

Through Frank Lloyd Wright's Usonian houses, the Korean floor-heating idea disseminated to postwar mass-produced houses in America, particularly Levitt and Eichler homes.

# Korean heat radiated: from Frank Lloyd Wright's Usonian houses to postwar mass-produced houses in America

Hyon-Sob Kim

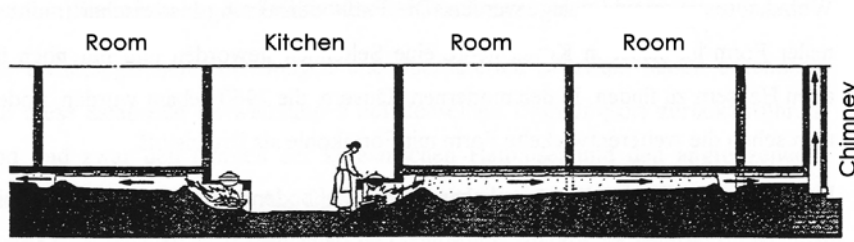
A confluence of cultures creates diversity, while also retaining uniqueness. With regard to architecture, it has been acknowledged that East Asian cultures inspired Western modern architecture, although a reverse influence was certainly dominant.<sup>1</sup> Japan's role in this field has been particularly remarkable in light of the Arts and Crafts Movement and Art Nouveau in the late nineteenth century, part of the so-called *Japonisme*.<sup>2</sup> However, China's impact was palpable in the *Chinoiserie* garden and interior of eighteenth-century Europe,<sup>3</sup> and Korea also had an influence to a varying extent. As is well known, it was the American architect Frank Lloyd Wright (1867–1959) who credited the influence of East Asian sources most explicitly, commending the spatial concept of China's Lao-Tzu (Laozi) and considering the Japanese house as a model for his organic architecture.<sup>4</sup> Furthermore, Wright described his experience with a floor-heated 'Korean room' as a 'discovery' which was to radically change the heating method applied in his domestic architecture.<sup>5</sup> If possibly rhetorical at times, it is undeniable that these sources nourished the architect and, consequently, modern architecture in general.

This study focuses on Wright's adoption of the Korean heating principle for his Usonian houses, starting with the Jacobs House I (1936–7) in Madison, Wisconsin. This modern application of Korean floor heating had a substantial impact on American homes through Wright's numerous followers. One of the most notable architects would be George Fred Keck (1895–1980), whose energy-sensitive design of the so-called 'solar house' includes Wrightian floor heating as its consistent element. The Kellett House (1939–40) in Menasha, Wisconsin, the first example of a floor-heated solar house, was designed after Keck spent a day with Wright at Taliesin, and the client also visited the Jacobs House.<sup>6</sup> While Keck designed hundreds of such houses in the 1940s, not only customised single-family houses but also prefabricated homes for builders,<sup>7</sup> it is still imperative to consider further buildings, particularly those with broader public recognition. Arguably, the best cases for investigation are the postwar mass-produced houses by Levitt & Sons in New York and Eichler Homes in California, two representative housing development companies in

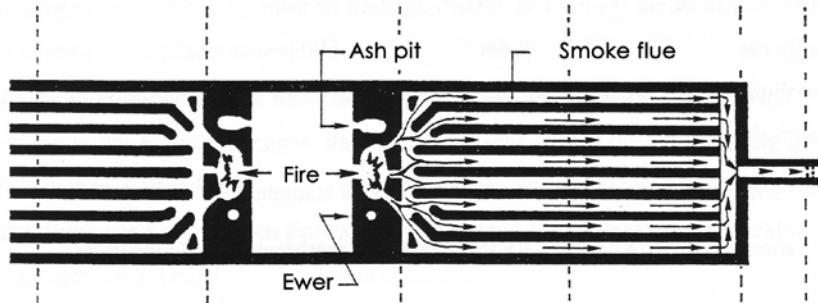
mid-century America. Their tract housing projects in the suburbs were targeted at ordinary families seeking to live the American dream in the renewed social context. In their homes, whether by Levitt or Eichler, floor heating (i.e., what is generally called 'radiant heating', although the meaning is different, as will be explained below) was one of the most typical features. Research on Levitt and Eichler homes has often mentioned the new heating method in relation to Wright's influence. However, in most cases, these are not only fragmentary, but also hardly identify the inspiration that Wright drew from Korea. If Wright's Korea-inspired heating method was transferred to developers' affordable houses for anonymous clients, it might be said that Korean heat warmed up the American dream, albeit indirectly. Ultimately, it would help us in understanding how modern architecture has amalgamated different cultural sources and how heating system technology evolved through adaptation. Accordingly, this study aims to investigate the history of 'heat transfer' together with its meaning.

## Korean floor heating and Frank Lloyd Wright's Usonian houses

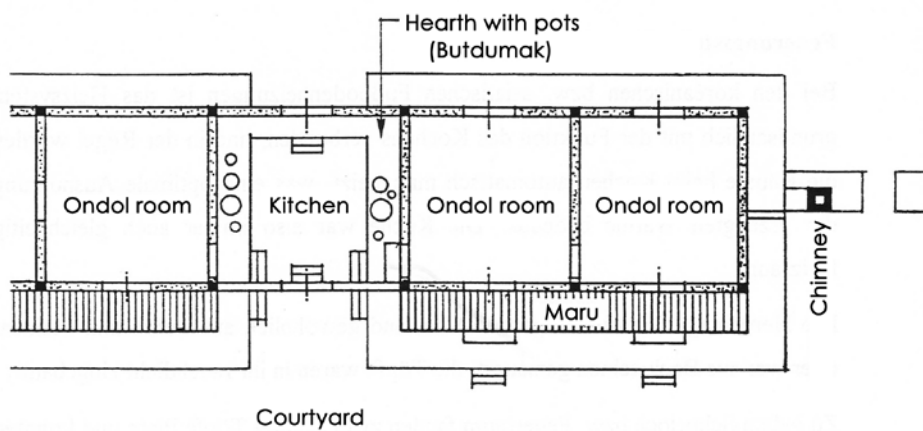
The first step is to explore how Wright encountered the Korean floor heating system called *ondol*, literally meaning 'warm stone' or 'warm flue'. He characterised the *ondol* room that he experienced as the 'Korean room'. The *ondol* is considered one of the most significant elements in traditional Korean architecture [1], and it is unique even when compared with the Chinese *kang* and Roman hypocaust. Whereas the *kang* heats the lifted bedding area only, the *ondol* heats the entire room. Importantly, while the former exists in the northern parts of China, the latter had spread across the Korean peninsula by the seventeenth century. Furthermore, the Roman hypocaust contrasts sharply with the Korean *ondol* since it had been used mainly for heating baths and disappeared during the Middle Ages.<sup>8</sup> Although there have already been a few serious studies on Wright's adoption of the Korean heating principle,<sup>9</sup> it is necessary to discuss this further. According to the architect's own account published in *An Autobiography* (1943) and *The Natural House* (1954),<sup>10</sup> Wright



1 Structure of the traditional Korean *ondol*, from Nam-Ung Kim, 'Stehendes' und 'liegendes' Feuer (Darmstadt: Beispiel, 1994), with English descriptions translated from the original German by the author.



2 Jacobs House I, Madison, Wisconsin, Frank Lloyd Wright, 1936-7: a recent view from the garden side, photographed by the author in October 2019.



experienced the 'Korean room' at his Japanese patron's residence in Tokyo, during one of his visits to the country for the new Imperial Hotel project (1913-23)<sup>11</sup> and was deeply impressed. For Wright, the 'indescribable warmth' from the floor, dispensing with any visible heating device, is a 'discovery'. Essentially, 'it was really a matter *not of heating at all* but an affair of *climate*'. His description of the *ondol* structure is very lucid: 'The Korean room

meant a room heated under the floor. The heat of a fire outside at one corner of the floor drawn back and forth underneath the floor in and between tile ducts, the floor forming the top of the flues (or ducts), made by the partitions, the smoke and heat going up and out of a tall chimney at the corner opposite the corner where the fire was burning.'<sup>12</sup>

Wright was eager to apply this discovery to his projects and successfully installed electric heating



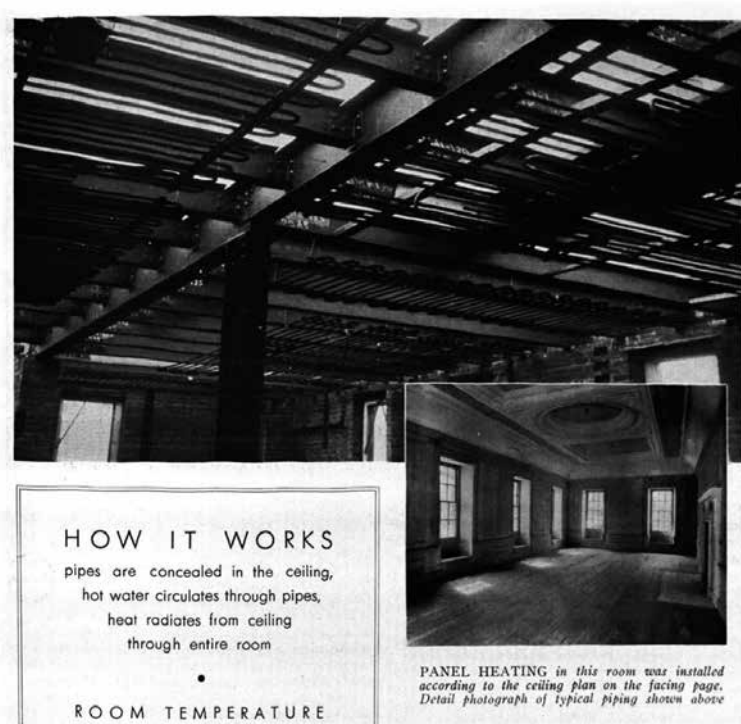
3 Wright testing the floor heating system of Jacobs House I, photographed by Katherine Jacobs. Art Institute of Chicago, Herbert and Katherine Jacobs Residence and Frank Lloyd Wright Records, Ryerson and Burnham Art and Architecture Archives, digital file #197701\_220408-023.

units beneath the bathrooms in the Imperial Hotel in Tokyo.<sup>13</sup> Soon after returning to America, he designed the floor heating for the Nakoma Country Club (1923–4) in Madison, Wisconsin, using steam pipes, but the design was not executed.<sup>14</sup> Therefore, it was at the Jacobs House, for the young Herbert and Katherine Jacobs family, that Wright realised the Korea-inspired floor heating for the first time in America [2]. The house was completed at the end of 1937.<sup>15</sup> Although floor heating had been planned in the Johnson Administration Building (1936–9) in Racine, Wisconsin, before the Jacobs House was commissioned, it was executed only after the experiment at the small house turned out to be successful.<sup>16</sup> The Jacobs heating system, which typifies that of subsequent Usonian houses, consists of a boiler in a small cellar and a thin concrete slab that incorporates wrought-iron heating pipes and rests on a gravel bed;<sup>17</sup> furthermore, it operates by forcing steam or hot water to circulate from the boiler. (The first steam heating in the Jacobs House was replaced by the more efficient hot-water heating in February 1940, two years and a few months after the family moved into the house.)<sup>18</sup> A construction photograph, depicting the scene of Wright's test on the heating, shows how the pipes branch out from the basement cellar (the boiler room) to each room on the ground floor [3].

