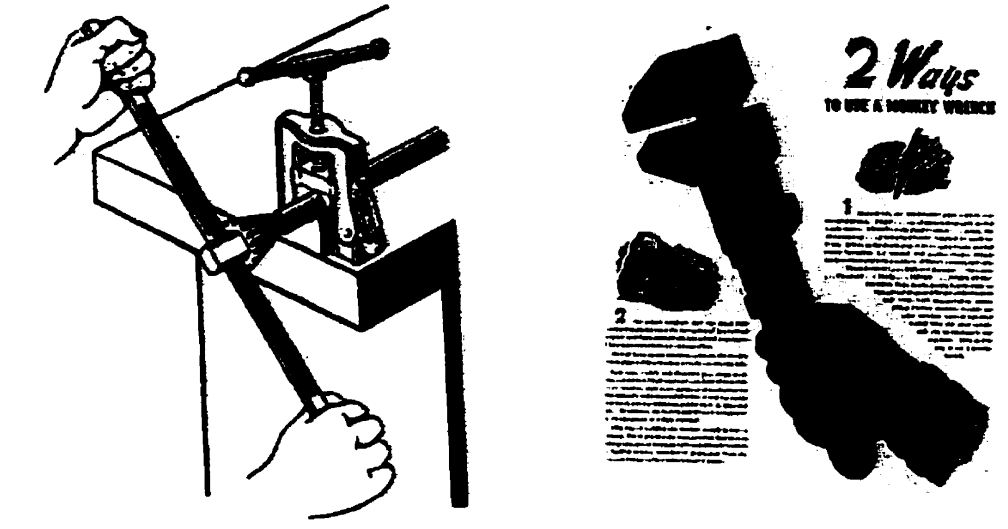


Fig. 4.14 Two examples of plumbing tools before the 1940s. Left: pipe vise used to hold the pipe. Right: wrench used to tighten the pipe joint. (Source: philbin, 1988)

In the period between the 1940s and 1990s, the exposed part of the old plumbing system was hidden within the structure in order to have more usable space and to make it neat. But the main plumbing system was still installed in the same way. Fig. 4.15 illustrates a typical plumbing system in this period. The invention of PVC pipes during this period greatly simplified plumbing work for home renovators and soon become very popular. This new type of pipe has many advantages: it is light, can be cut easily with a hack saw, joined simply with a special adhesive, and the resulting joint is stronger than

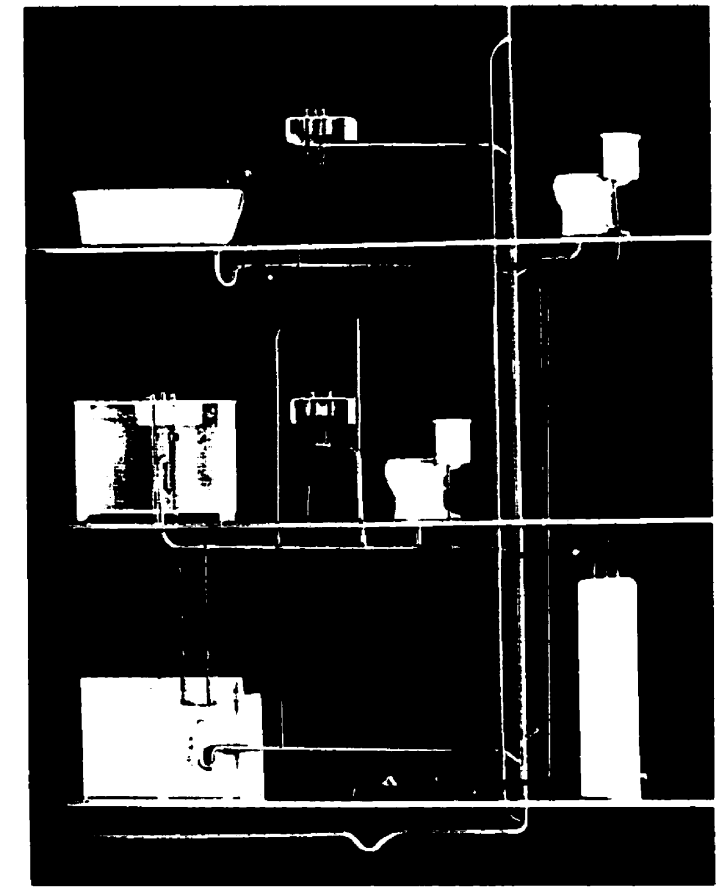


Fig. 4.15 A typical plumbing system between the 1940s and 1990s.
(Source: Time-Life Books, 1977)

Fig.4.16 PVC pipes can be easily cut with different types of tools.
(Source: Black and Decker, 1976)

the pipe itself. Transition fittings were also simplified. But PVC pipes were used more often in drainage pipes than in supply pipes. Fig 4.16 and Fig. 4.17 illustrate the simple methods of cutting and connecting PVC pipes with different kinds of tools.

Fig. 4.17 PVC pipes were designed to be easily connected.
(Source: Black and Decker, 1976)

For cold and hot water pipes, improved traditional materials like cast iron and copper tube were also widely used because they did not rust easily and had longer durability. Furthermore, a new kind of soft copper was developed which made cutting and connection easier than before. Hard-drawn (inflexible) copper could be used in conjunction with soft copper tubing (Philbin, 1988). By using these materials, renovators could install the hard-drawn type where the pipe lines ran in open space and the soft copper could be used where the pipes were in enclosed space, for example walls and floors. Another advantage for home renovators is that more prefabricated fittings were provided by the manufacturers, and tools including power tools were improved. All these

technological improvements simplified the work of home renovators. Fig. 4.18 and Fig. 4.19 show the tools used to cut pipes and open flaring.

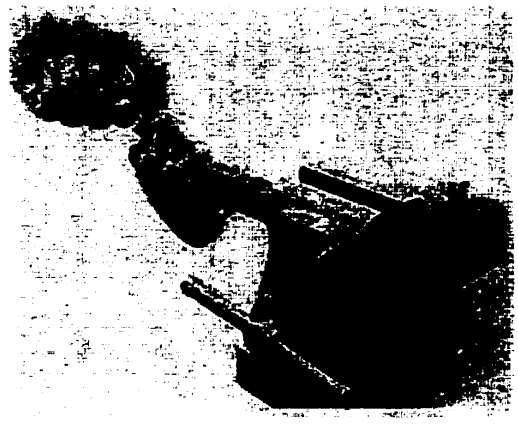


Fig. 4.18 A roller cutter is used to cut galvanized and copper pipe. (Source: Philbin. 1988)

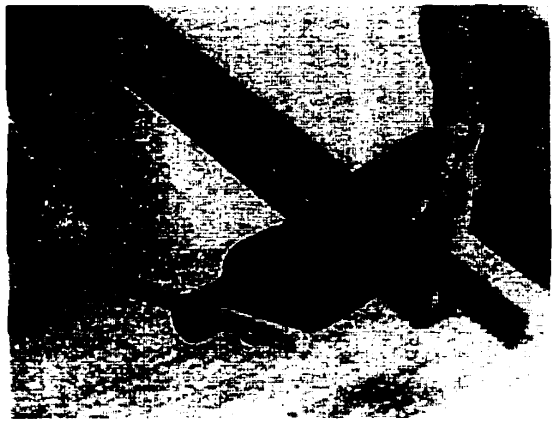


Fig. 4.19 Tool used to open flaring. (Source: Philbin. 1988)

Modification of plumbing in this period was still difficult because users could not attain much flexibility in the arrangement of the pipes. Most of the pipes still needed to be placed in a certain route inside the floors. When adding or moving fixtures in a kitchen or bathroom, pipe installation was always limited by the existing plumbing lines in the house, for reasons of economy and ease of installation. How the new drain and water supply lines ran would also depend on the floor and wall framing. The arrangement of hot and cold water pipes was generally parallel to the joists because of the convenience of installation. Hot and cold branches were located near the main pipe, and the soil branches were also arranged near the soil stack for the purpose of saving money. All these features limited the location of the bathrooms and kitchens.

In the 1990s, a product called BOWPEX was introduced. BOWPEX is potable water tubing for use in Hot and Cold Water Systems. This flexible pipe is made possible

by the invention of a unique durable plastic called Cross Linked Polyethylene. This soft polyethylene is formulated specifically to withstand high temperature and pressure, with a competitive price. The technological principle of this material is to create a three dimensional molecular bond within the structure of the plastic which dramatically improves many properties such as heat deformation, abrasion, chemical and stress crack resistance. At the same time, shrinkage is minimized and impact resistance is increased. Thus, the properties of the material have improved to perfectly suit being used in hot and cold water pipes. Not only does it provide good long-term performance, even at elevated temperatures and pressures, but it also provides great flexibility and easy installation for homeowners' plumbing modifications. Especially when it used in the open-web flooring structure, BOWPEX pipe can be installed freely in the open space between metal joists. Handy crimping and cutting tools and insert fittings have also been produced to make the cutting and connection with metal pipes much easier than before. Fig. 4.20 shows the BOWPEX pipes, main cutting and crimping tools, and insert fittings.

Traditionally, plumbing was just about the messiest modification job, second only to wet plastering. The material used for plumbing systems was the main restriction which prevented the improvement of piping modification processes. All the traditional materials like lead, iron and copper were pretty difficult to cut or connect. Furthermore, the stiffness of these materials restricted the route of the plumbing layout. Tools for plumbing were fairly crude, and the market for renovators was also lacking in prefabricated fittings. For economy and convenience, home renovators prefer to do the minimum amount of work required.

Fig. 4.20 The BOWPEX pipes, main cutting and crimping tools, and insert fittings. (Source: BOW Industrial Corp., 1998)

With the increasing development of housing stock, the industry started to provide renovators with new simplified tools and more prefabricated fittings. But renovators were still hampered by the restriction of changing pipes through the routine routes and the difficulty of dealing with rigid metal pipes. However, the soaring renovation market needs in the 1990s attracted more companies and organizations to the development of simplified products for home renovators. This lead to the successful invention of cross-linked polyethylene, making possible the revolutionary innovation of BOWPEX pipes.

4.3 FLOORING

Prior to laying finished floor in the period before the 1940s, the subfloor had to be first scraped free of any adhering materials and swept clean. There were two ways of installing floors for home renovators (Hawkins and Abbe, 1948). One of them was to lay it directly on top of the underfloor, using just paper between the two. Fig. 4.21 shows a detail of floor construction. In the other case, 1"x2" cleats were placed in lines on the underfloor, and on these the finished floor was laid. Thus a space of about an inch was maintained between under-floor and finished floor. This space served as an acoustic barrier when a good brand of sound-insulating felt was used between the two. The acoustic materials in this period were usually about ½ inch to 3/8 inch thick, and composed of two layers of heavy building paper stuffed with hair felt, tow, or seaweed. The latter was coarse grass from the sea, cast up by the waves, dried, and then woven into a heavy fabric good for acoustic and thermal insulation.

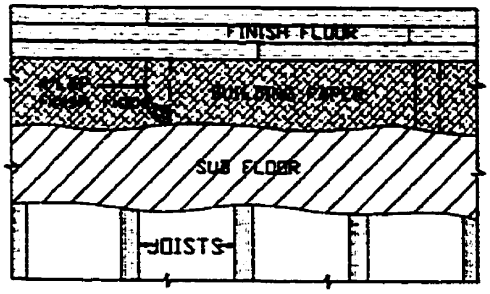


Fig. 4.21 A plan showing detail of floor construction. (Author)

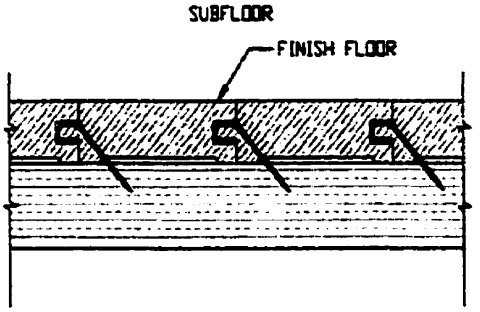


Fig. 4.22 A section showing panels with tongue and groove are blind nailed. (Author)

The "blind nailing" method was already used in this period (Fig. 4.22). The first few rows of boards, which were close to the wall, had to be nailed through their surface. Fig. 4.23 shows the nailing detail for first strip of finish floor. If the subfloor had been laid diagonally, renovators could lay the finish floor in either direction in relation to the joists. Finish flooring was usually laid parallel to the long dimension of the house or room and was run through the doors from room to room without a break at the door. To make the surface smooth the floor needed to be hand scraped or sanded over the entire surface. Both were very time consuming technical work. When the floor appeared to be smooth, it needed to be swept and inspected at close range in good light to guarantee that it was completely free of visible stains. Then it was varnished manually on site three times, with the first coat being allowed to dry about 24 hours (Berkeley, 1968). The last step was floor sealant and rubbing wax in the floor. A popular method was an oiled finish, which was done by heating raw linseed oil to the temperature of boiling water and brushing the hot oil on the wood. Three coats were needed and several days or even weeks would have to intervene between coats. Also, each coat had to be polished manually with a coarse cloth wrapped around a block of wood (Berkeley, 1968).

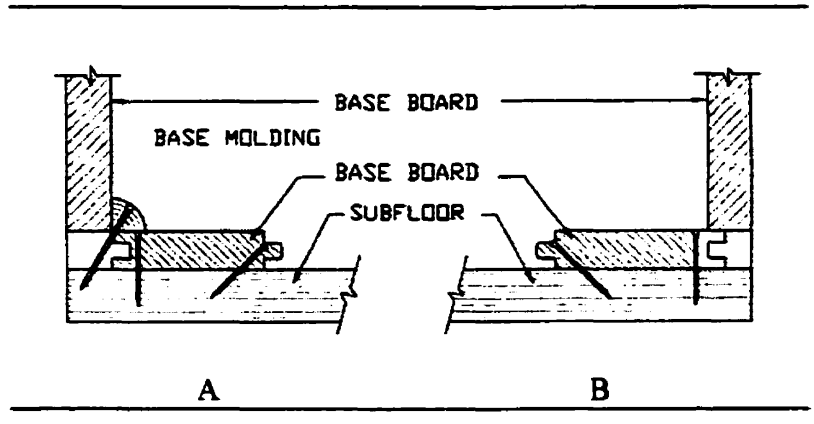


Fig. 4.23 Section showing nailing detail for first strip of finish floor. A: with base molding. B: without base molding. Face nails in B may be countersunk and the holes filled with plastic wood. (Author)

In the period between the 1940s and 1990s, the three major components of floors had not changed: supporting joist, sub-flooring laid at right angles or diagonal to the joist and finish flooring at right angles to the sub-floor. For home renovators at this time, most wood flooring was pre-cut into narrow strips in a variety of widths and thicknesses, random width planks or unit-blocks, and produced in sophisticated tongue and groove style by the manufacturers. Both ends and sides had been milled with either tongue or groove, so that the individual board would interlock in all directions (Berkeley, 1968). All kinds of strip floors were kiln-dried so that they would not warp out of shape in humid circumstances.