As 'Usonia No. 1', the Jacobs House has typical Usonian features, such as the compact organisation of interior spaces, gridded plan, close relation between the inside and outside (garden), combination of brick walls (including the fireplace with a chimney) and board-and-batten walls (including the succession of floor-to-ceiling windows), carport, overhanging eaves, built-in furniture, and the like. Undoubtedly, floor heating

was one of the most essential elements of the house as the clients suggest throughout their memoir *Building with Frank Lloyd Wright*. For them, this 'radically new heating system' was 'the most startling innovation', which 'produced draftless, even temperatures throughout'. In particular, Katherine Jacobs stated: 'It is the most pleasant heat I have ever experienced. [...] Thanks to the comfort of floor heating, temperatures could be kept about ten degrees lower than in conventional houses.'<sup>19</sup> John Sergeant regarded this 'overall heat without draft or temperature variation' as 'the most delightful type – cool head and warm feet',<sup>20</sup> meaning that the floor heating created satisfactory 'thermal qualities' within the Jacobs House and provided clients with what is now called 'thermal comfort'.<sup>21</sup> Client satisfaction could also be confirmed by the fact that their second Wright-designed house, that is, Jacobs House II (1948–9) in Madison, Wisconsin, had floor heating installed as well. It should be borne in mind that this new method of the heated slab-on-grade was directly related to the remarkable reduction in building costs by eliminating the conventional basement and radiators, which are inevitably expensive.<sup>22</sup> In addition to the quality of heat, this economic aspect is one of the most important concerns in the Jacobs heating system. Eventually, the moderate-cost but decently designed house is exactly what Wright dreamt of for ordinary families in 'Usonia' – his own name for the United States of America – after the Great Depression. Considering that Wright realised a good number of Usonian houses (as many as 140 according to research),<sup>23</sup> we cannot ignore the significance of their floor heating, for which he owed the idea to the Korean *ondol*.

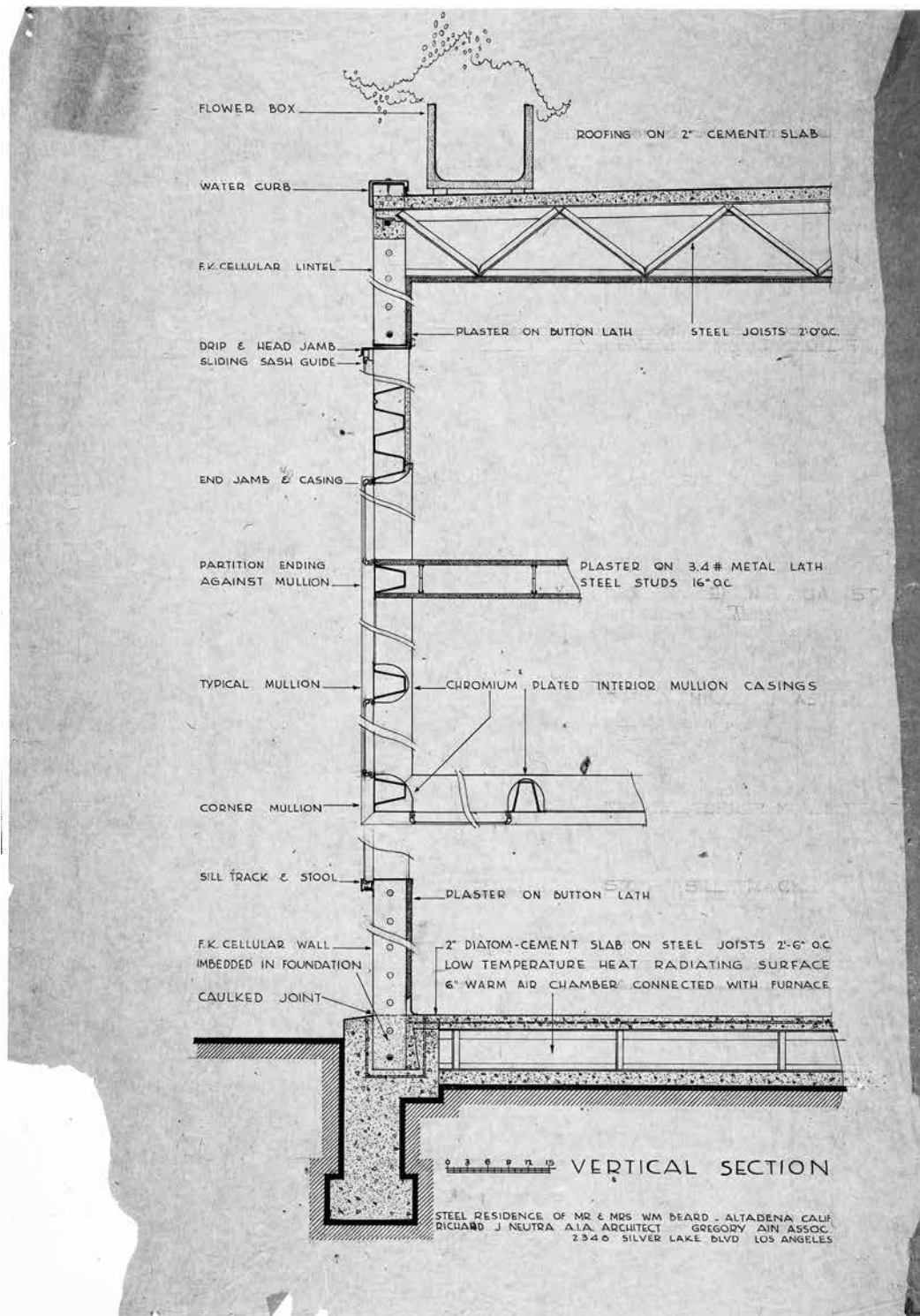
Discussing the Korean influence on Wright's floor heating, however, some critical opinions should be



4 Panel heating of the British Embassy in Washington, DC, Edwin Lutyens, 1927–30, as published in *The American Architect* (November 1930).

acknowledged. Above all, one may argue that it is ‘the Roman way’, rather than the Korean one, which Wright referred to when he once mentioned the Jacobs floor heating. In his special issue of *Architectural Forum* (January 1938) published soon after the house was completed, Wright wrote: ‘We will heat the house [in] the Roman way – that is to say – in or beneath the floors.’<sup>24</sup> His reference to the Roman way might be a safer strategy in this first official publication on the house, for justifying the new heating method. The effect of the unfamiliar Korean way was yet to be proved. Nevertheless, we cannot but pay attention to his actual fascination with the Korean method as expressed in his own books (1943; 1954). Wright was certainly inspired by the Korean *ondol*. A client’s description of how Wright persuaded his family is worth noting: ‘Have you ever heard of the Korean way of heating houses? [...] Would you like to be the first people in America to try this kind of heating in a home?’<sup>25</sup> At the same time, it should also be pointed out that a similar method called ‘panel heating’ or ‘radiant heating’ already existed in America by the early 1930s. The British Embassy in Washington, DC (1927–30) designed by Edwin Lutyens (1869–1944) is known as the first American building that adopted the panel-heating method. The embassy was warmed up by heat radiated from the ceiling – and from limited parts of walls and floor – where ‘coils of pipe through which warm water circulates’ were installed [4].<sup>26</sup> According to T. Napier Adlam, this “‘panel” radiant heating’ originated from a method using ‘small hot water pipes embedded in plaster or concrete’, which British Arthur H. Barker introduced in 1908, and a similar ‘warm air floor method’ was adopted at Liverpool Cathedral by G. N. Haden, a dozen years later.<sup>27</sup> If so, it can be supposed that certain buildings

in America had already applied these types of heating methods to the floor prior to the Jacobs House. The Beard House (1934–5) in Altadena, California, designed by Richard Neutra (1892–1970), is one such example. In this steel-framed house with metallic prefabricated components, warm air circulates in an underfloor ‘plenum chamber’ and the ‘vertical channels’ of the wall units, heating the interior space [5].<sup>28</sup> However, Neutra’s idea was very likely spurred by Wright – regardless of possible influence from European examples – if considering his close study of and intimate relationship with Wright, particularly in 1924 when the Nakoma Country Club project was undertaken.<sup>29</sup> Even if Neutra was not inspired by Wright’s method, it is arguable that the Beard House, as well as other precedents if any,<sup>30</sup> was nevertheless unusual: the new heating method was not widely known in general and was rarely executed in practice in American domestic architecture before Wright’s Usonian houses as confirmed in surveys by the *Architectural Forum – The 1936 Book of Small Houses* and *The 1938 Book of Small Houses* – which show that none of the 246 presented houses adopted floor heating.<sup>31</sup> Moreover, an article by the Chief Architect of the Federal Housing Administration (FHA), published in *The 1938 Book of Small Houses*, discourages readers from using ‘new methods [...] which have not been approved’.<sup>32</sup> When Wright attempted to use heating pipes for the Jacobs House, the Crane Company – a giant plumbing firm in New York – was sceptical of the unusual challenge and refused to get involved in the work, as both Wright and Jacobs testified.<sup>33</sup> In essence, the realisation of floor heating in the house was the result of Wright’s own serious experimentation, with the help of only a local plumber.



5 'Vertical Section' of the Beard House, Altadena, California, Richard Neutra, 1934-5, which shows an underfloor warm air chamber. Charles E. Young Research Library, UCLA, Library Special Collections, Richard and Dion Neutra papers.

Wright's modern application of traditional Korean heating was undoubtedly novel and marked a step towards the evolution of heating technology. The uniqueness of Wright's method is also demonstrated in his insistence on using his own term, 'gravity heat' rather than 'radiant heat', which suggests Wright's intention to emphasise the simple principle he experienced in person at the 'Korean room': hot air goes up as cold air comes down owing to gravity.<sup>34</sup> His terminology indicates that he focused on the floor, mainly regarding its 'convective' heat transfer, as distinct from other radiant heating installers –

including those of the British Embassy in Washington, DC – who would prefer to use the ceiling and walls to the floor in their radiant effect. The split between convective and radiant heat transfer from the floor is about half and half, whereas the percentage of radiant heat transfer increases if the heat passes from the wall and ceiling.<sup>35</sup> It means that neither 'gravity heat' nor 'radiant heat' is satisfactory for floor heating. At any rate, what is significant here is that Wright's experience at the 'Korean room' is highlighted by the term 'gravity heat'.

**Levitt houses (1947–68) in New York, Pennsylvania, and New Jersey**

If the Great Depression in the 1930s served as a catalyst to Wright’s Usonian houses, it was the end of the Second World War for mass-produced houses in America. The pre-existing housing shortage was accelerated by veterans returning from the war, and the subsequent baby boom. To address this issue, the FHA, which had been established to stimulate a low-cost private housing market in the 1930s, administered various financial support programmes for postwar housing projects, notably the Veterans’ Mortgage Guarantee Programme.<sup>36</sup> In this context, Levitt & Sons, under the leadership of William Levitt (1907–94), emerged as the most prominent company that developed large-scale tract housing districts in the suburbs, which became known as ‘Levittowns’.

Levitt & Sons was founded in 1929 by Abraham Levitt (1880–1962) in partnership with his two sons: his older son William Levitt managed the business, while the younger son Alfred Levitt (1911–66) ‘was in charge of design and planning’ although he had no formal architectural education.<sup>37</sup> In the prewar period, the company focused on modest developments for middle- and upper middle-class families. During the war, however, the Levitts constructed emergency housing for military workers in Norfolk, Virginia, in 1943, for which the basementless slab-foundation method was introduced. As often pointed out, this experience motivated them to graduate to large-scale developments after the war.<sup>38</sup> The first and most representative Levittown was developed in Long Island, New York, between 1947 and 1951, where approximately 17,500 houses were built for lower middle-class families.<sup>39</sup> The first 6,000 units (1947–8),

mainly for rent, adopted the so-called ‘Cape Cod’ style that has a traditional appearance with a pitched roof and clapboard siding [6]. This 1.5-storey minimum house with an unfinished attic had a compact composition of rooms within a simple box-like plan and was equipped with basic home appliances. In addition, each house was, without a basement, built on a concrete floor slab that incorporated hot-water heating coils. The next 11,500 units (1949–51) that were for sale adopted a model called ‘Ranch’, modifying the Cape Cod to be better suited for the market. This model was more modern and relatively bigger than the previous one, having a different room composition, but the essential features remained the same. These Levitt houses, Cape Cod and Ranch alike, were mass-produced by making the most of standardised components and rationalising the building process like Henry Ford’s factory assembly line [7]. Dispensing with the basement was one of the most critical factors that enabled the fast construction of houses at a lower cost. It was even said that a house was being built every sixteen minutes.<sup>40</sup>

In Levitt houses, the influence of Wright was multifaceted. For example, Gwendolyn Wright suggested that the Ranch model ‘combined the low-pitched roofs, deep eaves, and strong horizontal lines of Wright’s early prairie houses with more traditional elements like clapboards, shutters, and a wide front porch’.<sup>41</sup> Fundamentally, however, we can speculate that Wright’s Usonian ideal to provide

6 ‘Cape Cod’ model, Levittown, Long Island, New York, as published in *Architectural Forum*, 86:5 (May 1947).

**HOUSE FOR \$6,990** is equipped to the hilt to attract the value-conscious

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**DESIGN** of the 1947 model by Production Vice President Alfred Levitt is completely conventional, highly standardized and easily described by the simple descriptive adjective, ‘modern’. Varied with many and bold color combinations, the new standard exterior (shown) springs from a simple 28' x 30' ft. floor plan layout. Intended for future expansion, the plan may be used for dead storage. White closets are built, no provision is made for storage of garden tools, baby carriages and bicycles.

veteran. Long Island's Levitts will build 3,000 this year for sale and rent.

**CONSTRUCTION** is as conventional as the design. Frame is comprised of 2 x 4 in. studs, 16 in. on centers, sheathed with plywood or concrete block board. Ceiling joists and rafters are 2 x 6 in. roof sheathing is aluminum. For floor assembly, specifications include cleats for blocking, drainage, water and heating pipes and waste vents. Walls and ceiling are insulated with 4 in. of urethane, and the slab is insulated from the foundation walls. Whole only 700 sq. ft. of gross floor area are finished. A third bedroom (7'8" x 7'4") may be finished in the attic for about \$300. The entire standard expansion (34' x 34' ft.) would cost about \$1,000.

detail expansion's two bedrooms and bath (400 sq. ft.), roughly \$1,000. Basic improvements include a 6000 gal. cesspool, a machine for access to outside plumbing lines, 30 ft. black-topped concrete streets, concrete curbs, concrete sidewalks along through streets, access walks of stone set in concrete, and concrete landscaping of the 50 x 100 ft. lots.

Contract drawings show basic design for six-bed hot water radiant heat; renderings and photographs (next page) are of earlier model, without brick chimney, heated by gas-fired warm air. Heating coils take only about 400 ft. of pipe. Estimated monthly cost of heat and hot water: \$10.

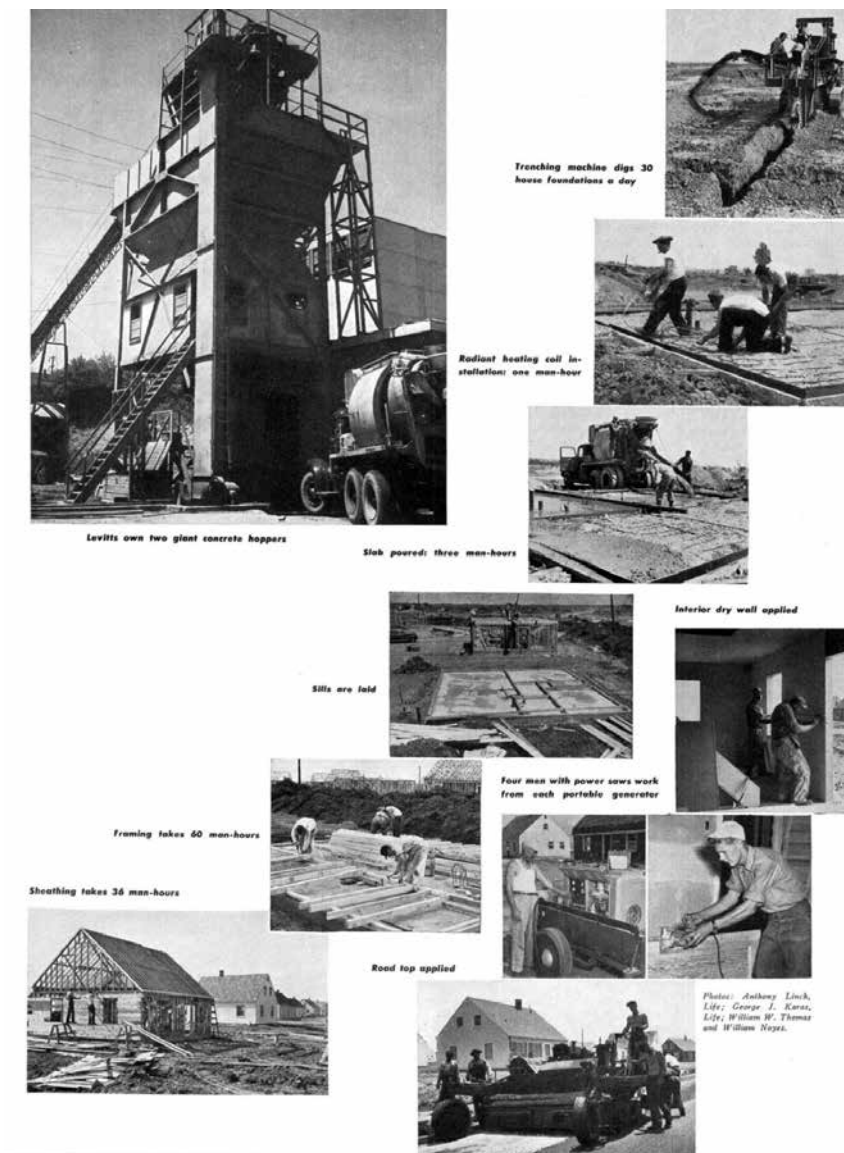
ordinary families in America with an affordable house was passed down to the Levitts, although in reality there was a crucial gap between the architect's customised houses and the merchant builder's tract houses for anonymous clients. According to Barbara M. Kelly, Levitt maintained that 'he had been able to produce the low-cost houses that Wright had only theorized' while 'Wright disdained the Levitt houses as trash'.<sup>42</sup> The primary source showing Alfred

Levitt's stance towards Wright is an early article published in *Fortune* (October 1952), on which most of the interpretations of the Wright-Levitt connection rely. The article introduces Alfred Levitt's on-site study of the construction of a Wright house in Great Neck, Long Island, for ten months in 1936.<sup>43</sup> (The house must be the Rebhuhn House, designed and built between 1937 and 1938,<sup>44</sup> because this is the only house that Wright erected in Great Neck, Long Island. Therefore, it was in 1938, rather than 1936, when Alfred Levitt observed the construction.) Despite his learning from the Wright house, as well as his in-person meeting with the architect,<sup>45</sup> Alfred Levitt stated that Wright's method, requiring many highly-skilled men, is unrealistic in mass-housing projects. Instead, he argued for a simple operation that can be repeated time and again, making the most of unskilled workers.