The complicated, time-consuming nailing job was facilitated by using a power nailer, a machine that actived by a swift blow with a five-pound mallet. Fig. 4.24 illustrates the power nailer that was used to install strip flooring. The renovator had to have perfect balance and aim, however, as he moved along the row with a steady rhythm of push, swing and bang. With one bang a board would be butted closely to another, and with the next, a nail would shoot through the tongue of a strip and into the sub-floor. The manual sanding was also replaced by the sanding machine. Fig. 4.25 shows two types of sanding machines. Although these power tools improved the sanding efficiency of home renovators, they were still difficult to operate. While operating a drum sander, if the renovator panicked and failed to keep it moving smoothly ahead or forgot to raise the revolving drum from the surface of the floor, he would dig the telltale trenches known as drummers. Working on the edges took even more time and care. Some handwork was also necessary in corners and in other restricted areas even when a power machine was used.

Fig. 4.24 The portable power nailer used to install strip flooring. (Source: Wagner, 1977)

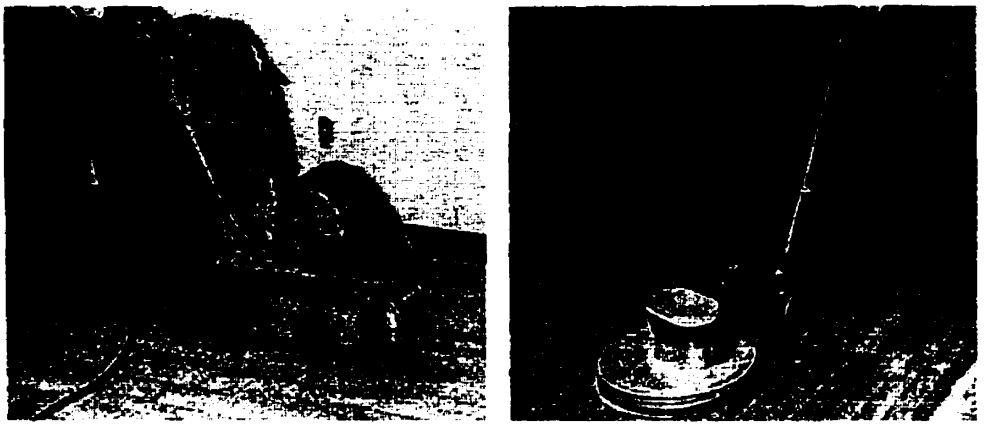


Fig. 4.25 The Floor sander or polisher greatly reduced the work of contractors. (Source: Berkeley, 1968)
Left: drum-sanding machine. Right: disk-sanding machine.

It was much more difficult for home renovators to install wood flooring over a concrete slab in the basement. The installation relied on sleepers attached to or embedded in the concrete surface. The sleepers served as a nailing base for the flooring material. If the concrete was placed directly on the earth, either at or below ground level, the building

paper between the subfloor and the strip flooring was replaced by polyethylene film that functioned as a vapor barrier. The sleepers consisted of 2x4 lumber about 30 inch long, laid flat side down and running at a right angle to the proposed direction of the flooring (Wagner, 1976). Fig. 4.26 shows the basic steps followed in making the installation. The floor was first cleaned and primed, and then chalk lines were snapped 16 inches apart.

Fig. 4.26 Installing strip wood flooring over concrete slab: A: applying rivers of mastic along layout lines. B: nailing bottom strips in space. C: spreading polyethylene film over bottom strips. D: nailing top strips to bottom strips. E: nailing strip flooring to sleepers. (Source: Berkeley, 1968)

Bands of adhesive for bonding were then applied along the layout lines. Treated wood sleepers were embedded in the adhesive and secured in place with 1.5 inches concrete nails. Then a layer of polyethylene film was laid over the strips after all bottom sleepers were in place. When the vapor barrier was in place, the second layer of strips was nailed to the bottom layer. Strip or plank flooring was then installed in the same way as previously described, taking care that no two adjoining flooring strips broke joints in the same space between sleepers.

Pre-finished floor started to be produced at this time but was not very popular because the price was relatively expensive and the installation had to be done with special care and accuracy (Landry, 1984). Although face nailing could be covered with special filler materials, it had to be minimized when working with pre-finished material. Hammer marks caused by careless blind nailing were extremely difficult to repair. Furthermore, it could not stand long-term wear and tear as the technology had not been extensively developed. However, the invention of linoleum and its efficient way of installation in this period enhanced the resistance of floor to the moisture.

In the 1990s, the invention of Medium Density Fiberboard (MDF) has made the innovation of laminated floor possible. It was invented especially for the convenience of home renovators. It has the comfort and appearance of real wood but has a much more affordable price and an easier installation process. Not only does this floor have exceptional quality and durability, but it also offers a great variety of textures that resemble different kind of natural wood. Furthermore, it can be installed on almost any kind of existing floor without unsightly nails, grouting or adhesive. All the pre-finished panels are tongue-and-groove held together by glue. Corners or front door areas are

finished with different types of moldings. Home renovators can even install it directly over the concrete slab in the basement, because the polyethylene foam under the floor and the melamine in the floor protects the floor from moisture damage.

The 8.2mm-thick floor contains 4 layers. The first layer is a highly durable protective coating which provides a wear-resistant surface. The second layer is the decorative surface which offers a wide selection of texture. The third layer is the high-density fiberboard which provides a tongue-and-groove system and the last is the balancing layer which provides dimensional stability and a moisture barrier for added protection. Fig. 4.27 illustrates the structure of the laminated floor. As all the panels are pre-finished, no heavy or power tools are needed for the installation. A special simple tool is provided in order to tighten the seams. Complete fittings and simple tools help the homeowner to enjoy their work while saving money. Fig. 4.28 illustrates this tool and the floor installation accessories. In order to facilitate home renovation, the manufacturers also provide videotapes to illustrate the whole process.

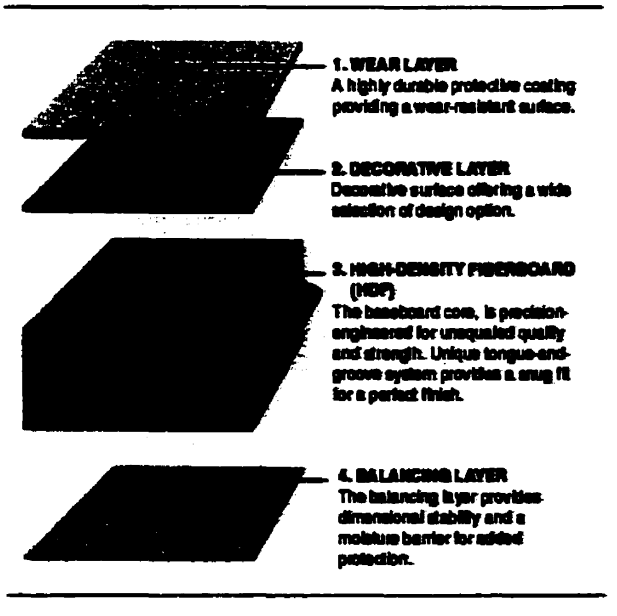


Fig. 4.27 The structure of laminated flooring. (Source: Quickstyle, 1998)

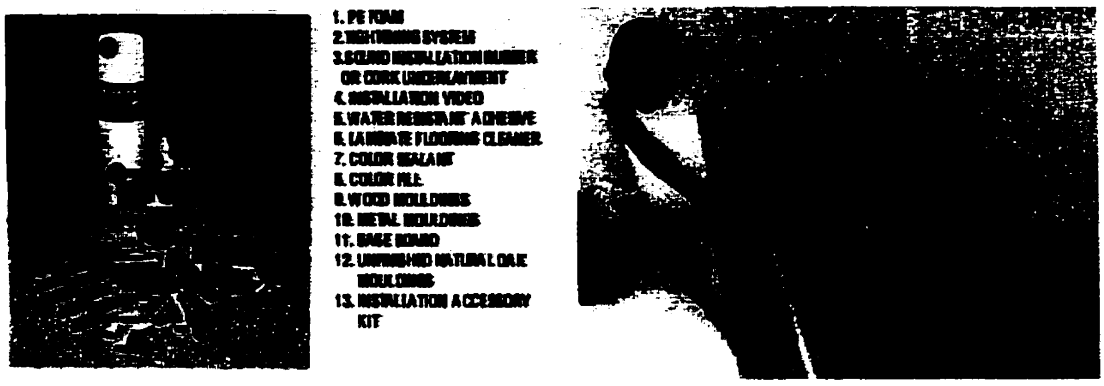


Fig. 4.28 The tightening tool and accessories of laminated floor installation. (Source: Quickstyle, 1998)

In summary, before the 1940s all floors were installed on site. Even sanding and varnishing were done manually on site with rugged tools. Normally it took a long time to complete the whole process. For these reasons, although the industry had already started to produce prefabricated flooring panels with tongues and grooves on the end as well as the edge in the early 1910s, few homeowners would considered handling the job by themselves (Charles & White, 1912). Mass housing accelerated the inventions of new tools like the power nailer and more sophisticated prefabricated flooring strips which increased the speed and efficiency of new floor construction. Naturally, these inventions were beneficial to home renovators, but the difficulty of controlling these tools was still an obstacle for most. Mainly stimulated by the market demand, more manufacturers started recently to develop products that facilitate renovators' modifications. Multi-Bond System and Wood-Based Core were typical products which focused on the need of home renovators and which lead to the innovation of laminated floor.

4.4 INTERIOR PAINTING

Painting is certainly one of the most popular projects for do-it-yourself home renovators. Almost every homeowner has tried painting for the purpose of improving his or her living environment.

Before the 1940s the range of colours that users could choose from was very limited and many colours needed to be manually mixed by renovators. The most popular paints were those consisting of a base of white lead or a mixture of white lead and zinc oxide, and an oil vehicle, a paint which was commonly referred to as oil paint. Both of these bases were white in colour and any paint of which they formed the base had to be "stained", as it was termed, by the addition of suitable pigments to obtain a colour finish. If two kinds of pigments were to be used in the paint, they were broken down in separate containers and were mixed only when both were fluid enough to run freely (Molloy, 193-?).

Brushes were the tools used in all kinds of painting. Ladders were often used with the buckets full of paint hanging beside the ladders, but some areas such as ceilings remained difficult to reach. Fig. 4.29 illustrates the use of a brush for painting. Users chose different sizes and types of brushes when painting on different kinds of textures and surfaces. It required significant care and skill to avoid large numbers of brush marks or streaks. Furthermore, the efficiency of large-area painting was decreased because the professionals recommended using narrow brushes. The reasoning was that applying paint in narrow strips would ensure that the edge of each strip remained sufficiently wet for the next one to blend freely into it. Thus the top edge of the strip would not become dry or

Fig. 4.29 The brush was the only tool for painting in this period and some places were difficult to reach. (Source: Goldstein, 1998)
Right: a homeowner painting with a brush.
Left: a homeowner painting a ceiling.

comparatively dry before the bottom half of the strip was finished, which would result in distinct marks between the strips. But no matter how careful one might be with the application of paint by brush, it was still difficult to avoid unsightly marks. The method of "stippling" was developed to solve this problem. This consisted of the application of a special "stippling" brush to the surface after the paint had been applied with an ordinary paintbrush and while the work was still wet. Fig. 4.30 shows the painting and stippling technique.

Left: Fig. 4.30 A crude method of painting before the 1940s: to get a satisfactory surface texture, it was better for two people to work together, one to distemper while the other used the stippling brush on the freshly distempered wall. (Source: Molloy, 193-?)

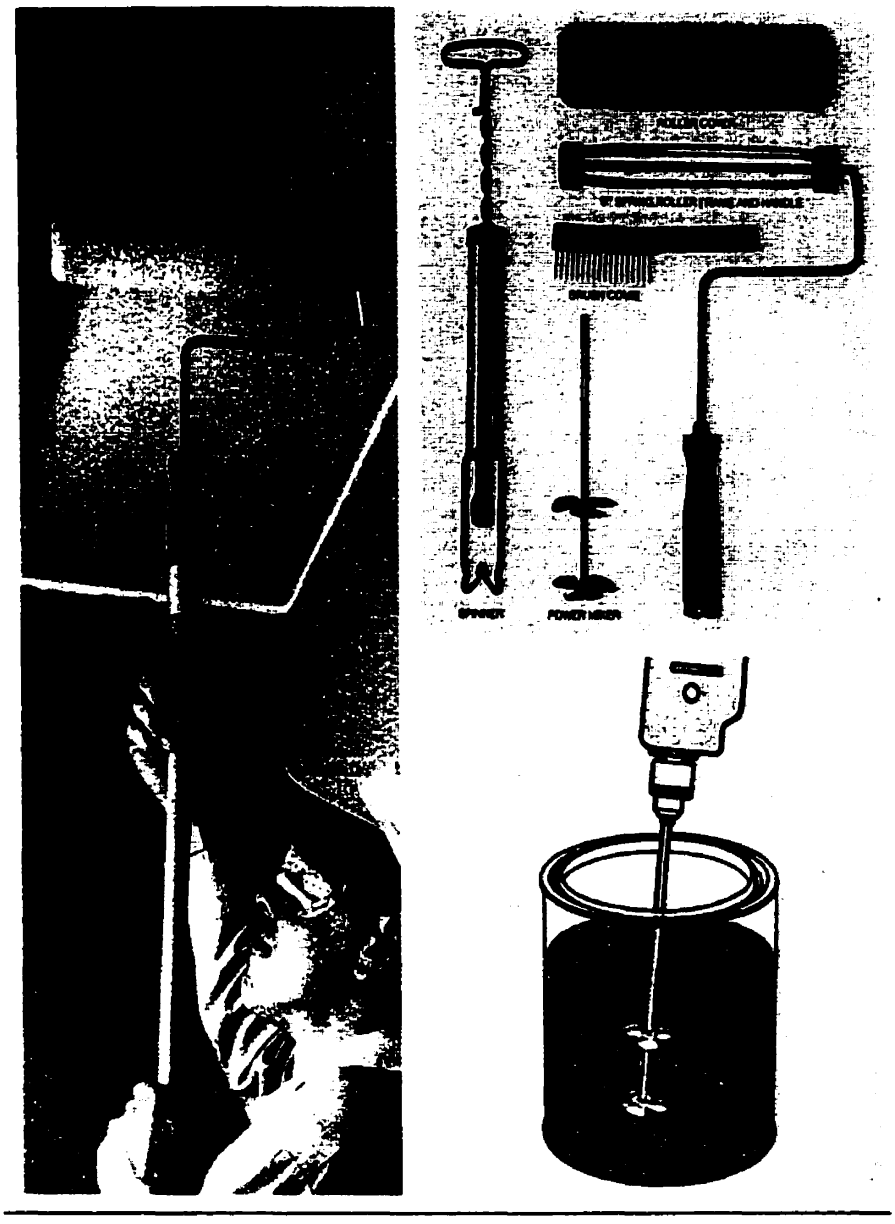
Right: Fig. 4.31 The first generation of airbrush outfit which was invented in the 1930s consisted of a hand pump with air tank. The spray was controlled in volume, and could be started and stopped by thumb pressure on the Paint container. (Source: Molloy, 193-?)