Among the elements that the Levitts learnt from Wright, floor heating is arguably the most critical.<sup>46</sup> It was reported that Levitt & Sons tested all types of heating systems in 1946, concluding that the radiant hot-water floor heating was the most satisfactory.<sup>47</sup> Principally, as shown in the Jacobs House, this

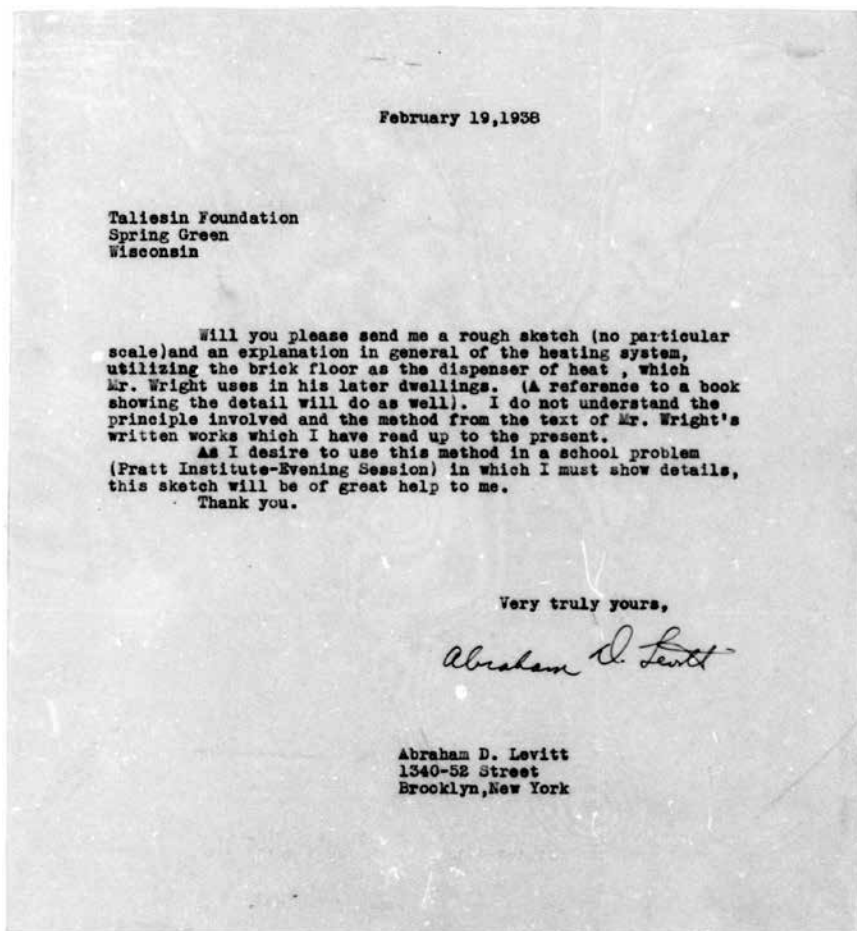


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7 Levittown, Long Island, New York, as published in *Architectural Forum*, 90:4 (April 1949): (a) One of the earliest subdivisions; (b) Rationalised building process like the factory assembly line.

7b



8 Abraham Levitt's letter to Taliesin, 19 February 1938, requesting Wright's heating system drawing and explanation. Frank Lloyd Wright Foundation Archives (The Museum of Modern Art | Avery Architectural & Fine Arts Library, Columbia University), Fiche ID Lo40D03.

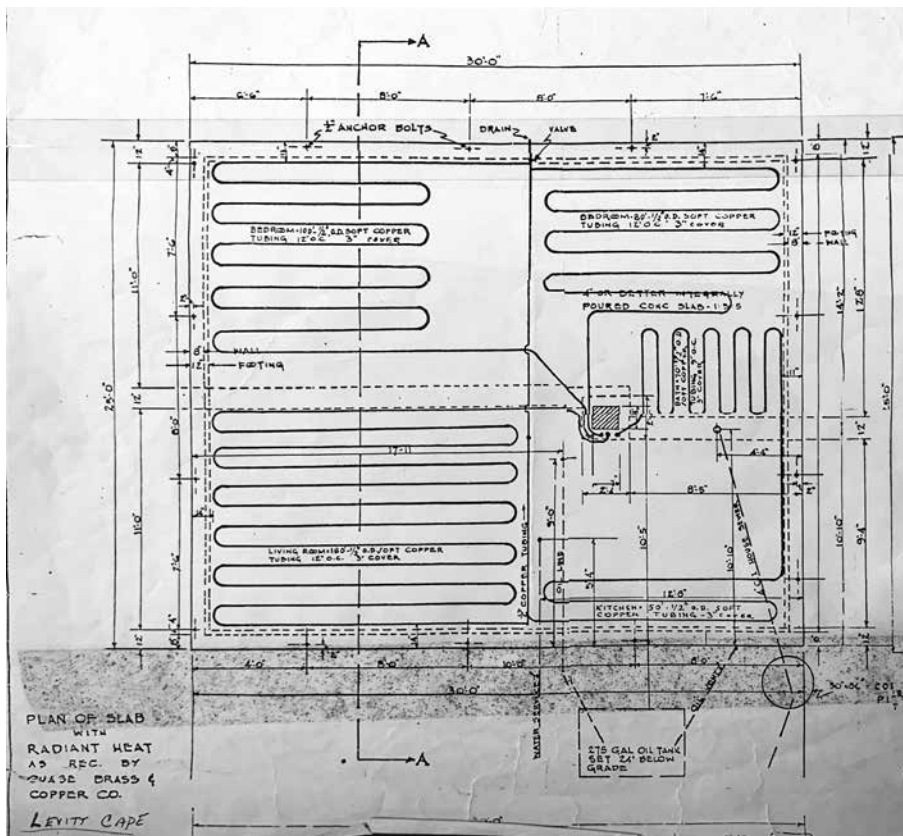
method could heat a room uniformly and provide comfort to the residents, even with a much lower temperature.<sup>48</sup> One of the former Levittown residents recollected: '[The] radiant [heat] kept many of us cozy while we were growing up.'<sup>49</sup> This cosiness, or 'thermal comfort', would be what corresponds to the 'indescribable warmth' that Wright discovered in the 'Korean room' and 'the most pleasant heat' that Jacobs experienced at the Usonia No. 1. On a practical level, the floor-heating method was decisive in Levitt houses since its slab system made the construction inexpensive and expeditious. Fortunately, the interest of the Levitts in Wright's floor heating can be proved in Abraham Levitt's letter to Taliesin. The letter, dated 'February 19, 1938', begins with his direct request for Wright's heating-system drawing and explanation [8]: 'Will you please send me a rough sketch (no particular scale) and an explanation in general of the heating system, utilizing the brick floor as the dispenser of heat, which Mr. Wright uses in his later dwellings? [...] I do not understand [...] Mr. Wright's written works which I have read up to the present.'<sup>50</sup> There is a description of the floor-heating idea of the Jacobs House in the 'January 1938' issue of *Architectural Forum* but without drawings of the heating system.<sup>51</sup> Considering this, the house that Abraham Levitt referred to cannot but be the Jacobs House, and his mention of 'the brick floor as the dispenser of heat' appears to be a confused one.<sup>52</sup> Alfred Levitt's observation of the Rebhuhn House construction, which commenced around the time

when the letter was sent, might be related to his father's strong interest in Wright's works (although floor heating itself was not applied here).<sup>53</sup> The slab-foundation method employed in the 1943 Norfolk housing was perhaps the first result reflecting this interest (although its heating method was not reported). At any rate, Abraham Levitt's letter reveals one aspect of how Wright's floor heating, inspired by the Korean *ondol*, was transferred to the Levitts right after the Jacobs House was completed.

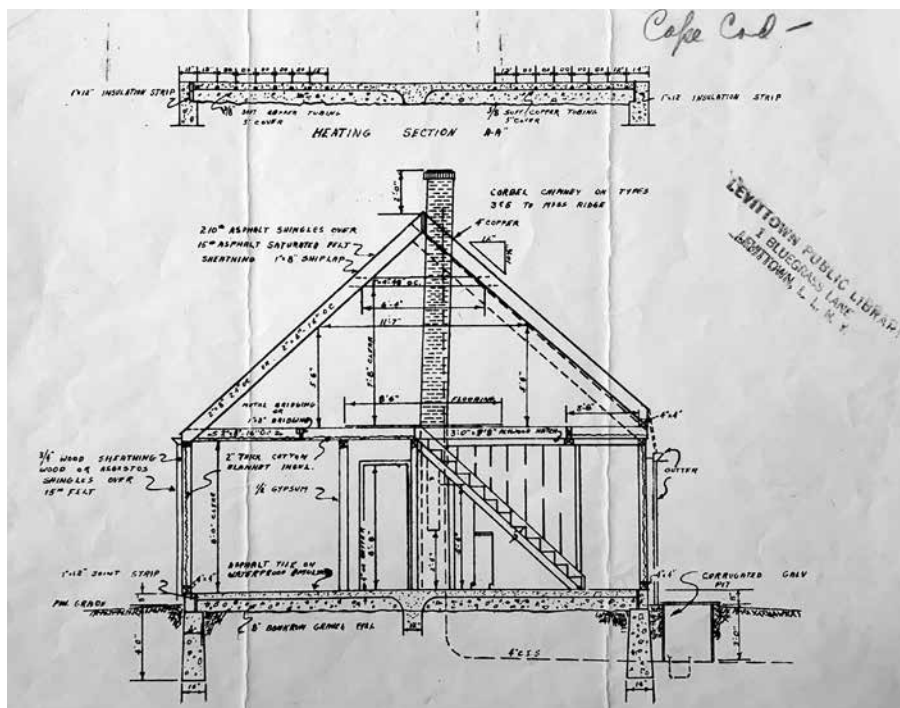
The floor-heating arrangement of Levitt houses could be gauged from their drawings. For example, the 'Plan of Slab with Radiant Heat' of the 1947 Cape Cod model (Type 4) illustrates the layout of heating coils in each room, and its 'Heating Section' depicts that the copper tubes of the coils were positioned at the bottom of the concrete slab, which in turn rests on gravel [9]. Drawings of the 1950 Ranch model also show us the same system [10].<sup>54</sup> This heating system could be confirmed in a photograph taken when the heating coils were being installed [11]. The success of the Levittown in Long Island, New York, led to the second and third Levittowns in Bucks County, Pennsylvania (1951–7), and Willingboro, New Jersey (1958–68), before Levitt & Sons was sold to the International Telephone and Telegraph Company in 1968.<sup>55</sup> Approximately, 17,000 and 12,000 houses were constructed there, respectively. Although the types of houses came to be diversified and modified according to market preferences in these later developments,<sup>56</sup> the floor-heating system adopted in