Another technological improvement was the production of ready-mixed paints in the early 1940s, but users still preferred to mix the color paints at home because they were too expensive and could not be purchased in small quantities. The airbrush was also invented to increase efficiency in painting large areas (Fig. 4.31). But it was difficult to operate and it could not reach remote areas because of the limited pressure created by

compressed air. It was also difficult with airbrushing to attain a sharply defined edge and a dense, even texture (Molloy, 193-?).

In the period between the 1940s and 1990s, the most important innovation was the invention of the painting roller in the 1950s (Goldstein, 1998). The painting roller not only greatly improved the efficiency of painting but also the quality of homeowners' work. Homeowners were pleased to find that a fresh infusion of new colour could transform the most ordinary room into an inviting living space even without changing expensive furniture or carpeting. Fig. 4.32 illustrates the simplified method of ceiling painting and Fig. 4.33 illustrates the components of a painting roller, the power mixer and the spinner used to clean the roller. The painting roller composed of a roller cover and a roller frame and handle. The cover is wrapped in a spiral around the central core (if it were not made this way, ridges would appear in the painted surface). The frame has a spring cage that holds the core firmly in place. Nylon bearings at the end caps of the frame help the cover turn smoothly. The handle is contoured for a comfortable grip, and the end of the handle is threaded to accept an extension pole. This is very important because people often need to paint the ceiling or higher places, and they need an additional pole to help them reach. The spinner makes it easy to clean the cover after painting, whereas the brush was very difficult to clean after use.

In another development, manufacturers produced a variety of paints suited for different kinds of surfaces, ranging from washable flat latex to gloss enamel. Gloss enamels dried to a shiny, reflective surface and were used for surfaces that might be washed often, like bathrooms and kitchens. Flat paints were most commonly used for wall and ceiling applications in family rooms and bedrooms. The job of mixing was



Left: Fig. 4.32 Top right: A renovator using a roller to paint the ceiling. (Source: Black and Decker, 1976)
Right top: Fig.4.33 The components of a painting roller and the spinner used to clean the cover. (Source: Time-Life Books, 1976)
Right bottom: Fig. 4.34 Power mixing is more convenient than manual mixing. (Source: time-life books, 1976)

gradually taken over by the paint dealer who would use a machine to give paints a vigorous shake at the time of purchase. Manual mixing by the homeowner was replaced

by power mixing which made the mixing more convenient and efficient (Fig. 4.34). A variable-speed electric drill with a two-blade mixing attachment could stir a can of paint quickly.

In the 1990s, durable thin roller frames of different sizes can help renovators reach corner areas or do some small-area painting without moving their furniture. Roller covers are designed to hold more paint and provide finishes of a higher quality. Different kinds of special tools including the airless sprayer have been invented for home renovators to paint on surfaces which are hard to reach (Fig. 4.35). Masking tape, another grate invention, is also used for protecting fixtures or certain areas that

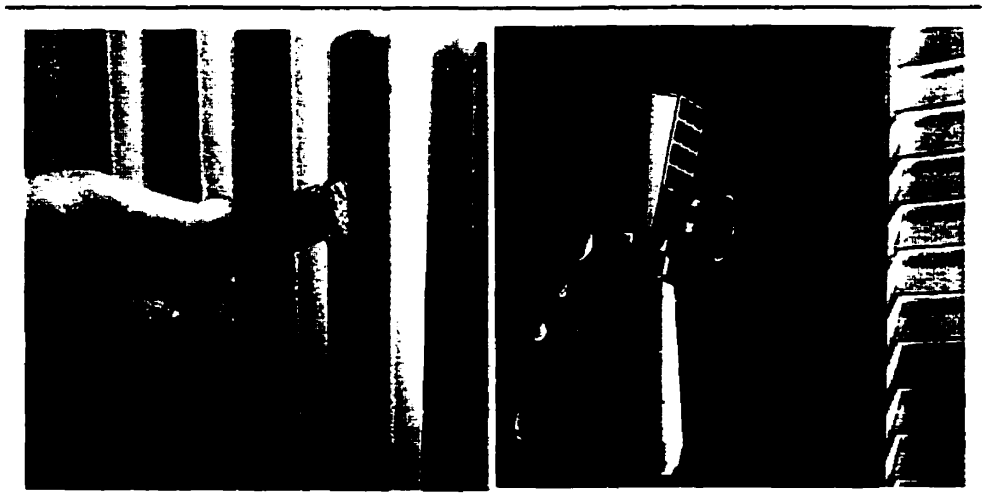


Fig. 4.35 A variety of tools invented for renovators to paint on different kinds of surfaces. (Source: Black and Decker, 1976)

homeowners do not want to paint. Adjustable extension poles help renovators to reach any place in the room without erecting a ladder. Another important innovation is that all colours are now formulated by computer and mixed by machine. Home renovators can have exactly the same customized color in just a few minutes. They no longer need to do

the messy mixing at all. On the other hand, the quality of the paints has also been greatly improved. Not only they are water-washable (no hazardous solvents needed) and environmental friendly, but also they have little odour and excellent adhesion. Many of them are quick-drying and can be top-coated in the same day. For renovators who need to use a sprayer, there are also items designed for easy spraying. These improvements offer renovators more convenience and help them obtain better finishes with less effort.

In summary, interior painting has long been one of the best ways to improve the living environment at an affordable price. For this reason, many manufacturers have focussed on the technological improvement of this market. The most important invention, the painting roller, happened as early as the 1950s. During the following years, this market continue to be one of the most competitive markets for manufacturers because of its huge potential. Thus, varieties of painting tools which suit different surfaces have been developed and also the quality of paint has been continuously improved. Sophisticated computer technology today allows for computerized color mixing, which offers home renovators more accurate colour tones and a wider range of colour choices.

4.5 PARTITIONS

Before the 1940s, the most popular partition used by renovators was called a "studded" or "lath and plaster" wall, which was comparatively light and quite capable of being supported by the standard joists (Molloy, 193-?). It was constructed with a number of timbers 3 by 1.5 inches that were nailed on top of the floorboards and under the ceiling joists. Upright studs were then erected between these two rails, evenly spaced about 14 inches apart except where the doorway occurred. Fig. 4.36 shows the bare studding of a

lath and plaster partition. The framework needed to be stiffened with horizontal bridge pieces between the uprights, about 3 feet apart as shown to distribute any side pressure caused by, for example, an individual leaning against it. Sometimes a diagonal strut had to be employed in addition to the bridge pieces. Also, laths needed to be nailed horizontally across the studs on either side of the frame to prepare for the plaster (Fig. 4.37). Even not counting the messy wet plaster, on-site woodwork was also difficult.

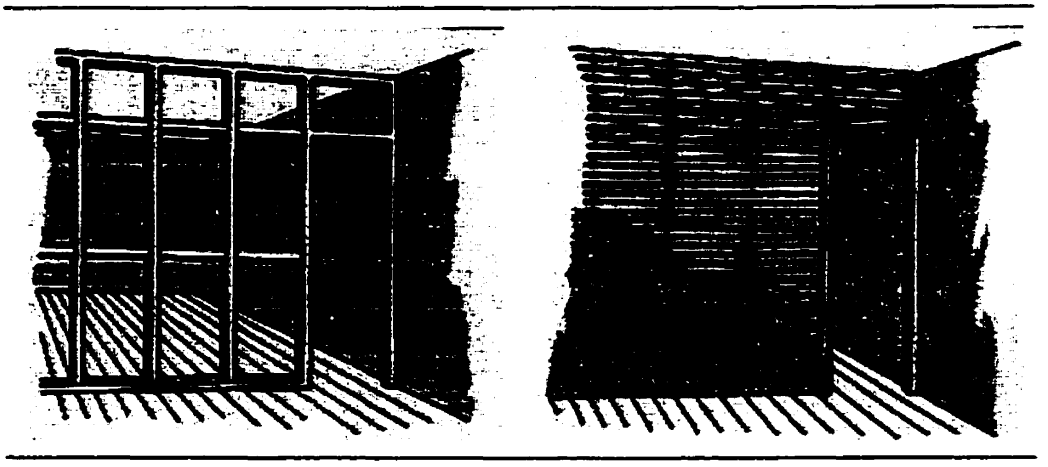


Fig. 4.36 The bare studding of a lath and plaster partition..
(Source: Molloy, 193-?)

Fig. 4.37 Lath and plaster partition shown partly plastered. The partition was totally finished by wet plastering.
(Source: Molloy, 193-?)

In the period between the 1940s and 1990s, the use of prefabricated gypsum board wall panels with different finish colours and textures greatly simplified partition building for home renovators. It is made of plaster, pressed into a sandwich, usually ½ inch thick, 4 feet wide and 8 feet long, with heavy white, gray or off-white paper on the front and heavy kraft paper on the back. It can be easily cut with a saw or knife into different-size panels (Fig. 4.38). One easy way to build a partition was like hanging a curtain: the frame of the new partition was installed not from the floor up, but from the ceiling down. Only

in the last step was it fastened to the floor. Most of the frame could be assembled flat on the floor. It was then lifted as a unit over a beam called a sole plate that was nailed to the floor. Once upright, the wall frame was fastened in place by nails driven through a second beam called a top plate, and into the joists hidden above the ceiling. Finally the bottom of the assembly was secured by nails driven through the sole plate (Black and Decker, 1976).

Fig. 4.38 Wallboard was developed to be cut with a knife or saw. Left: cutting the board with a knife. Right: cutting the board with a power saw. (Source: Wagner, 1976)

For this final step, renovators had to master the technique of toe-nailing. In order to make it more stable, the new partition could run either across the ceiling or under a single joist, so that the top plate could be nailed directly into a beam or beams above it. All the studs were pre-finished and other parts of the partition could be cut in the store when renovators bought them. Even the door was prefabricated from the manufacturer. That way, the Gypsum wallboard could be cut into customized sizes and installed directly on the frame. Fig. 4.39 shows a renovator installing wallboard on a partition frame.

Fig. 4.39 A renovator installing wallboard on a partition frame.
(Source: Black and Decker, 1976)

The innovation in partition-building for home renovators in the 1990s is the invention of demountable pre-fabricated partition systems. One of the most popular products is the Westroc modular partition. The ready-to-install partition kit contains main panels which are made with different kinds of finishes, colours and varieties of fittings. This system is very easy to install and can be quickly reassembled or disassembled without disturbing the adjacent walls. The use of innovative Econo Clips not only simplifies the installation process, but also eliminates damage to wood floors or unsightly holes in the carpet. In addition, home renovators can also benefit from the low maintenance cost and the accommodation of future modifications because of electrical,

mechanical or communications requirements. Fig. 4.40 illustrates this demountable partition system. All the wiring can easily pass through the partition, and it costs much less to move a demountable wall than it does to remove and re-build a partition built in the traditional method.

Fig. 4.40 The demountable partition system used in the Next Home. (Source: Friedman, 1996)

Partitions are used to re-define space when the composition of a household changes. At the beginning of this century, the method of on-site building and wet plastering was very time-consuming and difficult. Both the wood working and especially the wet plastering was definitely beyond the ability of most home renovators. The invention of gypsum panels made panel wall assembly possible, and power tools simplified the process of cutting the panel into customized sizes. On the other hand, the need for flexibility in commercial buildings accelerated the invention of removable.

Today, the latest technology has been successfully transferred to residential buildings. The innovation of prefabricated demountable partitions not only offers home renovators easy installation, but also the possibility of removing the partition to accommodate family change. The Westroc Partition provides full flexibility at an affordable price, without damaging the floor, ceiling or walls.

4.6 CEILING

Before the 1940s, the opal ceiling and the suspended ceiling had the best reputations among home renovators. An opal ceiling was often used in the kitchen or bathroom (Fig. 4.41). It used wood batten and opal glass as the material to decorate the ceiling.

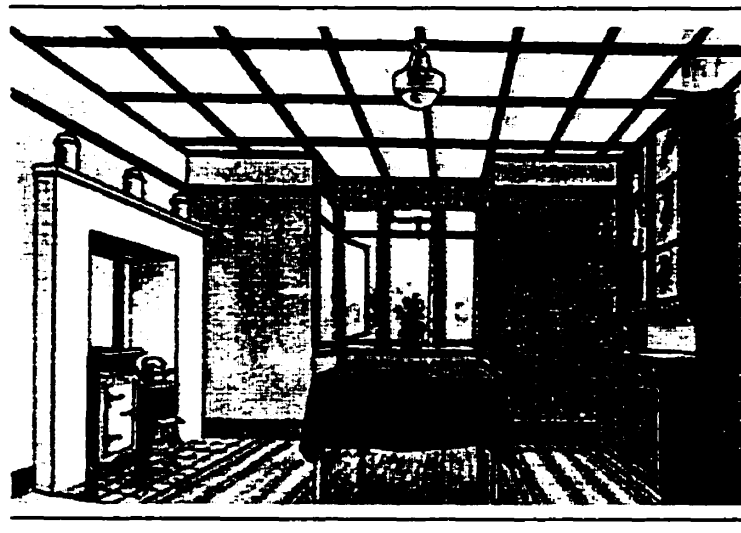


Fig. 4.41 Opal ceiling was once very popular for the kitchen or bathroom. (Source: Molloy, 193-?)

First the whole ceiling area had to be divided into squares with slats. The opal sheets were then put up and held in position by a flat molding with a small rebate along each edge that was screwed to the foundation of battens. At first the grooved molding was cut with a special plane in two edges of the flat slats. Later it was produced in factories but the price was relatively expensive. Before the rebated molding could be fixed, it had to be measured carefully and cut into suitable lengths (Molloy, 193-?). Often the moldings had to be painted to match the room colour, another time-consuming job. Then the panes were slid in row by row. Fig. 4.42 shows a detail of the opal ceiling.