9 Cape Cod (Type 4), 1947: (a) 'Plan of Slab with Radiant Heat'; (b) 'Heating Section'.



9a



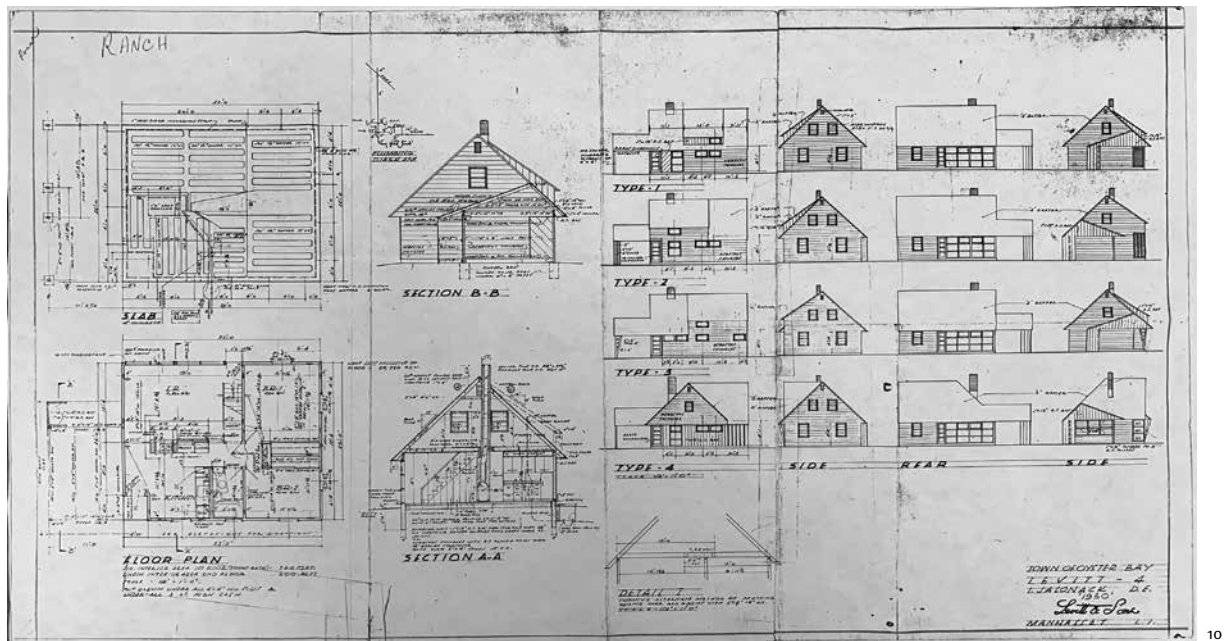
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the first Levittown was considered one of the most salient characteristics in the Levittowns that followed. This is verified by various sources. For example, sales flyers for Bucks County models – such as, ‘Rancher’ (1952), ‘Jubilee’ (1954), and ‘Country Clubber’ (1954) – emphasise ‘Hot Water Radiant Heating’ as one of their highlighted features, and Bucks County residents report: ‘Children especially loved this feature, as they could lie on the warm floor and watch television.’<sup>57</sup> Likewise, drawings of

Willingboro houses – such as the first three models in 1958 named ‘House A, B, C’ – also illustrate ‘Copper Heat Coils’ within the concrete slab.<sup>58</sup>

**Eichler homes (1949–74) in California**

In 1947, the same year the development of the Levittown in Long Island, New York, commenced, Joseph Eichler (1900–74) initiated his home-building business ‘Sunnyvale Building Company’ in California, selling prefabricated homes to clients



10



11

10 Ranch, 1950: Set of construction drawings, including 'Slab' and 'Section A-A' that show the floor heating system.

11 Construction photograph of presumably 'Ranch' houses, Levittown, Long Island, taken when the heating coils were being installed.

having their own land. However, the business transitioned to the development of architect-designed houses in subdivisions in the late 1949, after Eichler renamed his company 'Eichler Homes'.<sup>59</sup> It had built more than 10,000 houses by 1966 when the company was handed over to new owners owing to financial problems, but Eichler continued to build homes until his death in 1974 through new companies such as J. L. Eichler Associates.<sup>60</sup> While Eichler's scale of development was limited compared to Levitt & Sons [12], Eichler homes were targeted at middle-class families, relatively better off than earlier Levitt house buyers. This targeting of potential clients was related to the fact that Eichler pursued more modern designs in the open atmosphere of California – or those of the so-called

'everyday modern'<sup>61</sup> – by employing talented architects. (Eichler's employment of architects contrasted with the Levitts' more conservative practice although the Levitts' later works were possibly influenced by Eichler's architects.)<sup>62</sup> Furthermore, the modern sensitivity of Eichler Homes was well reflected in its elaborate sales brochures [13] and stylish photographs depicting ideal middle-class families in mid-century America.<sup>63</sup> Meanwhile, Eichler accepted Wright's design ideas and vocabularies more actively than the Levitts. Specifically, the Usonian houses were the basis on which Eichler developed his prototypes. Among the Eichler characteristics derived from Usonian precedents, the floor-heating system was the most explicit and advanced. In the monograph *Eichler*:

*Modernism Rebuilds the American Dream*, Paul Adamson rightly pointed out that Wright’s ‘slab-on-grade foundations with built-in radiant-heat piping [...] pushed the limits of residential construction technology’,<sup>64</sup> although he failed to notice any allusion to Korea in the Wright method.

It is obvious that the Wright-Eichler association was much closer than the Wright-Levitt connection. There were two specific causes or contexts behind it. The first was Eichler’s own experience of staying at one of Wright’s Usonian houses – the Bazett House (1938–40) in Hillsborough, California. This house was characterised by a hexagonal grid, similar to the

Hanna House (1936–7) in Palo Alto, the better-known Wright house in California. Sergeant regarded the Bazett plan as ‘an hexagonal version of the Jacobs plan’.<sup>65</sup> As expected, it had typical Usonian features within its overall V-shaped form, not to mention the floor heating. One photograph shows how the heating pipes were installed before the slab concrete was poured [14]. Eichler had lived in the house between 1943 and 1945, which deeply affected him. This experience was undoubtedly one of the motives that made the developer launch the home-building business: ‘I began to dream of building homes for sale that would incorporate some of the same advantages I enjoyed in my own house [Bazett House]’.<sup>66</sup> However, the actual connection between Eichler’s houses and Wright’s architecture was made only after Robert Anshen (1909–64), like Eichler an admirer of Wright, was involved in the design.<sup>67</sup> This is the second context. Anshen and his partner, the architect William Stephen Allen (1912–92), both of whom graduated from the University of Pennsylvania, established their office Anshen & Allen Architects in San Francisco in 1940, with Anshen as the lead designer. Anshen & Allen came to work for Eichler from the late 1940s. In addition, Anshen also had opportunities to experience the interiors of the Bazett House as a guest at gatherings at the house<sup>68</sup> and, at one point, he even regarded himself as ‘a successor to Wright’.<sup>69</sup> Therefore, it is natural that the collaboration of two Wright admirers resulted in Wrightian features, including floor heating. This tendency began from their first project – Eichler’s own residence designed by Anshen in 1947–8.<sup>70</sup>

Under the name ‘Eichler Homes’, Eichler developed a few subdivisions without architects<sup>71</sup> – only a draftsman was hired for a while – but soon commissioned Anshen & Allen to design prototypes for the second phase of Sunnyvale Manor (1949–50) in Sunnyvale, California.<sup>72</sup> This project, advertised in



12



13

12 Eichler homes in Fairmeadow subdivision, Palo Alto, California, 1953, featured as a cover image of *Fortune* (February 1955).

13 *Eichler Homes: Designed for Better Living*, Eichler’s sales brochure, 1952–3.



14

14 Construction photograph of the Bazett House, Hillsborough, California, Frank Lloyd Wright, 1938–40, taken after the heating pipes were installed. Frank Lloyd Wright Foundation Archives (The Museum of Modern Art | Avery Architectural & Fine Arts Library, Columbia University), FLWPH.4002.0010.

15 Eichler AA-1 house in Sunnyvale Manor subdivision, Anshen & Allen, 1949–50, as published in *Architectural Forum*, 92:4 (April 1950).

## GAMBLE IN MODERN pays off in better living for buyer, quicker sales for builder

LOCATION: Sunnyvale, Calif.  
JOSEPH L. EICHLER, Builder  
ANSHEN & ALLEN, Architects

This 51-house development represents a builder's "gamble" that hit the jackpot. Joseph Eichler, who has built approximately 300 houses since 1945, liked the work of Anshen & Allen a young team of architects who designed his own \$50,000 house last year. He asked them to try their hands at small subdivisions. Although horrified, at first, by their requested \$5,000 a year retainer plus a royalty of \$100 per house, he gave them a go-ahead signal.

The differences between A & A's meticulous blueprints and the plans formerly whipped up by Eichler's struggling staff were evident from the start. "Before this," said Eichler, "we were always running into bugs . . . we'd have to revise as we went along. It wasted time for everybody, especially the carpenters." Now money was saved on accurate material orders, by smooth scheduling of the job. The final proof of the planning came, as usual, in the selling—all 51 houses were snapped up within two weeks of the model house opening.

Sunnyvale's package offers bonanza value with no design compromises. Its \$9,400 cost include a 54 x 96 ft. lot; three fair-sized bedrooms; a 16 x 17 ft. living room with large brick fireplace and floor-to-ceiling glass wall; an additional 9 ft. square dining area; a service yard completely screened by a redwood fence; a two-car garage with room at the back for a workshop or generous storage space—a total of 1,044 sq. ft. in the house; 400 in the garage.

The most popular single feature of the house (which had to be coaxed past FHA) is the free-standing breakfast bar overhung by an open dish shelf. The service yard, which adds to frontal privacy, provides a protected play space for small children—in full view of kitchen windows.

Simple construction methods, as well as skilled planning, have made this building bargain possible. They have also allowed the use of redwood tongue-and-groove siding for the whole exterior, redwood plywood throughout the interior. Ceiling beams (6 x 10 in. members set on 7 ft. centers) are left uncovered and are backed up by 2 in. redwood sheathing and 1/2 in. insulation. The asphalt-tiled concrete floor holds radiant heating coils.

Very satisfactory postscript to the story is the fact that Anshen & Allen are already designing three more subdivisions for Eichler—who adds in true happy-ending style: "They'll do all my plans from now on."

COST BREAKDOWN	
Carpenter labor	\$970
Lumber	750
Redwood plywood	240
Siding	275
Milwork	755
Masonry	845
Electrical system	200
Hardware	100
Plumbing	700
Painting	380
Heating	400
Roofing & insulation	265
Windows & glazing	267
Lot	1,200
Miscellaneous	844
Profit	1,009
<b>TOTAL</b>	<b>\$9,400</b>

145

15

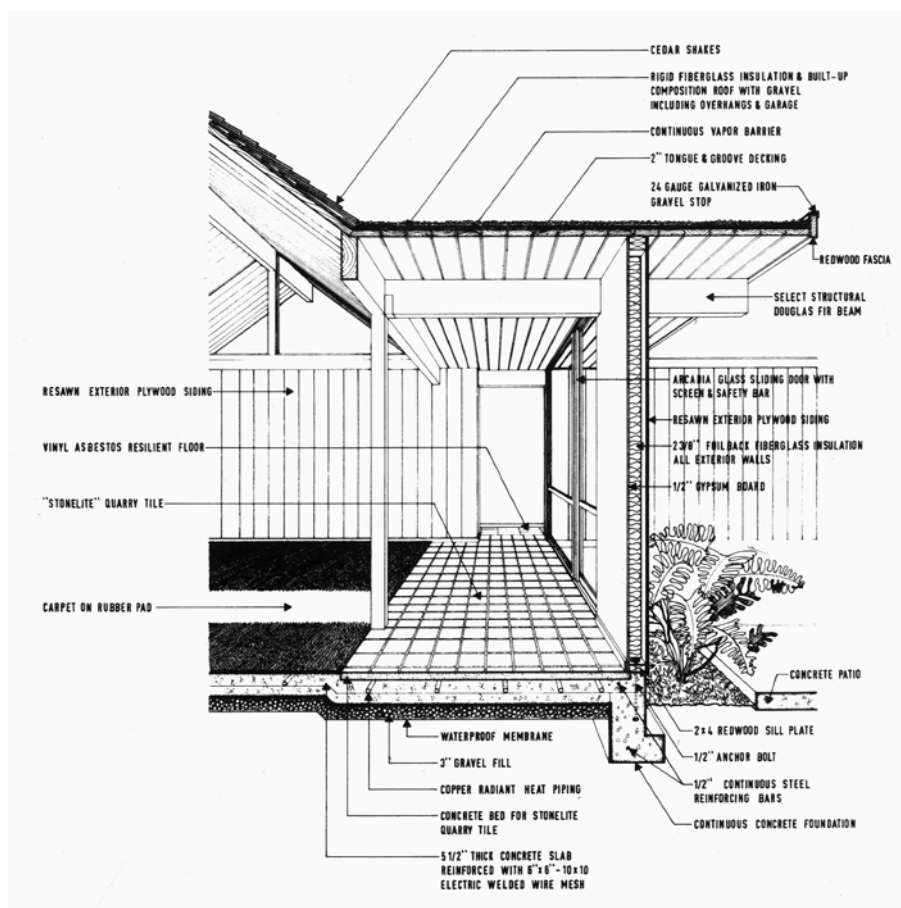
*Daily Palo Alto Times* on 17 February 1950, turned out to be successful since all its 51 houses were sold out in two weeks, according to the April 1950 issue of *Architectural Forum*.<sup>73</sup> Three months later, the same magazine even urged Long Island builders – ‘200 large builders’ represented by the Levitts – to learn from it: ‘In their field survey of Long Island houses, FORUM editors did not find one house which equalled, in price and quality, the Palo Alto (Calif.) builder house. [...] To get this better product, Joe Eichler did some hard-headed planning with his architects, Anshen & Allen.’<sup>74</sup> Sunnyvale Manor was followed by four other subdivisions designed by Anshen & Allen, from 1950: El Centro Gardens, Green Gables, Greer Park in Palo Alto; and Atherwood in Redwood City. They were collectively named ‘Subdivision of the Year’ by *Architectural Forum* (December 1950).<sup>75</sup> As a matter of course, Anshen’s designs for Eichler alluded to basic ideas of the Usonian houses, while the mass-producible units for tract houses needed to be much more straightforward, compact and economical than Wright’s customised houses.

This can be seen in the AA-1 model (1949–50), for example. It was the prototype for the successful Sunnyvale Manor houses [15], and its variations were applied to subsequent subdivisions. Even the architect Robert Anshen himself regarded AA-1 as ‘one of the best houses he ever designed’.<sup>76</sup> Here, its T-shaped plan is so efficiently arranged to include all necessary rooms within the limited space, but the living room has quite an open plan combined with the kitchen and dining area. Therefore, it looks much ampler, and the interior space visually expands towards the outside through a series of floor-to-ceiling windows as in the Jacobs House. According to the report of *Architectural Forum* (April 1950), one of the most popular features was ‘the free-standing breakfast bar overhung by an open dish shelf’. Unquestionably, however, much more crucial in the present discussion is its floor-heating system. It was considered useful to create a cosy warmth as well as a simple space not hindered by radiators. In addition, the basementless slab foundation with the built-in heating made the house not only modern but also economical – as emphasised among the Wright and Levitt houses. We can see how Eichler made the most of the new heating system in the above-mentioned advertisement for the Sunnyvale Manor (*Daily Palo Alto Times*, 17 February 1950). It listed the heating as its first noticeable feature: ‘RADIANT HEAT ... ordinarily found only in expensive homes. Thermostatically controlled, the entire house is cozy warm: no chilly drafts or cold spots’ [16].<sup>77</sup> In this manner, floor heating was established as the most important selling point for Eichler from the start.

Although Anshen & Allen’s designs were successful, Eichler continued commissioning other promising architects to refine earlier models and meet new demands.<sup>78</sup> A. Quincy Jones (1913–79) was hired in 1951, followed by other architects, such as Rafael Soriano (1904–88) and Claude Oakland (1919–89), a former employee at Anshen & Allen. Accordingly, Eichler homes could evolve in diverse ways. For

16 Advertisement of Sunnyvale Manor, *Daily Palo Alto Times* (17 February 1950, p. 15), highlighting the ‘RADIANT HEAT’ as its first noticeable feature.

17 ‘X-100’, Eichler steel house model, A. Quincy Jones, 1955–6, featured as a cover image of *Living for Young Homemakers* (February 1957).



18

18 Section of an Eichler home, Claude Oakland, c. 1968, that shows copper heat pipes within the slab-on-grade.

example, a steel-frame house type was introduced in the mid-1950s: first, through Soriano's steel house prototype in 1955; and then through Jones's model named 'X-100' [17].<sup>79</sup> The incorporation of an atrium became a distinctive feature of Eichler homes from the late 1950s – most Eichlers from 1958 had an atrium that could 'liberate interior spaces from the tight constraints' of previous models. Furthermore, some models expanded in size to respond to the economic boom in the 1960s as shown in Oakland's gallery house (1964) – whose 'roofed-over atrium nicknamed "gallery"' creates a luxurious atmosphere within its multilayered space.<sup>80</sup> Despite these transformations, Eichler retained the basic principles that the earlier models adopted, particularly floor heating. We can confirm the array of heating pipes within the slab-on-grade in a section drawing by Oakland, which illustrates the typical components of an Eichler model during the late 1960s [18].<sup>81</sup>

#### Radiated Korean heat and cross-fertilisation of cultures

As discussed so far, the Usonian floor-heating method, for which Wright had been indebted to the traditional Korean *ondol*, was applied to Levitt and Eichler homes, the most remarkable mass-produced houses in postwar America, and developed in very different regions of the United States of America – East Coast and West Coast – respectively. Furthermore, it was not only these two developers that applied floor heating to their houses; many other merchant builders also adopted this new system, not to mention individual architects like

George Fred Keck referred to in the introduction. The July 1950 issue of *Architectural Forum* reports that 'a majority of Long Island builders were 'taking the switch to slabs [that incorporate heat coils]', illustrating a section drawing of its 'typical FHA-approved installation' [19].<sup>82</sup> (In this FHA approval of floor heating, we cannot but be reminded of the 1938 advice of FHA that opined against using any new methods yet to be proved.<sup>83</sup> The dozen-year time gap saw significant progress in both the technique and public recognition of floor heating.) Three months earlier, the same magazine had already shown diverse builders' houses – along with Levitt and Eichler homes – that adopted the floor-heating system.<sup>84</sup> We can clearly see here that the modernised Korean heating method radiated widely to postwar American houses. It must be underscored that, even though modern heating technology developed in the West should not be overlooked,<sup>85</sup> radiated Korean heat was certainly remarkable.

The progress of floor heating from the traditional Korean *ondol* to the modern hydronic system in postwar American houses deserves further discussions, above all, about how the technology (or technique) of domestic heating evolves through adaptation. Richard Sennett's idea of 'metamorphosis' in *The Craftsman* seems relevant here.<sup>86</sup> According to him, metamorphosis, one form of 'material consciousness', is directly related to a change of things or technological evolution 'as when potters switch from molding clay on a fixed platter to building it up on a rotating wheel', and it occurs

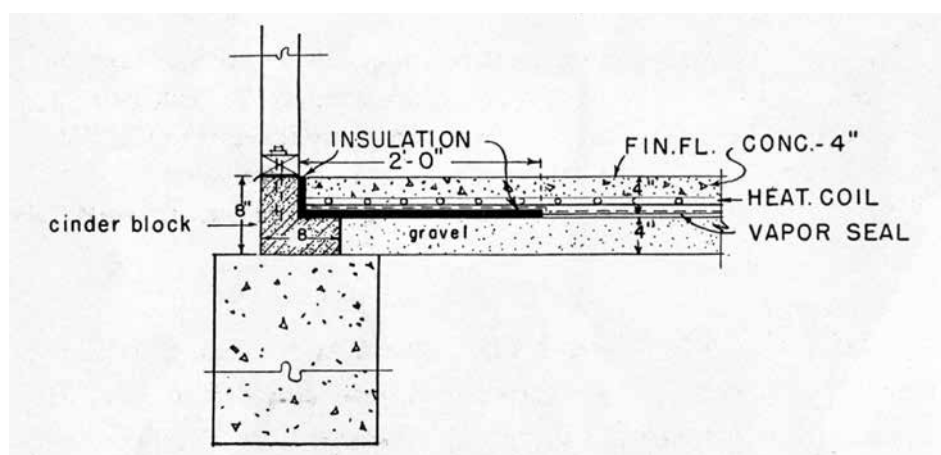
through the internal evolution of ‘a type-form’ (or a ‘generic category of object’), the ‘mixture and synthesis’ of different elements, and a ‘domain shift’ (which ‘refers to how a tool initially used for one purpose can be applied to another task’). The first two ways of Sennett’s metamorphosis correspond to the evolution of the heating system discussed in this paper. That is, Wright’s adaptation of the Korean *ondol* principle to his modern slab-on-grade corresponds to Sennett’s mixture of different elements for metamorphosis, while the Levitt and Eichler homes’ adaptation of Wright’s slab-on-grade system to their mass-produced conditions corresponds to Sennett’s internal evolution of a type-form. Likewise, the evolution of the floor heating system can similarly be perceived as a process of technological metamorphosis.