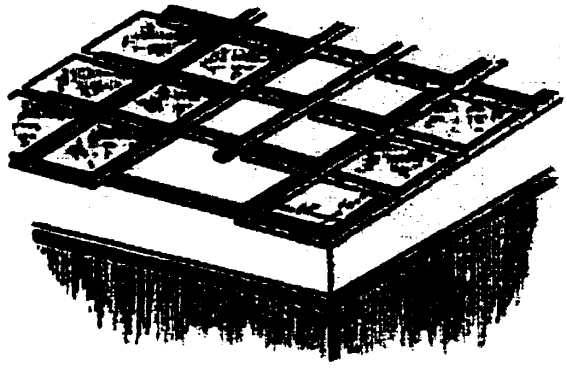


Fig. 4.42 Opal ceiling of a room corner with one Opal pane removed showing construction. (Source: Molloy, 193-?).

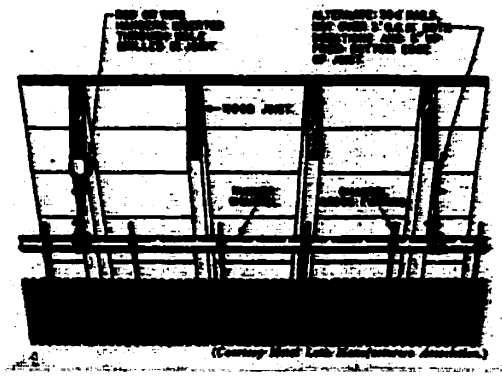


Fig. 4.43 Suspended ceiling constructed with metal runners and lath. (Source: Hawkins & Abbe, 1948)

Later a suspended ceiling was invented for the same purpose. Such a ceiling was constructed of metal runner channels, metal-channel cross furring, and metal laths (Fig. 4.43). The hangers were located about 4 ft. apart, so that one of them would support more than 16 sq. ft. of ceiling. Suspended ceilings could also be built on frameworks of wood suspended from the ceiling joists (Fig. 4.44). The suspended framework had to be built to make a suitable backing for the particular surface material. If the construction shown in

Fig. 4.43 was to be covered with plywood panels, the suspended framework had to be constructed of wood to provide nailing supports for the plywood panels, the drawback being that nail holes would show on the surface. Also fiberboard tiles began to be put into use (Hawkins & Abbe, 1948). To install ceiling tiles, first wood furring had to be carefully installed and then the tiles were attached with adhesive. Fig. 4.44 illustrates how fiberboard tile was attached with adhesive.

Fig. 4.44 Attaching fiberboard tile with adhesive.
(Source: Hawkins & Abbe, 1948)

Between the 1940s and 1990s, one innovation in the installation of suspended ceilings consisted of a metal framework especially designed to support a given type or size of tile or panel. To install such a ceiling, homeowners first needed to determine the height of the ceiling and attach a metal molding to the perimeter of the room. Then the main runners were installed by resting them on the wall molding and attaching them to wires tied to screw eyes (Fig. 4.45). After all the main runners were in place, carefully leveled and securely attached to the supporting wires, the cross tees were installed (Fig. 4.46). Then the renovator would check the required spacing for the tiles or panels and insert the end tab of the cross tee into the runner slot. Then the panels could be installed. Each panel was tilted upward and turned slightly on edge so it would fit through the opening, as illustrated in Fig. 4.47.

Fig. 4.45 Left: installing screw eyes in a joist to support metal runners. Right: tying a runner to a screw eye with wire. (Source: Wagner, 1976)

Fig. 4.46. Installing cross-tees between main runners. (Source: Wagner. 1976)

Fig. 4.47 Ceiling panels were raised above the grid and then lowed into place. (Source: Wagner, 1976)

Another innovation in the installation of tiles was the stapling installation method. Furring strips were built in the same way as was done conventionally, but the tiles were stapled to the furring strips one by one with a special stapler according to the width of the border tile. Fig. 4.48 illustrates the installation of the furring and Fig. 4.49 shows the tile being stapled.

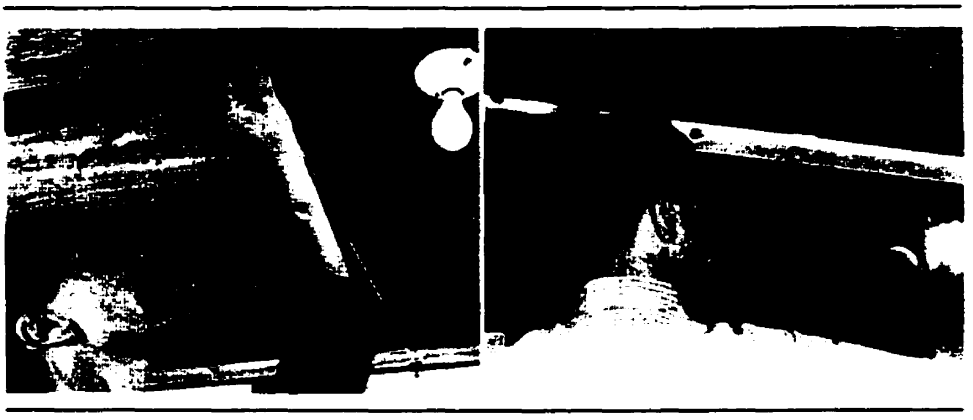


Fig. 4.48 Installing furring. (Source: Wagner, 1976) Left: using a chalk line to mark the place of ceiling layout. Right: nailing the furring stripes one by one.

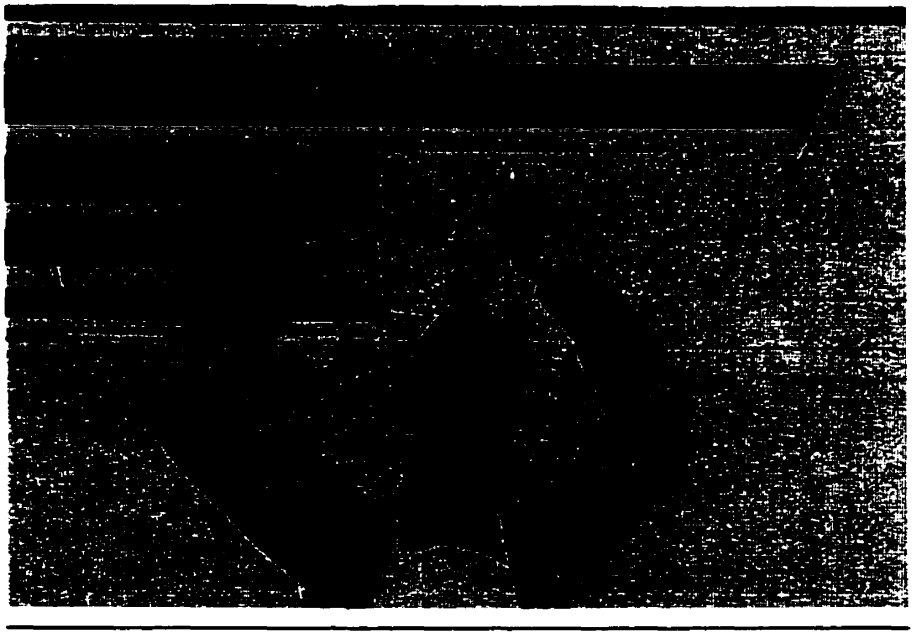


Fig. 4.49 Stapling tile to furring strips. (Source: Wagner, 1976)

In the 1990s, The Armstrong Corporation developed three kinds of prefabricated ceiling kit. They are user friendly and designed especially for home renovators' do-it-yourself projects. Each of them is very easy, quick, and less costly to install, and can be used either for basement renovation or for installing a new ceiling in an existing living area. The first is the Suspended Ceiling Grid Kit. With all the prefabricated panels and fittings, the installation process is extremely simple: first install the wall molding, suspend the hanger wires, and main beams, and then install the cross tees and panels. Fig. 4.50 illustrates the installation of this suspended ceiling. This package not only provides easy access to electrical and plumbing fixtures, but also increases the efficiency of heating and cooling systems. For renovators who do not have the space to hang a suspended ceiling, Armstrong provides the Ceiling Tile Installation Kit. The use of special furring tapes helps renovators install ceiling tiles directly onto an existing dry wall ceiling without messy adhesives or special tools (Fig. 4.51). For renovators who want to cover damaged drywall ceilings, There is a third choice: by using tile tracks, tiles can easily be installed to cover the damaged drywall (Fig. 4.52).

Fig. 4.50 The easy installation of the suspended ceiling kit. (Source: Armstrong, 1999)

Fig. 4.51 By the use of innovative furring tapes, tiles can be directly installed on drywall ceilings. (Source: Armstrong, 1999)

Fig. 4.52 Installing tiles on damaged drywall ceilings. (Source: Armstrong, 1999)

Before World War II, when houses were often treated as shelters for households, little attention was paid to the appearance of ceilings. Renovators had to pay large amounts of money and spent a great deal of time to install ceilings, with limited choices of design. The post-war boom in the housing industry not only incubated innovation in construction technique but also technological innovations which facilitated home renovators' modifications. For example, the industry started to provide prefabricated panels and metal runners. Simultaneously, households were no longer satisfied with the house as shelter, but also expected comfort and beauty. The metal frame suspended ceiling was therefore invented to improve the room aesthetically and also to cover the pipes and wires above the ceiling. Again, in recent years the increasing demand of the do-it-yourself market is the main incubator of the ceiling kit systems for renovators.

4.7 STORAGE ACCESSORIES

In the first twenty years of this century, homeowners used to use a small dresser as a storage place for clothes (Fig. 4.53). Later they realized the convenience of more storage place for daily life, and renovators started to plan and build closets with sizable dimensions. Built-in storage and bigger freestanding closets were put into use according to different space arrangements. Fig. 4.54 shows an efficient built-in storage space. These storage spaces were all built on site, and the tools used were all manual and crude. To open a hole, the keyhole saw had to be used (Fig. 4.55) and to open a small hole for a screw, a twist was required (Fig. 4.56).

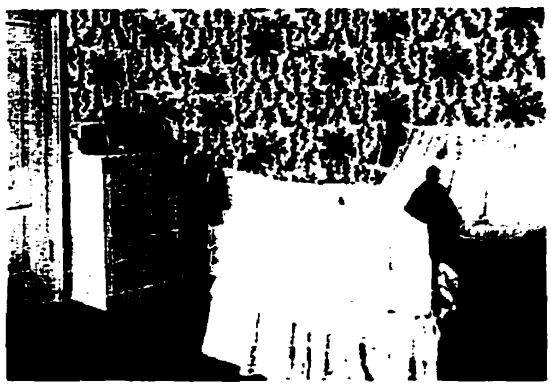
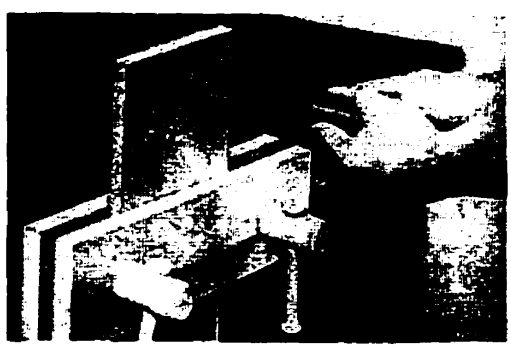


Fig. 4.53 A small dresser was used to store clothes in the bedroom.
(Source: Dunham & Thalberg, 1945)

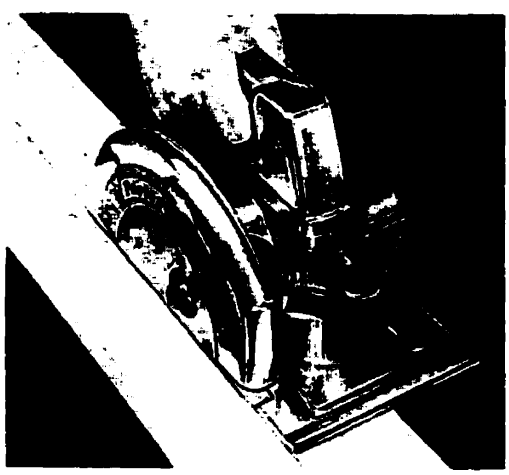
Fig. 4.54 An efficient built in storage closet in the bedroom.
(Source: Hawkins & Abbe, 1948)



Left: Fig. 4.55 Opening a hole with a Keyhole saw. (Source: Molloy, 193-?)

Right: Fig. 4.56 Boring through wood using a twist. (Source: Molloy, 193-?)

In the period between the 1940s and 1990s, the freestanding closet was manufactured by the industry but most of the storage cabinets were still built on site. The innovation of woodworking power tools like the electric drill (Fig. 4.57) greatly reduced the time required to perform many operations and enhanced the accuracy of the carpentry work. If you compare these tools with the tools used in the previous period, the remarkable improvements brought about by technology are evident. The power plane (Fig. 4.58) provided the renovator with a tool that produced a finished surface with speed and precision. The motor operated at a speed of about 20000-rpm and drove a spiral cutter. It could be operated just like the hand plane. The portable circular saw (Fig. 4.59) which was also called the electric hand saw could be used to make different kinds of cuts by changing the saw blades. The portable router (Fig.4.60) was used to cut irregular shapes and to form various contours on edges. It could also be used to cut dados, grooves, mortises and dovetail joints. The portable sander (Fig. 4.61) could easily sand the surface of different kinds of wood. Another tool worth mentioning was the saber saw. It was a portable electric jig saw that could be used for a wide range of work. Fig. 4.62 illustrates the different uses of the saber saw. Fig. 4.63 shows a renovator making a closet and Fig. 4.64 shows the use of power tools to build the closet.



Left top: Fig. 4.57 The electric drill was one of the first industrial-purpose tools to become a staple of home workshops. (Goldstein, 1998)

Right: Fig. 4.58 Using the power plane to surface a board. (Source: Wagner, 1976)

Left bottom: Fig. 4.59 Using a portable saw to rip along a line. (Source: Wagner, 1976)

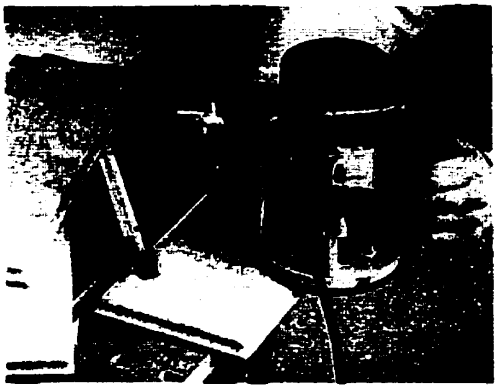


Fig. 4.60 Using a Portable router to cut a groove. (Source: Black and Decker, 1976)

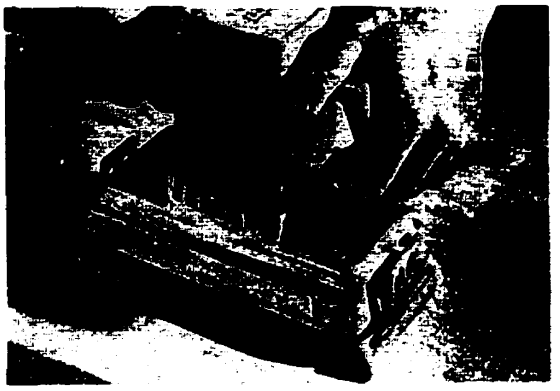


Fig. 4.61 The portable sander was another kind of tool which simplified woodworking for homeowners. (Source: Wagner, 1976)

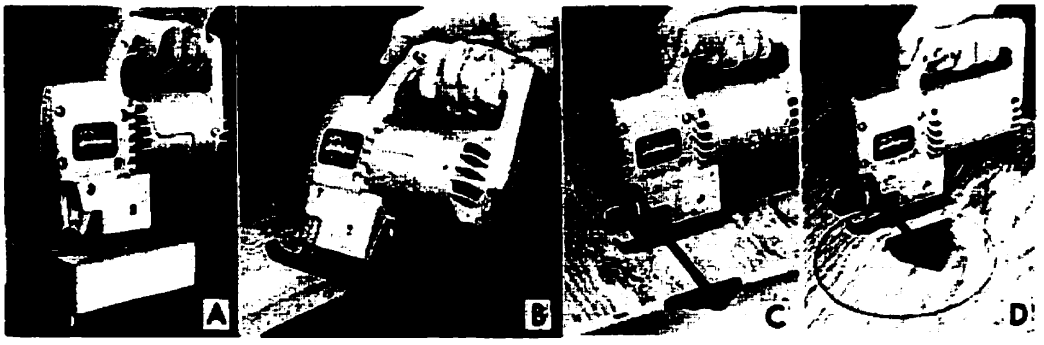


Fig. 4.62 Different uses of the saber saw: A: straight cutting. B: angle cutting. C: using a fence. D: circle cutting. (Source: Wagner, 1976)

Fig. 4.63 Most of the closets were still built on site between the 1940s and 1990s. (Source: Wagner, 1976)

Fig. 4.64 Power tools simplified the carpentry work. (Source: Black and Decker, 1976)

In the 1990s, different sizes of prefabricated closet kits have been manufactured by the industry. These innovations have made the work of renovators simpler than ever. Manufacturers provide not only many varieties of freestanding closets that can be used in the bedroom, living room or bathroom, but also adjustable shelves, doors (including bi-fold and sliding doors) and all the fittings for walk-in wardrobes and built-in closets. Even full packages of adjustable shelving systems (including adjustable brackets and mounting tracks) are available in many hardware depots (Fig. 4.65). Most of the products are available in kits of popular sizes and some can even be custom-made. Flexible combinations allow home renovators to tailor the kit to their individual preference. Fig. 4.66 shows a built-in closet that can be easily assembled by renovators. Fig. 4.67 shows the easy assembly steps of a kit closet package.

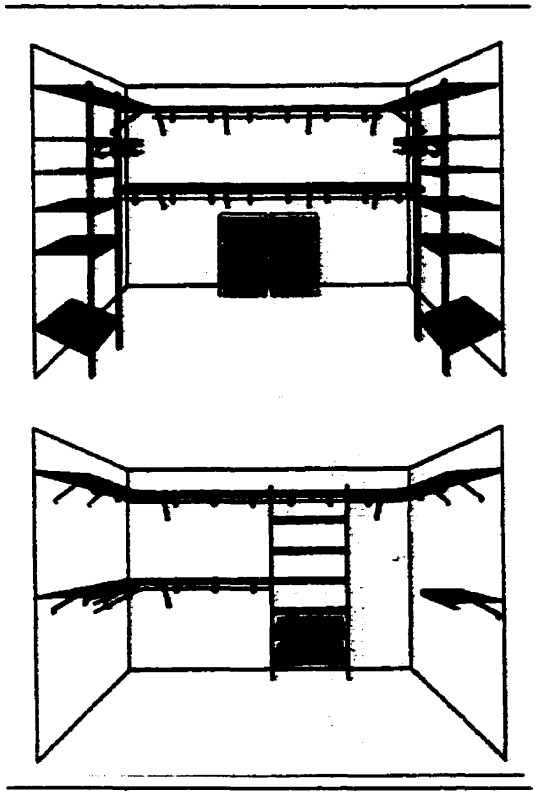


Fig. 4.65 Examples of adjustable kit shelving systems. (Source: MaxTrack, 1999)

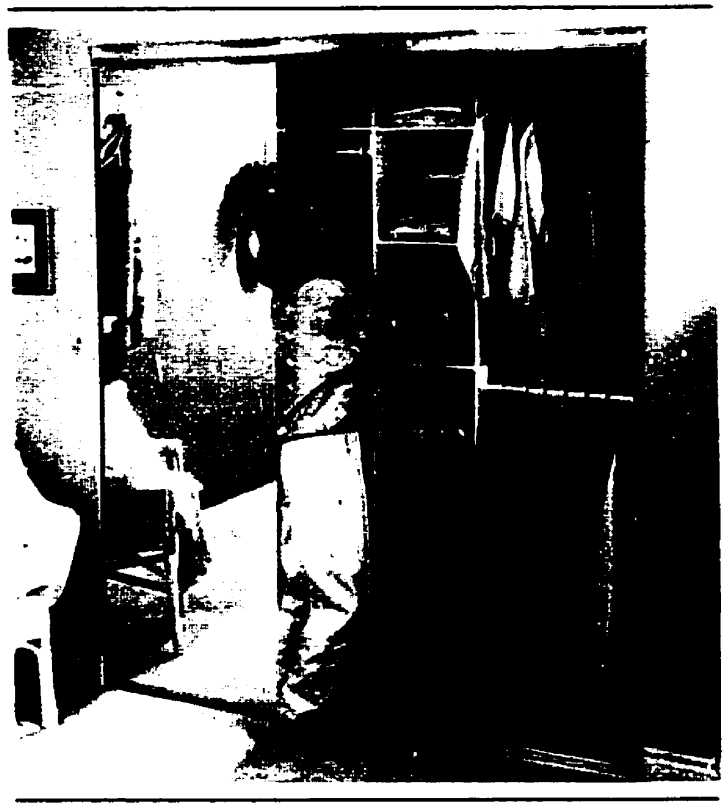


Fig. 4.66 A closet like this is very easy to assemble. (Source: Staney, 1999)

Fig. 4.67 The easy installation steps of a kit closet package. (Source: Staney, 1999)

The increasing need for more storage room is the main reason for innovations in the building of storage space. At the beginning of this century, a freestanding closet was enough for family storage. Soon it was replaced by built-in storage because it is an efficient way to add more storage room within limited space. The invention of particle board, masonite, and hinge helped to simplify the assembling process. Also, the invention of power tools for woodworking improved on-site working efficiency and enticed more homeowners to build storage space themselves. In the 1990s, more homeowners have started to build additional storage in order to accommodate family changes. Prefabricated storage kits are a result of manufacturers' competition stimulated by market need. These revolutionary packages relieve renovators of complicated on-site carpentry work. Renovators no longer need to spend several days building storage space on site, but only a few hours in assembling the kit package.

4.8 STAIRS AND RAILINGS

Before the 1940s, building stairs was extremely difficult for renovators because all the whole components, such as treads, risers, handrails or springboards, were made manually. To keep every component in firm connection renovators had to cut each part to precisely defined dimensions.

A staircase was mainly composed of carriages, stringers, risers, treads and rails. Carriages or rough stringers were the main framework that supported the stair treads and risers. Stringers were the sloping sideboards against which the risers and treads terminated. Sometimes they might serve also as a carriage and support the risers and

treads. Treads were the horizontal planks that acted as small beams and spanned the gap between the stair carriages. Risers were the vertical boards that also served as mini beams and helped make the stair construction rigid. To build such a structure, home renovators needed to make every component manually on site. The riser and treads were tongued and grooved into one another and strengthened by short triangle blocks (at first they were square blocks). The grooves were tapered and with the treads and risers in position wedges were glued and driven in under and behind them respectively. Fig. 4.68 shows the old-fashioned assembling of a handrail.

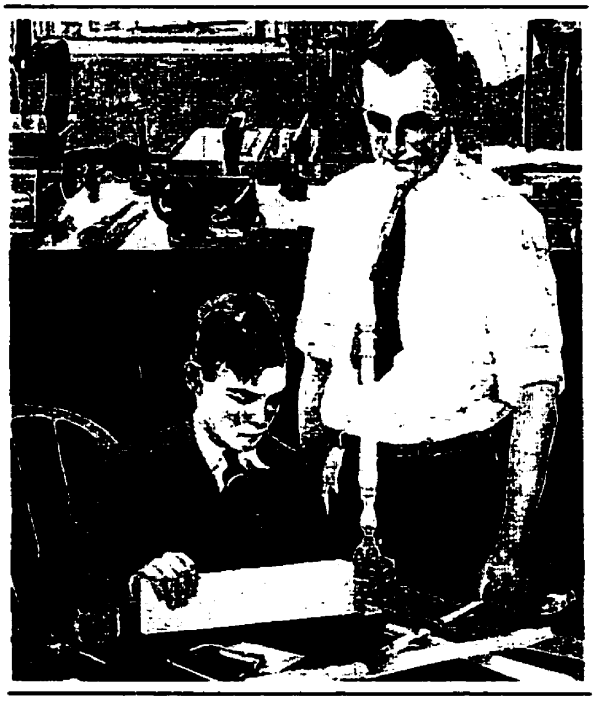


Fig. 4.68 Making a handrail with basic tools.
(Source: Goldstein, 1998)

In residential building, the one-story house had dominated the last period before the war, and this had minimized the necessity of stair construction for many years. In the period between the 1940s and 1990s, however, the trend towards traditional styling, along with split-level and multi-level designs, placed a new emphasis on this important item. To add a new staircase after removing the old one, renovators usually had to build temporary stairs from wasted lumber to provide easy access to the other level of the structure until the permanent stairs were installed. Sometimes carriages were installed during the rough framing and temporary treads were attached. Later, these treads would be replaced by other finished parts. The invention of power tools in this period also accounted for improvements in the construction of staircases.

Another innovation was that some of the components, like treads and risers, started to be prefabricated by manufacturers (Gerald, 1979). This was largely stimulated by increasing market demand. Although the carpentry work was simplified by the use of these components, only those homeowners who understood all the components very well and knew the construction procedure could handle the whole process (Fig. 4.69). Fig. 4.70 illustrates renovators' main procedure for building a staircase. A: A stair carriage consisting of three strings is built. B: A skilled carpenter installing the first two risers. The top edge of the riser must be perfectly aligned with the supporting members so that no crack would show when the treads were installed. C: The first tread is installed. In addition to face nailing of risers and treads, several nails are driven through the back, lower edge of the riser into the tread. D: The balustrade is assembled. The handrail is installed temporarily and then the position of the balusters are laid out on the tread and projected to the rail.

Fig. 4.69 Most staircases were still built by professionals. (Source: Wagner, 1976)

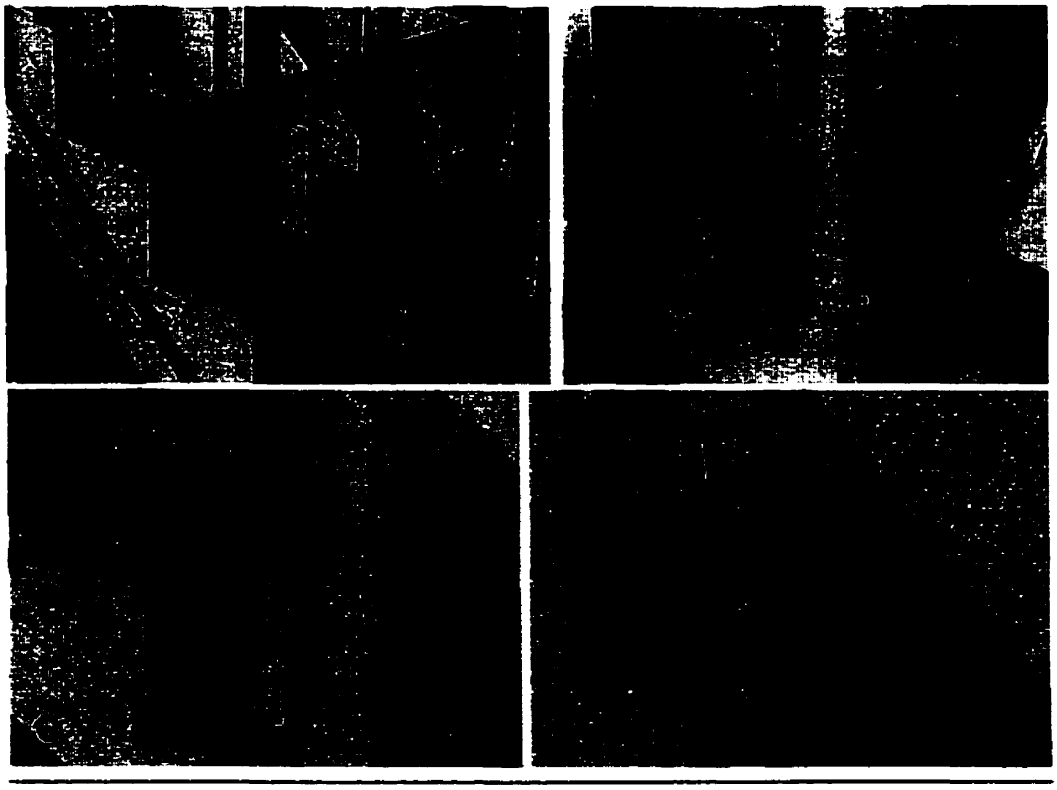


Fig. 4.70 Typical procedure for building a staircase. (Source: Wagner, 1976)

In the 1990s, the greatest technological improvement has been that the handrails, balusters, newels, and fittings, including classical and contemporary styles are manufactured by the industry. Fig. 4.71 shows some prefabricated components of the staircase. Two innovative approaches to staircase building in this period are the APC system (adjustable prefabricated carriage system) as illustrated in Fig. 4.72 and the prefabrication of the whole staircase as illustrated in Fig. 4.73. With the APC system, the stair carriage was prefabricated for the first time. By adjusting the metal panel on the carriage, renovators can choose the size of treads and risers themselves. Moreover, the whole staircase can also be prefabricated in plywood, and renovators just need to assemble it between the floors.