However, this modernised floor heating system could also be discussed from a critical point of view towards modernism, especially that with a phenomenological approach. Although residents of Levitt and Eichler homes as well as clients of the Jacobs House were satisfied with the ‘thermal comfort’ from the uniformly-heated floor, they certainly had no direct sensory relation with the concealed pipes in the same way they could have with, representatively, the traditional fireplace – if borrowing Lisa Heschang’s critical idea about the thermal qualities of modern radiant ceilings.<sup>87</sup> As she described vividly in the Bachelardian way, there is a totality in fire’s sensory stimulation: ‘The fire gives a flickering and glowing light, ever moving, ever changing. It crackles and hisses and fills the room with the smells of smoke and wood and perhaps even food. [...] Every sense is stimulated and all of their associated modes of perception.’<sup>88</sup> In the same vein, Stamatis Zografos wrote recently: ‘With the advent of the modern movement, fire and architecture are irreversibly divorced. [...] We can still sense the heat radiated through them [concealed pipes between floor slabs and floor finishes], but the lack of direct visual contact leads to an abstract, decentralised appreciation.’<sup>89</sup> What is implied here is our loss of primitive and existential qualities of heat that we once enjoyed, and the loss is perhaps unavoidable and irretrievable in the modern (floor) heating system. Obviously, Zografos’s discussion about ‘fire

and architecture’ reflects the present critique of the modern functionalist axiom that each function occupies its own space – the pipes occupy their own space below or concealed within floor slabs.

Notwithstanding, it is unfortunate that the floor heating, which is still attractive and useful without a doubt, could not have been established as a universal method in American domestic architecture. The reason must be related to practical issues more than the above-mentioned hermeneutical issues of thermal qualities or modernist axiom. Particularly, the heating system itself has some technical limitations, notably, difficulty in repairing the embedded pipes when required (e.g., when water leaks are detected).<sup>90</sup> For this reason, it is said that many homeowners in Levittowns have replaced it with something like baseboard heaters, although the drawback seemed to be less severe in Eichler homes.<sup>91</sup> Nevertheless, the more important cause of its unsustainability must be the cultural difference in living. Americans, who are generally unfamiliar with floor heating, do not need to insist upon it when faced with serious technical problems, whereas Koreans, who have lived in a floor-heated room, take it for granted and wish to solve problems by any means. There would be no house in Korea without floor heating, although its specific techniques have been continually updated. Moreover, the problems inherent in the mass housing development of the time were decisive in the stagnation of floor heating in America. Many issues were targets of attack by critics: from the monotonous repetition of identical houses to (sub)urban sprawl; and from class conflict to racial segregation – the latter was particularly problematic in Levittown as is well known.<sup>92</sup> Consequently, floor heating is now largely regarded as a stylish and expensive item in American domestic architecture, adopted for select clients only. This recognition is far different from the original intention when it was first introduced.

Despite the present context, it is arguable that Korean heat, by way of Wright, contributed to the development of postwar American houses, or the rebuilding of the American dream. As already suggested, ordinary American families’ hope for a modest home in the renewed postwar context (e.g., economic expansion, growing liberty, returning



19 Section of a ‘typical FHA-approved’ slab, c. 1950, which incorporates heat coils, *Architectural Forum*, 93:1 (July 1950).

veterans, baby boom, accelerated housing shortage, etc.), particularly in a suburb, constituted an image of 'rebuilding the American dream'.<sup>93</sup> Therefore, the application of the Korea-inspired heating method to postwar American houses could be considered to signify that the Korean heat warmed the American dream. Rather ironically, however, Korea came to re-import the modernised floor-heating system(s) from America during reconstruction following the Korean War (1950–3), although Korea's own efforts to modernise the traditional *ondol* structure had continued, particularly since the Japanese colonisation period (1910–45).<sup>94</sup> The Haengchon (Hyang-Chon) Apartments (1955–6) and Mapo Apartments I (1961–2) in Seoul illustrate the situation.<sup>95</sup> Constructed as the American-Korean Foundation's 'Homes for Korea' project initiated to solve Korea's postwar housing problem, Haengchon Apartments (forty-eight units) applied the so-called 'Combined Radiant and Convective Heating' to the floor: centrally-forced warm air goes through hollow voids in the floor slab (radiant heating) while floor registers at the opposite end of the supply convect the warm air (convective heating). As its technical director from America regarded this heating system as 'suitable for either western or eastern living',<sup>96</sup> it was not only modern and Western (as much as the apartment-type house itself was modern and Western in Korea at that time) but also obviously Korean. One

of the principles of the project was that the housing had to 'fit into Koreans' way of living'.<sup>97</sup> Nevertheless, what has become universalised in Korea is the hot-water piping system, which was first applied to the bedroom of Mapo Apartments I (while their living room was heated by a radiator). Intended to symbolise the beginning of Korea's rapid economic growth after the war, this large-scale development of apartments (450 units) should be modern in its overall design, including the heating system, and it was supported by the United States Operations Mission, among others. The modern hydronic floor heating, which had already considerably evolved in America well before the Mapo Apartment project, was imported to Korea on this occasion.<sup>98</sup>

It is an interesting intersection of cultural flows, which entails the technological evolution outlined by Sennett. Obviously, technology is one form of culture. This intersected trajectory of heat transfer demonstrates how one culture influences another, resulting in cross-fertilisation. The later development of the heating system would reveal additional layers of cultural and technological flows. For example, the current common use of polyethylene tubes known as 'PEX', a major improvement from the previous metal pipes, came through crucial refinements in Sweden and Germany in the 1950s and 1960s.<sup>99</sup> Throughout these intersections, Korean heat was further radiant.

## Notes

- This study stems from the author's short presentation 'The Korean Heating Effect: from Wright's Usonian Houses to the Eichler Homes in California', made at a session titled 'Diversity and Mixture' of UIA 2021 RIO: 27th World Congress of Architects, 7 July 2021 [online]. For the overall description of the East Asian contribution to Western modern architecture, see the author's previous studies, for example, Hyon-Sob Kim, 'Cross-Current Contribution: A Study on East Asian Influence on Modern Architecture in Europe', *Architectural Research*, 11:2 (2009), 9–18.
- See, for example: Gabriel Weisberg and others, *Japonisme: Japanese Influence on French Art 1854–1910* (Cleveland, OH: Cleveland Museum of Art, 1975); and Siegfried Wichmann, *Japonisme: The Japanese Influence on Western Art since 1858* (London: Thames & Hudson, 1981).
- See, for example: Osvald Sirén, *China and Gardens of Europe in the Eighteenth Century* (New York, NY: Ronald, 1950); and Hugh Honour, *Chinoiserie: The Vision of Cathay* (London: John Murray, 1961).
- Frank Lloyd Wright, *An Organic Architecture* (London: Lund Humphries, 1939), pp. 3, 11.
- Frank Lloyd Wright, *An Autobiography* (San Francisco, CA: Pomegranate, 1943), pp. 494–6 and *The Natural House* (New York, NY: Horizon, 1954), pp. 98–101.
- Robert Boyce, *Keck and Keck* (New York, NY: Princeton Architectural Press, 1993), pp. 73–4. To control sunlight and heat for energy saving and domestic comfort, Keck's solar houses made the most of the orientation of the house, fixed-glass windows, ventilation louvers, projecting eaves, water-carrying roofs, and the like, as well as radiant floor heating. For the latter, he even patented a panel heating system, called 'RadianTile', with Clay Products Association in 1944. *Ibid.*, pp. 71–107.
- For his project list, see Boyce, *Keck and Keck*, pp. 154–60. Apart from a large number of single-family houses, he made a contract with the builder Edward Green for 'Ready-Built' prefabricated homes in 1943, and 'well over a hundred' of them were built after the war. *Ibid.*, pp. 83–107.
- For a comparison of the Korean *ondol* with *kang* and hypocaust, see Nam-Ung Kim, 'Stehendes' und 'liegendes' Feuer (Darmstadt: Beispiel, 1994); and Hyon-Sob Kim, 'The Appearance of Korean Architecture in the Modern West', **arq**: 14:4 (2010), 349–61. For a recent and comprehensive account of history of the *ondol*, see Ki-Ho Song, *Hanguk ondol-ui yeoksa [History of Korean Ondol]* (Seoul: Seoul National University Press, 2019).
- Nam-Ung Kim and others, 'A Study on Frank Lloyd Wright's Experience of the Korean Traditional Floor Heating System Ondol' (text in Korean with English abstract), *Journal of Architectural Institute of Korea: Planning and Design*, 203 (2005), 155–66; Kim, 'The Appearance of Korean Architecture in the Modern West', pp. 349–61; and Hyon-Sob Kim, 'The First Adoption of the Korean Ondol Principle in Usonian Houses: Jacobs House I, Designed by Frank Lloyd Wright', *SPACE*, 632 (2020), 30–7.
- See note 5. The two books have a chapter titled 'Gravity Heat', and the contents are almost the same.
- Wright's 'Korean room' was most likely an *ondol* room at a Korean building removed from the Gyeongbokgung Palace in Seoul to the patron's residence in Tokyo in 1916. Considering this and the timings of Wright's visits to Japan, the earliest possible date of his encounter with the *ondol* would be