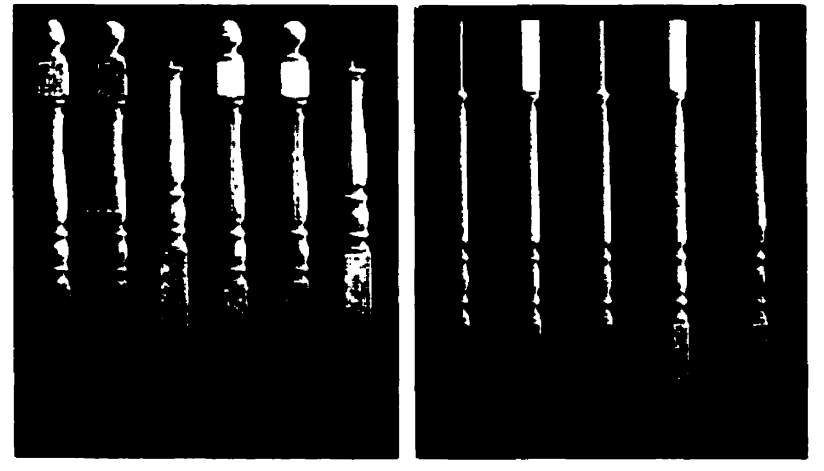


Fig. 4.71 Varieties of stair components produced by manufactures.
(Source: Colonial Elegance Inc., 1999)

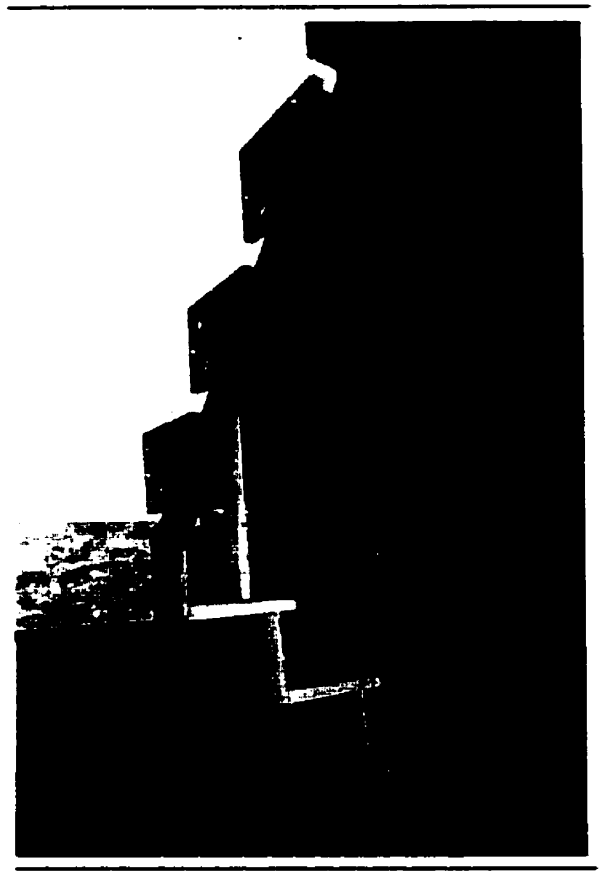


Fig. 4.72 The APC system makes stair building much easier than before. (Source: Stairframe, 1999)

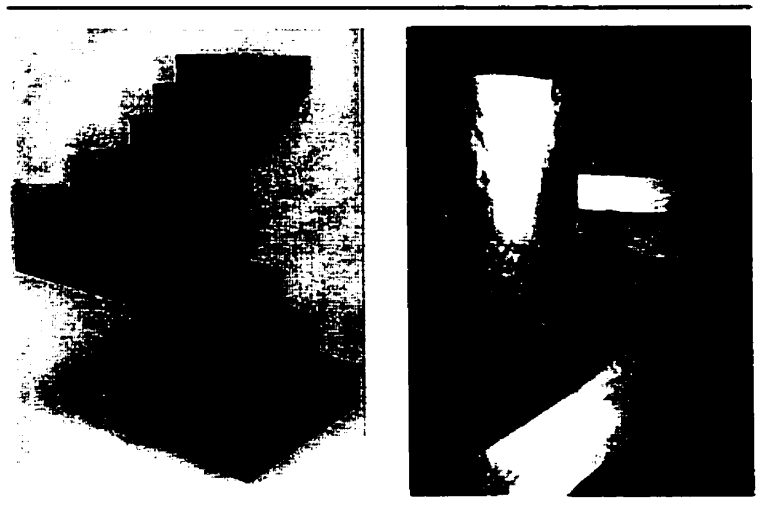


Fig. 4.73 Two examples of prefabricated stairs. (Source: Stairframe, 1999)

Before the basement was used as living space, few renovators would think of making stair modifications by themselves. Stair modification was mainly done by professionals. The invention of power woodworking tools and the availability of prefabricated stair components like handrails and balusters attracted more renovators to do-it-yourself stair building projects. The use of particle board also simplified the stair-building process. Recently, more households have started to take advantage of the basement as additional living space. The frequently functional alterations that happened in the basement increased the market need and stimulated the industry to manufacture more low-cost prefabricated fittings, even the whole staircase. The invention of the Adjustable Prefabricated Carriage system revolutionize the stair building process and can be used to further facilitate the renovators' work. The ability of renovators to intervene in stair modification has been greatly enhanced.

4.9 KITCHEN CABINETS

Before the 1940s, kitchen appliances were very simple and cupboards were not built around the stove or above the stove, but were freestanding. Fig. 4.74 shows a kitchen with a freestanding cabinet on the right side. To build such a cabinet, first renovators needed to make the skeleton framework and each part of the cabinet. Then the framework was joined at all corners using a modification of the simple halved joint. Offset cabinet hinges were not available at this time. The next step was fitting its floor, sides and the back that had been cut in the right dimensions. Then all the doors had to be made and assembled (Molloy, 193-?). All the cabinets in this period were carefully

designed and constructed by renovators using manual tools: handsaw, plane, hammer, screw driver and chisel.

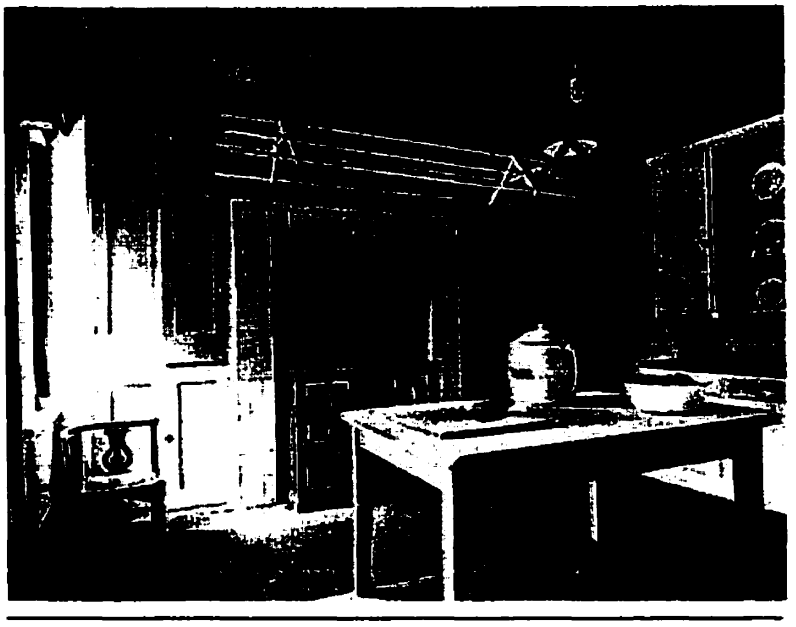


Fig. 4.74 A typical kitchen in 1908 with site-built cabinet and simple appliances. (Source: Phillips & Woolrich, 1921)

In the period between the 1940s and 1990s, convenient cabinets were installed both on the floor and on the wall of the kitchen and they eventually became an essential component of most kitchens. Often they were still built on site. Cabinet making was also made easier by the invention of power carpentry tools and prefabricated fittings, such as hinges and knobs. To build a cabinet, two procedures were commonly used. The first consisted of cutting the parts and assembling them in place: attaching each piece to the floor, wall, or to other pieces. After the basic structure was assembled, facing strips and other fittings were marked, cut to size and attached. In the second procedure, the entire unit was first assembled and then placed in position on the floor or attached to the wall.

The structure was formed with end panels, partitions and backs, joined by horizontal frames. Fig. 4.75 illustrates the main steps in building a kitchen cabinet: the wall cabinets are installed before the base units (this makes it easier to work on the wall cabinets since the renovator can work directly below them); the frame of the floor units was then built and the entire floor units assembled.

Fig. 4.75 The main steps in making a kitchen cabinet. (Source: Black and Decker, 1976)

Another innovation in cabinet making in this period was that homeowners could choose from a variety of wood or laminated finish materials with different textures that were produced by manufacturers. No messy painting was required.

In the 1990s, renovators have benefited from the popularity of pre-finished cabinets in the home-improvement market. Base units and wall units with adjustable shelves, hinged doors and different kinds of finished textures are all prefabricated in the factory. Not only are they made to be long lasting, but they are also renewable and

repairable. Renovators can also choose from varieties of carved decorative appliques, dovetail joints, custom nook moldings and fluting details which are all prefabricated. Fig. 4.76 shows a cabinet production line. Renovators can easily carry the package and install the cabinets themselves with the help of a user's guide (Fig. 4.77). Moreover, most hardware depots or manufacturers also provide renovators with free Auto-Graph computerized design. With the help of professionals, renovators are able to see how their new kitchen will look, according to their customized kitchen plan, before any final decisions are made.

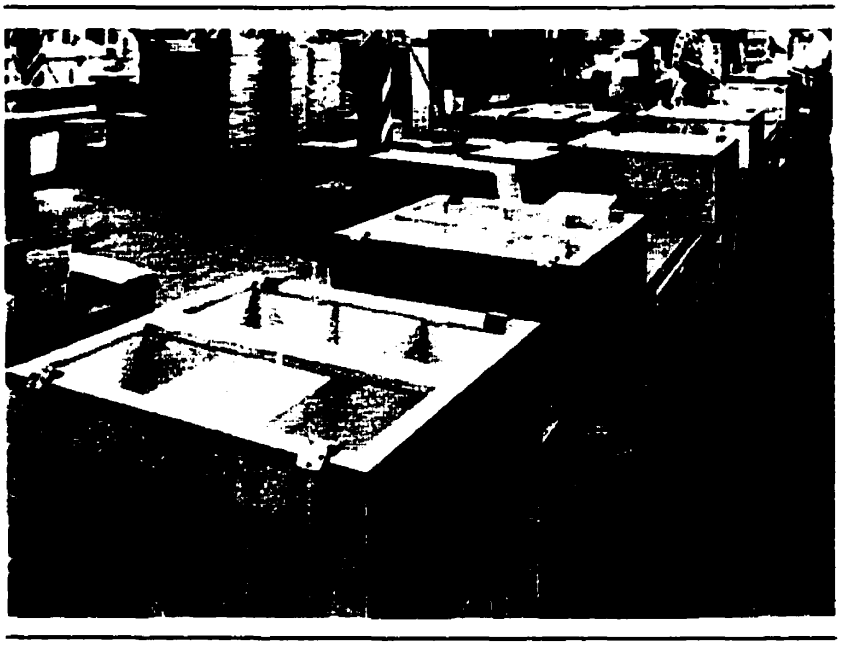


Fig. 4.76 In the 1990s, most cabinets are prefabricated in the factory. (Source: Reno Depot, 1999)

Fig. 4.77 Full prefabricated cabinet package today. (Source: Reno depot, 1999)

Early in the century, most kitchens were simply furnished. Later, households found it was a place where housewives would spend a great deal of time and those who worked there wished it to be a cheerful and convenient space. Many households began to improve the quality of the kitchen environment. As a result, kitchen cabinets were invented which could offer storage efficiency and tidiness. The invention of particle board, melamine and varieties of prefabricated laminated-finished materials in the post-war period also helped renovators to abandon messy painting, and offered renovators richer decorative possibilities. The availability of hidden hinges and power tools greatly increased the assembling process. More recently, the increasing market for kitchen modification is driving more manufacturers to compete in this field. For the same reason,

low-cost prefabricated kitchen cabinet packages have been produced for home renovators. Varieties of cabinet panels with different types of finish materials provide renovators numerous versatile options. The use of computer technology allows homeowners to visualize their cabinets before making decisions.

4.10 BATH WALL TILING

At the beginning of 1900s, some waterproof material was already being used for at least the lower portion of bathroom walls. Although other water-resistant materials like linoleum, tile wallboards, or metals coated with a fuse-on porcelain enamel could also be used, ceramic tile was the standard material (Plant et al., 1908). Fig. 4.78 shows a bathroom with ceramic tiles on the wall and the methods of cutting tiles. For home renovators, installing ceramic tiles was a very time-consuming job, and the holes for fixtures and pipes were very difficult to cut, especially if they wanted a good finish. The earliest shower was made by manufacturers and could not be installed by homeowners. It was made of nickel-plated brass and usually had a curtain to prevent water from spraying outside (Plant et al., 1908). It was not popular in this period because it was too expensive and needed a lot of space. Fig. 4.79 illustrates a luxury bathroom with a shower.

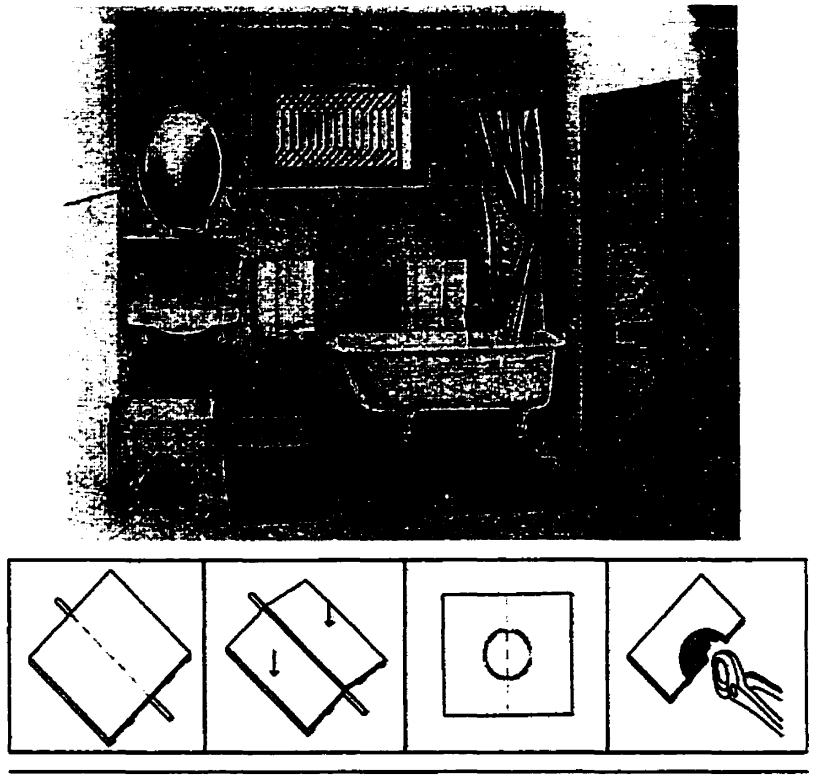


Fig. 4.78 Top: a typical bath in the early 1900s: the wall beside the bath was finished with ceramic tiles. Bottom: the basic method of cutting tiles. (Source: Hawkins & Abbe, 1948)

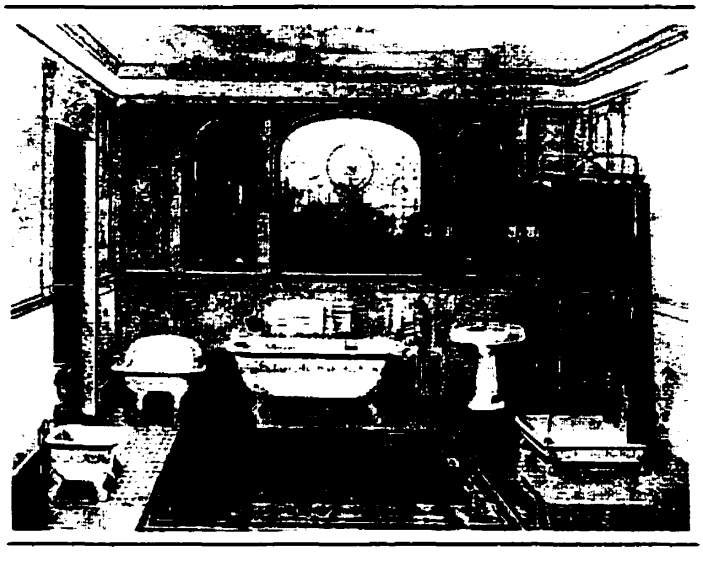


Fig. 4.79 A luxury bathroom with a shower: the wall beside the bath was finished with ceramic and the shower was enclosed by a customized curtain to prevent water from splashing out. (Source: Plant et al., 1908)

After the 1940s, the shower became popular, while the main method of waterproofing bathroom walls was still installing ceramic tiles. But renovators could choose from more textures and colours. Although the quality of the tile was also improved, the main innovation in this period was that more efficient tools had been invented for cutting and installation. Fig. 4.80 and Fig. 4.81 show some of the tools needed to install ceramic tiles. This technological improvement was very important, because making notches or holes in the tile to fit the shape of the bath fixtures or plumbing stub-outs had long been the most difficult part of installing tiles on bathroom walls. The process of tile installation was still time-consuming: first renovators needed to measure and draw the elevation of the area to be covered, the lowest line of the wall to be tiled and also the location of the fixtures and pipes in the tiling area. Then the cove or base row of tile was laid first, using a notched trowel to spread the adhesive, pressing firmly, against the backing surface of each tile (Fig. 4.82). The correct amount of adhesive has to be applied uniformly, otherwise the tiles would not lie in the same plane or the water would penetrate the groove between the tiles and damage the wall. In order to get a better finish, renovators needed to check the tile line with a level and try to space the tiles evenly. Finally, edge tiles and trim pieces were installed (Ching & Miller, 1983). Fig. 4.83 shows tiles being installed, carefully aligned with the reference line.

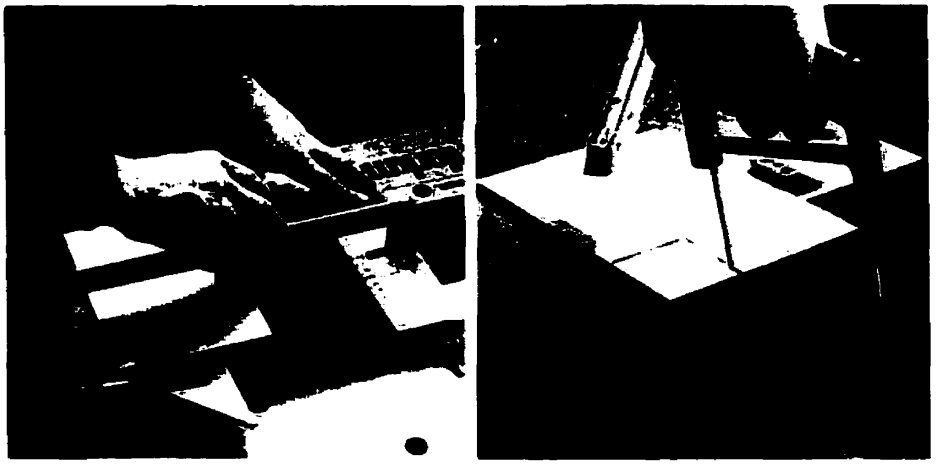


Fig. 4.80 Tools for cutting ceramic. Left: the tile cutter can cut a tile evenly to any width. Right: a rod saw, with an abrasive blade designed for cutting tile, can make notches and curved cuts in tiles. (Source: Black and Decker, 1976)

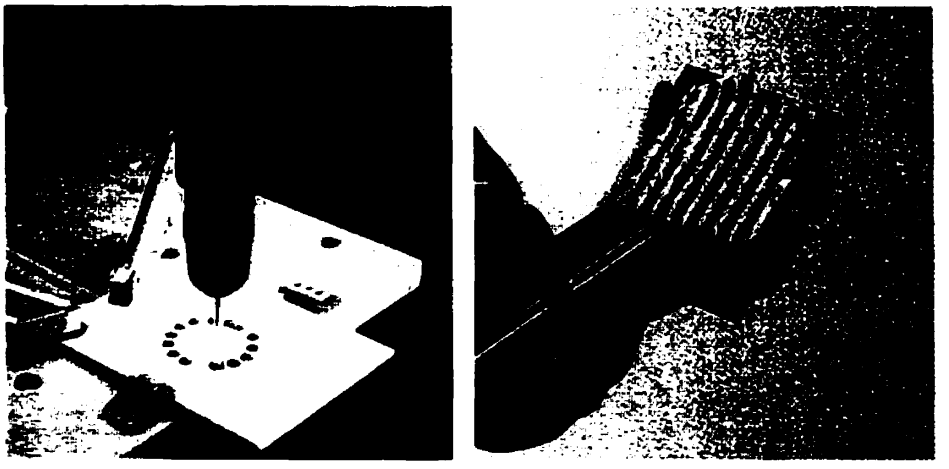


Fig. 4.81 Holes in a tile can be cut by drilling around the edge of the hole outline.(Source: Black and Decker, 1976)

Fig. 4.82 Using a notch trowel to cover the back of every tile. (Source: Wolf, 1995)

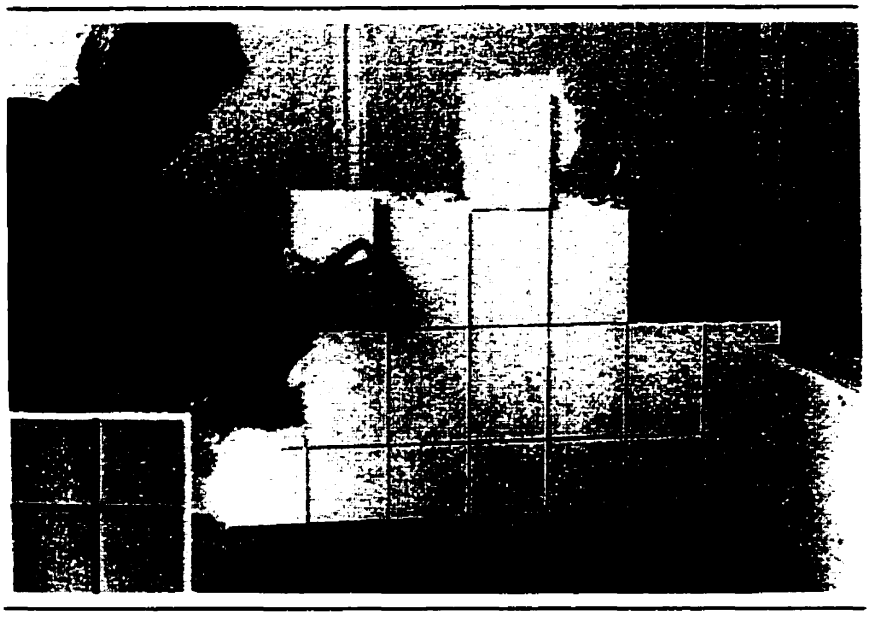


Fig. 4.83 Tiles installed one by one and aligned with the reference line. (Source : Wolf, 1995)

In the 1990s, the innovation of prefabricated wall system kit has totally changed how bath walls are installed (Fig. 4.84). This laminated wall system has not only classic colours and patterns but also a durable life span. Fixtures and showers can be custom designed by the manufacturer to fit renovators' individual needs. Also, because the system uses the revolutionary Solid Surfacing Veneer (SSV) which is just one-eighth inch thick compared to the traditional half-inch solid surface, the price is pretty affordable. It is easier to install than tile and more protective than paint. It is made in four formats: Tub, Two-Wall Shower, Three Wall Shower and Garden Tub, and each is available in different colours and textures. With the complete molding package and detailed installation guide included, renovators can easily install it in a short time.

Another innovation is the waterproof wall panel. It is also made of laminated material and available in contemporary colours, textures and finishes. It can be easily cut by normal saws and is installed with solvent-based adhesive.

Fig. 4.84 The prefabricated kit bath wall system is a product invented specially for renovators. (Source: Wilsonart, 1999)

Because of low market demand, few useful cutting tools for tile installation were available early in the century. This is the main reason that prevented many renovators from installing tiles by themselves before the 1940s. The demands of Word War II led many manufacturers to develop new tools and techniques. Later this knowledge was

applied to adapt industrial-purpose tools and machinery for home use, which resulted in the invention of tools such as the tile cutter, rod saw and electric drill to facilitate tile-cutting. Also, the use of prefabricated tile spaces simplifies tile alignment and installation. But the basic method of installing tiles remained the same and was extremely time-consuming. However, the innovation of laminate wall system kit and waterproof panels frees renovators from on site tile-setting and radically simplifies the bath wall installation process. This innovation is largely dependent on the invention of revolutionary Solid Surfacing Veneer. Waterproof veneer is a relatively costly material, but SSV's one-eighth inch thickness makes it possible to produce this system at an affordable price for home renovators.

CHAPTER FIVE: CONCLUSIONS

Do-it-yourself home renovation has for over a century been a source of personal satisfaction as well as a way to save money while improving the quality of renovators' living space. However, before the 1940s technical restrictions prevented many homeowners from getting involved in renovation activity. Tools were basic and installation processes were complicated. Even a simple freestanding storage dresser needed to be made piece by piece with manual tools. Most items were too difficult to build for most renovators. After the 1940s, technological breakthroughs such as the invention of power tools, gypsum board, and PVC pipes, greatly simplified installation processes for interior modifications. Nevertheless, the industry still did not provide enough prefabricated components to significantly shorten installation time. In the 1990s, the Wiremold raceway system and prefabricated bath wall panel technology improved the wiring and bath wall installation processes. Laminated floor allows renovators to install a wood floor without nailing. Demountable partitions offer renovators the opportunity to define space according to their own needs. Flexible BOWPEX pipes surmount the obstacles presented by pipe arrangement. Furthermore, well-developed prefabricated kit systems greatly enhance renovators' working efficiency. The increasing construction labor cost and homeowners' job insecurity also generates more renovators' working enthusiasm. A huge potential do-it-yourself market will continue to produce innovations which facilitate renovators' post-occupancy modifications.

5.1 SOURCES OF INNOVATIONS

Market demand is the most important factor that drives innovations. Different kinds of societal demands compel industry and research organizations to respond with the development of new products. The extended recession and lack of job security in the 1990s are also reshaping product development trends. The present economic reality forces the younger generation to accept more modest housing aspirations. The increasing tendency towards adult living with parents longer and the emergence of more home businesses combine to intensify the frequency of modifications to existing home stock. The continuously growing market implies a huge potential for innovations.

The invention of new tools is another important factor in the simplification of installation processes. Power woodworking tools invented in the 1940s, like the power drill and saber saw, not only vastly improved the efficiency of closet and cabinet building but also reduced the amount of labour involved in stair and partition building and bath wall installation. Even the installation of suspended ceilings was simplified by the use of these tools. The power nailer and sanding machine greatly enhanced renovators' ability to install flooring themselves. The painting roller, ceramic tile cutter and rod saw are other innovative tools which benefit home renovators.

The invention of innovative materials is the third key precondition that for the improvement of home renovation processes. Gypsum board relieves renovators of the necessity for messy wet plastering in ceiling and partition modifications. The introduction of plastic was significant not only for its use in pipes but also in electrical cable, which made technical tasks much easier for renovators. In the late 1960s, the invention of

polyvinyl chloride (PVC) piping made plumbing additions and repairs possible with just a simple saw and high-strength glue. Latex paint was developed that could be thinned and cleaned up with water, and which dried into washable films. In the 1990s, innovations such as Crossed Linked Polyethylene, used in water supply pipes; High Density Fibers, used in laminated floors; Furring Tapes used for ceiling tile installation; and Solid Surfacing Veneer, used in bath wall panels, have all created new possibilities for home renovators.

The fourth factor that contributes to innovative home improvement products is creative thinking: that is, how can these materials and tools be used. Wiremold raceway, BOWPEX pipes, laminated floorboard and demountable partition are all the result of great ideas. The availability of computer software for renovation professionals also enhances the accuracy and efficiency of calculation and modeling.

The changing use of the basement is the fifth reason that innovations have happened. In order to upgrade what had been a simple storage space to a livable environment, many modifications, such as flooring, ceilings, partitions, painting, built-in closet construction, and even plumbing and wiring, are frequently required. This increasing need attracts the attention of manufacturers and organizations in this field and results in substantial innovation.

5.2 REFLECTIONS ON NEW PRODUCTS DEVELOPMENT

For manufacturers, innovations are dependent on market demand as well as existing products and technology. Inventions which are new to both manufacturers and

market involve the greatest cost and risk. At Sony, over 80 percent of new product activity are undertaken to modify and improve existing Sony products. On the other hand, manufacturers that fail to develop new products are putting themselves at even greater risk. Existing products are vulnerable to changing consumer needs and tastes, new technologies and increasing domestic and foreign competition.

Product innovation, as a method to enhance the product's convenience and affordability for renovators often takes a long time to be accepted. What are the challenges that manufacturers face in developing successful innovations? In other words, what are the factors that affect the creation of new products? First of all, the idea must perfectly match the market need, and the product must be simple enough to operate. The main reasons for the quick popular acceptance of the painting roller by the market are that the old painting brush was one of the products renovators most commonly used and that the roller is so easy to operate.

Second, materials and tools in related areas must also be available to meet the requirement of the new product. If the tools are too difficult to operate or too expensive to obtain, or if the materials can not fulfill the functional needs, then the innovation will not be adopted. For example, handy BOWPEX crimping and cutting tools need no special skill to operate and the price is quite affordable; renovators can even rent them if they choose. In another case, if the revolutionary water-proof one-eighth inch thick Solid Surfacing Veneer had not been invented, the laminated wall system kit would not have been accepted by the market because it would have been too expensive for renovators. Often, the screening of new ideas is an important step, and the manufacturer has to generate many new ideas to find just one worthy of development.

Innovations must also meet the requirements of government. In order to improve the quality of materials and products, and to protect the health and safety of renovators, the National Research Council (NRC) developed the first National Building Code and set minimum standards for materials and products used in renovation. The codes consist of both performance standards and prescriptive requirements, such as fire resistance, sound resistance and grades such as adequate, safe, sufficient. Provincial and municipal governments have the power to further increase the requirements of the code, thereby further complicating the development of innovations. The Canadian Construction Materials Center (CCMC), a division of the NRC, tests new products to determine if they meet the standards set by the code (Sternthal, 1993). Government legislation is another factor which affects the development and dissemination of innovations.

Finally, successful innovations must have a rapid development time. Many competitors are likely to get the same idea at the same time, and the upper hand often goes to the first to bring a product to the market. The development time span and the cost both all be greatly reduced by using computer-aided design and modeling. In general, though, the success of new products is dependent on unique superior properties such as higher quality, new features or higher value in use and sophisticated concept before development.

Renovators show vast differences in their readiness to try new products. Some renovators are pioneers in adopting new products and others adopt them much later. The manufacturers' challenge is to identify the characteristics of the pioneers among home renovators. Early adopters tend to be younger in age, have higher social status and a more favorable financial situation. Personal influence is an important factor, especially in the

evaluation stage of the adoption process, and it has more influence on late adopters than early adopters do.

5.3 INNOVATION AND AFFORDABILITY

In order to make housing more affordable for first time homebuyers, homes can be built smaller and simpler in appearance and later improved by the homeowner themselves. The dwelling could also contain open and unfinished areas to adapt to unforeseeable family dynamics, and to allow renovators to improve their living environment according to their own taste. Basements and mezzanines have the flexibility to accommodate a large range of functional needs. Less elaborate finishes and greater provision of unfinished space could be advantageous in these areas. Even on the main floor, the interior of the house can be designed as simply and as open as possible to reduce the cost of housing.

Many products used in post-occupancy modifications can also be used in pre-occupancy decoration to achieve the dream of home ownership by buying a simple living space and taking the advantage of do-it-yourself products. For example, floors in certain areas can be left unfinished, to allow homeowners to finish them by themselves in their spare time. More open space can be offered to allow more flexibility in defining space with demountable partitions. Walls could be left unpainted, with only a base coat, since the market has provided so many kinds of quality paints and tools that are easy to use. Kitchens can be left unfinished because homeowners have so many available choices of cabinet styles and materials. Storage closets can also be left to the future renovators.

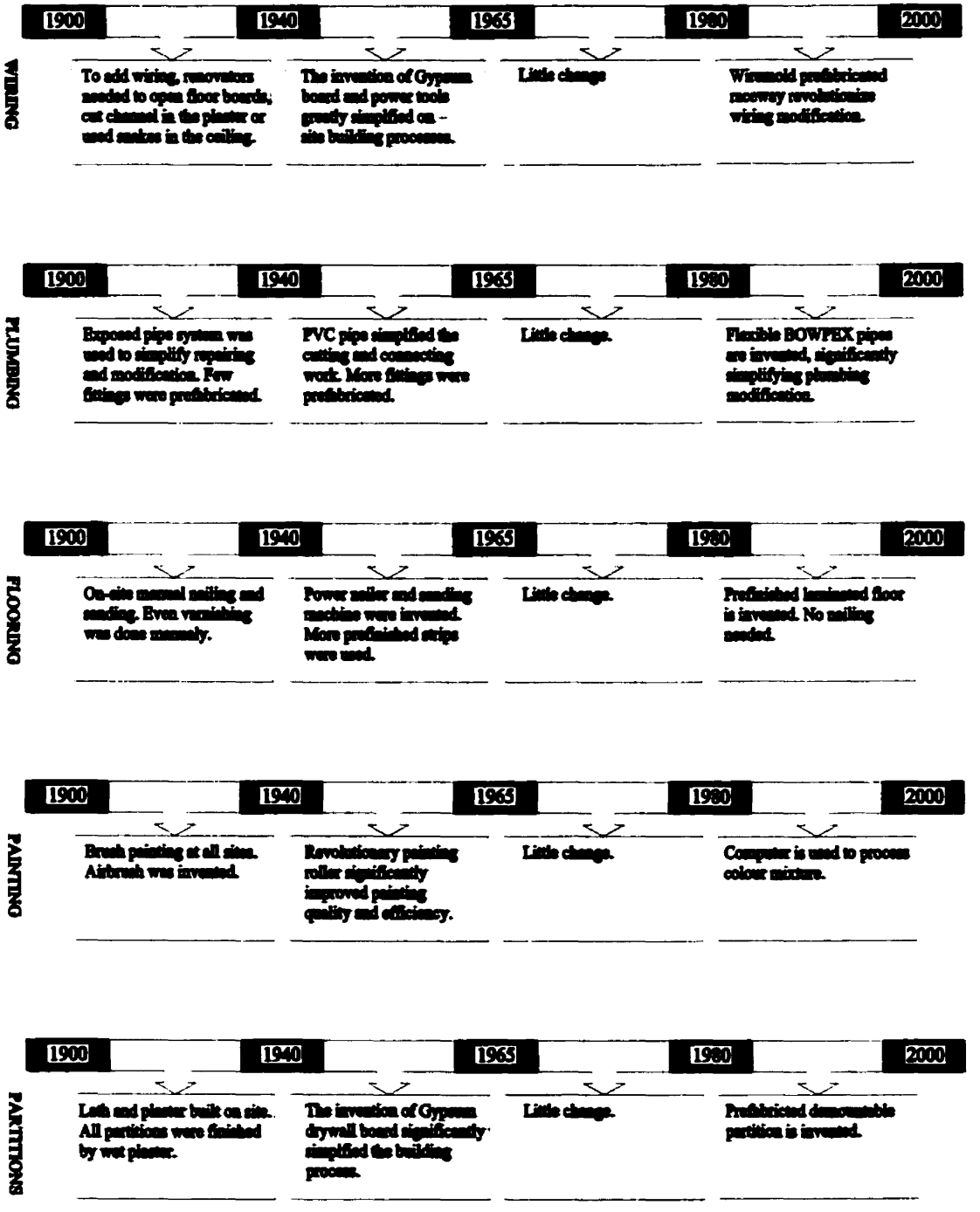
Prefabricated closet system kits offer renovators convenient installation and different kinds of fittings for assembly. Additional bathrooms can be added later since plumbing is no longer a difficult task using POWPEX pipes, and laminated bath wall systems are easy to install. A suspended ceiling is also unnecessary since kit systems offer renovators customized choices.

5.4 FURTHER RESEARCH

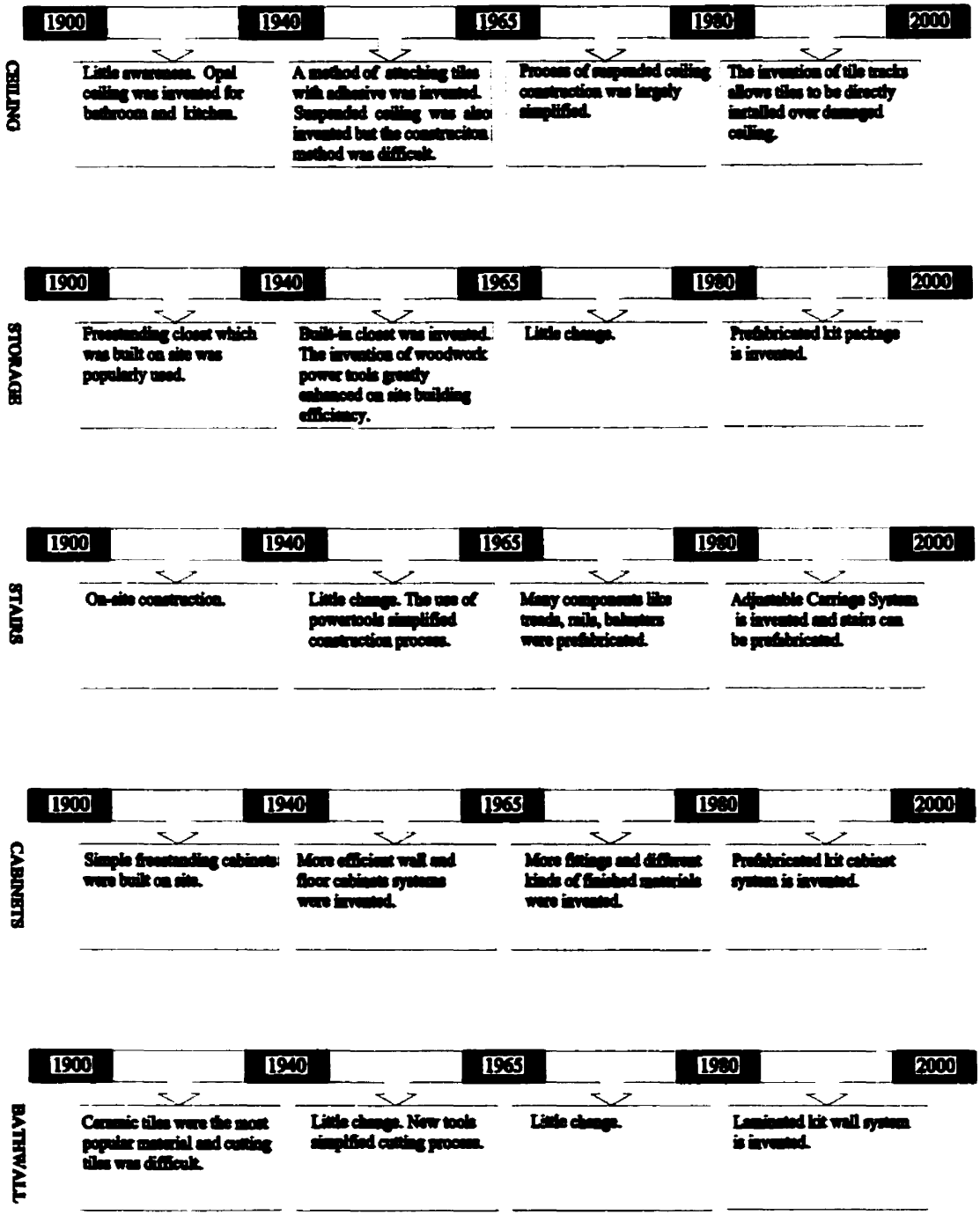
The renovation market will continue to be a profitable one for manufacturers because of the growing potential that exists in this field. A longer weekend means that renovators have more spare time that can be used for their dwelling modifications. Media promotions like *The Old-House Journal* and *This Old House* from PBS attract more households to join the do-it-yourself movement and also instruct renovators in the work they undertake. From a social point of view, the government should sponsor more research organizations to develop innovations that benefit home renovators. The availability of more sophisticated power tools and equipment, new material with superior performance, high recycled content or low pollutant emissions, together with improving computer software, will enable manufacturers to improve prefabrication technology, which will bring renovators more sophisticated kit systems with affordable prices.

"Innovation has brought the industry to its current position. Innovation will guide it into an exciting and bright future" (CMHC, 1993).

APPENDIX I


1900
1940
1965
1980
2000
WIRING
To add wiring, renovators needed to open floor boards, cut channel in the plaster or used soffits in the ceiling.
The invention of Gypsum board and power tools greatly simplified on - site building processes.
Little change
Wiremold prefabricated raceway revolutionize wiring modification.
1900
1940
1965
1980
2000
PLUMBING
Exposed pipe system was used to simplify repairing and modification. Few fittings were prefabricated.
PVC pipe simplified the cutting and connecting work. More fittings were prefabricated.
Little change.
Flexible BOWFEX pipes are invented, significantly simplifying plumbing modification.
1900
1940
1965
1980
2000
FLOORING
On-site manual nailing and sanding. Even varnishing was done manualy.
Power nailer and sanding machine were invented. More prefinished strips were used.
Little change.
Prefinished laminated floor is invented. No nailing needed.
1900
1940
1965
1980
2000
PAINTING
Brush painting at all sites. Airbrush was invented.
Revolutionary painting roller significantly improved painting quality and efficiency.
Little change.
Computer is used to process colour mixture.
1900
1940
1965
1980
2000
PARTITIONS
Lath and plaster built on site. All partitions were finished by wet plaster.
The invention of Gypsum drywall board significantly simplified the building process.
Little change.
Prefabricted demountable partition is invented.

APPENDIX II


1900
1940
1965
1980
2000
CEILING
Little awareness. Opal ceiling was invented for bathroom and kitchen.
A method of attaching tiles with adhesive was invented. Suspended ceiling was also invented but the construction method was difficult.
Process of suspended ceiling construction was largely simplified.
The invention of tile tracks allows tiles to be directly installed over damaged ceiling.
1900
1940
1965
1980
2000
STORAGE
Freestanding closet which was built on site was popularly used.
Built-in closet was invented. The invention of woodwork power tools greatly enhanced on site building efficiency.
Little change.
Prefabricated kit package is invented.
1900
1940
1965
1980
2000
STAIRS
On-site construction.
Little change. The use of powertools simplified construction process.
Many components like treads, rails, balusters were prefabricated.
Adjustable Carriage System is invented and stairs can be prefabricated.
1900
1940
1965
1980
2000
CABINETS
Simple freestanding cabinets were built on site.
More efficient wall and floor cabinets systems were invented.
More fittings and different kinds of finished materials were invented.
Prefabricated kit cabinet system is invented.
1900
1940
1965
1980
2000
BATHWALL
Ceramic tiles were the most popular material and cutting tiles was difficult.
Little change. New tools simplified cutting process.
Little change.
Laminated kit wall system is invented.

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