- January 1917, even as late as early 1920, although Wright (1943; 1954) wrote that this occurred in 1914. For discussions, see Kim, 'The Appearance of Korean Architecture in the Modern West', pp. 349–61 and 'The First Adoption of the Korean *Ondol* Principle in Usonian Houses', pp. 30–7.
12. Wright, *An Autobiography*, p. 495 and *The Natural House*, p. 99.
  13. Ibid. Considering the history of the Imperial Hotel project, it was at the bathrooms of the Imperial Hotel annex constructed in 1920, rather than of the new Imperial Hotel completed in 1923, that the electric floor heating was installed. See Kathryn Smith, 'Frank Lloyd Wright and the Imperial Hotel: A Postscript', *The Art Bulletin*, 67:2 (1985), 296–310.
  14. Besides Wright's own account, see 'Unique Lodge, Plan in Nakoma', *Wisconsin State Journal* (4 August 1924); and Mary Jane Hamilton, 'The Nakoma Country Club', in *Frank Lloyd Wright and Madison*, ed. by Paul Sprague (Madison, OH: Elvehjem Museum of Art, 1990), pp. 77–82.
  15. Specifically, the family moved into the house on 27 November 1937, with the finishing touches having been done by the end of December. Herbert Jacobs and Katherine Jacobs, *Building with Frank Lloyd Wright: An Illustrated Memoir* (San Francisco, CA: Chronicle Books, 1978), pp. 41–7.
  16. Wright, *An Autobiography*, p. 496 and *The Natural House*, p. 100; and Jacobs and Jacobs, *Building with Frank Lloyd Wright*, pp. 4–5.
  17. Strictly speaking, the concrete slab of the Jacobs House rests on a bed of sand rather than gravel, which is different to other Usonian houses. Donald G. Kalec, 'The Jacobs House I', in *Frank Lloyd Wright and Madison*, ed. by Sprague, pp. 91–100. Concerning the installation of the wrought-iron pipes in the house, see Jacobs and Jacobs, *Building with Frank Lloyd Wright*, pp. 27–8; and Kim, 'The First Adoption of the Korean *Ondol* Principle in Usonian Houses', pp. 30–7.
  18. Jacobs and Jacobs, *Building with Frank Lloyd Wright*, p. 59.
  19. Ibid., pp. 4, 20, 50. Regardless, they also enjoyed the fireplace. Ibid., pp. 45, 54.
  20. Sergeant perhaps referred to Jacobs's earlier description in Herbert Jacobs, *Frank Lloyd Wright: America's Greatest Architect* (New York, NY: Harcourt, Brace & World, 1965), pp. 129–30. He further discusses diverse benefits of the heating system based on a scientific analysis of 1940, while pointing out the limitation of 'the looped piping buried under the slab'. Therefore, the wrought-iron pipes that most Usonian houses used were replaced by copper pipes in later Usonians. John Sergeant, *Frank Lloyd Wright's Usonian Houses* (New York, NY: Whitney, 1976), pp. 21, 28–9.
  21. The American Society of Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE) defines 'thermal comfort' as 'the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation' (*ANSI/ASHRAE Standard 55: Thermal Environmental Conditions for Human Occupancy*, 2013) and has published standards to achieve it. Although some reports suggest that the 'comfort zone' lies in a specific range of temperature (e.g., between 69°F and 80°F in the United States), factors in thermal comfort, not only quantitative but also qualitative, are diverse and interrelated. See Lisa Hescong, *Thermal Delight* (Cambridge, MA: MIT Press, 1979), pp. 15–17. In this book, she deals with 'thermal qualities – warm, cool, humid, airy, radiant, cozy' – as 'an important part of our experience of a space' (p. vii).
  22. Jacobs and Jacobs, *Building with Frank Lloyd Wright*, pp. 4, 13. Wright's solution for 'the house of modest cost' was 'to get rid of all unnecessary materials in construction [...] to eliminate, so far as possible, field labor, which is always expensive'. The conventional basement, as well as radiators, belongs to the inessential elements to be dispensed with: 'The old-fashioned basement, except for a fuel and heater space, was always a plague spot. A steam-warmed concrete mat four inches thick laid directly on the ground over gravel filling, the walls set upon that, is better. [...] We need no radiators.' Frank Lloyd Wright, 'Usonian House for Herbert Jacobs', *Architectural Forum*, 68:1 (January 1938), 78–83.
  23. Kalec, 'The Jacobs House I', pp. 91–100 (p. 91). In 1954, Wright wrote that he had built 'over a hundred' Usonian houses and 'many of the Usonian buildings' had floor heating. Wright, *The Natural House*, pp. 97, 101.
  24. Wright, 'Usonian House for Herbert Jacobs', p. 79.
  25. Jacobs, *Frank Lloyd Wright*, pp. 129–30. Also, see Jacobs and Jacobs, *Building with Frank Lloyd Wright*, p. 4.
  26. Harold F. Blanchard, 'First United States Installation of Panel Heating', *The American Architect*, 138:2589 (1930), 32–3, 90–8.
  27. See T. Napier Adlam, *Radiant Heating* (New York, NY: Industrial Press, 1947), pp. 6–9; and Neville S. Billington and Brian M. Roberts, *Building Services Engineering: A Review of Its Development* (Oxford: Pergamon, 1982), pp. 156–63. There have been diverse studies on the development of heating methods in the modern West. For a concise but overall description on the history among them, see Billington and Roberts, *Building Services Engineering*, pp. 156–63; and Kiel Moe, *Thermally Active Surfaces in Architecture* (New York, NY: Princeton Architectural Press, 2010), pp. 54–65.
  28. 'Residence of William Beard', *Architectural Forum*, 62:4 (April 1935), 400–03. Also, see 'Vertical Section' of UCLA Library Special Collections, Beard House, Oversize Folder 935 in 'Richard and Dion Neutra Papers, 1925–1970'. The author's own research at Charles E. Young Research Library, University of California, Los Angeles on 9 July 2019.
  29. Wright's preliminary design of the Nakoma Country Club was approved in December 1923, and its working drawings were completed by August 1924. Hamilton, 'The Nakoma Country Club', pp. 77–82. Neutra's relationship with Wright had developed since they first met in April 1924. In particular, during his stay at Taliesin between September 1924 and February 1925, he had worked intensively for H. De Fries' edition of *Frank Lloyd Wright: Aus dem Lebenswerke eines Architekten* (Berlin: Verlag Ernst Pollak, 1926), which includes the Nakoma Country Club. Concerning Neutra's intimate but complex relationship with Wright, see Richard Neutra, *Life and Shape* (New York, NY: Appleton-Century-Crofts, 1962), pp. 160–89; and Raymond Richard Neutra, *Cheap and Thin: Neutra and Frank Lloyd Wright* (Pacific Grove, CA: Neutra Institute Press, 2022).
  30. It was reported that L. M. Persons, Chief Engineer of White-Rodgers Electric Co., St Louis, developed a 'system of forced air heating', in which 'heated air is pumped into the floor cavities', and he applied the system to his own house in 1936. This system appears to be similar to that of the Beard House. See 'An Experiment in Domestic Air Conditioning', *Architectural Forum*, 68:1 (January 1938), pp. 8, 10, 56, 60.
  31. *The 1936 Book of Small Houses*, ed. by

- Editors of *The Architectural Forum* (New York, NY: Simon and Schuster, 1936) and *The 1938 Book of Small Houses* (New York, NY: Simon and Schuster, 1937). The two books selected contemporary small houses, 115 and 131 respectively, and provided their buildings specifications.
32. 'Don't use new materials, new methods of construction or mechanical equipment which have not been approved by a recognized laboratory or which have not proved themselves by continued usage.' Howard Leland Smith, 'Fifty "Don'ts" for the Prospective Home Builder', in *The 1938 Book of Small Houses*, pp. xxxvii–xxxviii.
  33. However, engineers of the company visited the house after it was completed and tried to learn how the heating system works, amazed at its successful operation. Jacobs and Jacobs, *Building with Frank Lloyd Wright*, pp. 27, 51. Also, see Wright, *An Autobiography*, p. 496 and *The Natural House*, p. 100.
  34. Wright, *An Autobiography*, pp. 494–6 and *The Natural House*, pp. 98–101.
  35. The split between convection and radiation is about 43% and 57% in terms of wall; and about 30% and 70% in terms of ceiling. Richard Woolsey Schoemacher, *Radiant Heating* (New York, NY: McGraw-Hill, 1948), pp. 9–10; and Kalec, 'The Jacobs House I', pp. 91–100. For an updated and diagrammatic study on this matter, see Moe, *Thermally Active Surfaces in Architecture*, p. 34. Apart from convection and radiation, however, conduction is also considered important regarding the heat transfer at the Korean *ondol* room, in which people sit directly on the floor. Myoung-Souk Yeo and others, 'Historical Changes and Recent Energy Saving Potential of Residential Heating in Korea', *Energy and Buildings*, 35 (2003), 715–27; Jun-Bong Kim and others, *Ondol: Geu challanan gudeul-munhwa [Ondol: The Brilliant Floor Heating Culture]* (Seoul: Chunghong, 2008), p. 38; and Song, *Hanguk ondol-ui yeoksa*, p. 25.
  36. Gwendolyn Wright, *Building the Dream: A Social History of Housing in America* (Cambridge, MA: MIT Press, 1981), pp. 240–61; and Avi Friedman, 'The Evolution of Design Characteristics during the Post-Second World War Housing Boom: The US Experience', *Journal of Design History*, 8:2 (1995), 131–46.
  37. Richard Longstreth, 'The Levitts, Mass-Produced Houses, and Community Planning in the Mid-twentieth Century', in *Second Suburb: Levittown, Pennsylvania*, ed. by Dianne Harris (Pittsburgh, PA: University of Pittsburgh Press, 2010), pp. 123–74 (pp. 126–7). Although Herbert J. Gans simply wrote that Alfred 'was trained in architecture', his formal education was not proved. See Herbert J. Gans, *The Levittowners* (New York, NY: Columbia University Press, 1967), p. 4.
  38. 'William Levitt recounted that Norfolk "infected us with the fever of mass building. [...] We saw house-building [...] with a tract of land as a factory, turning out low-cost houses as its product.'" Longstreth, 'The Levitts, Mass-Produced Houses, and Community Planning in the Mid-twentieth Century', pp. 133–8. Also, see Barbara M. Kelly, *Expanding the American Dream: Building and Rebuilding Levittown* (Albany, NY: University of New York Press, 1993), p. 24 and 'Levittowns', in *The Encyclopedia of Housing*, ed. by Andrew T. Carswell (Los Angeles, CA: Sage, 2012), pp. 421–3.
  39. The numbers of constructed houses in Levittowns have been suggested slightly differently depending on sources. This study follows Kelly, 'Levittowns', pp. 421–3.
  40. Gwendolyn Wright, *Building the Dream*, p. 252. Or, it was also said that they built forty houses a day. 'The Most House for the Money' and 'Levitt's Progress', *Fortune*, 46 (October 1952), 151–68.
  41. Gwendolyn Wright, *Building the Dream*, p. 251.
  42. Kelly, *Expanding the American Dream*, p. 217.
  43. 'Levitt's Progress', pp. 154–68.
  44. The house seemed to be mostly designed in December 1937, and it did not take long before the construction started after the design. Caroline Rob Zaleski, 'Ben and Anne Rebhuhn House, Great Neck, 1938', *Long Island Modernism 1930–1980* (New York, NY: Norton, 2012), pp. 52–7.
  45. However, no information about Alfred's meeting with Wright was provided in the *Fortune* article.
  46. Irwin Jalonack was specified as Levitt's technical director for heating and cooling. 'Levitt's Progress', pp. 154–68. His daughter even argues that he 'made the decision to use oil-fired, hot-water radiant systems in the houses of Levittown'. Dan Holohan, *Classic Hydronics* (Bethpage, NY: Dan Holohan Associates, 2011), p. 139.
  47. Edgar Daniel, *Mass Producing the American Dream* (Long Island, NY: Independent Publishing, 1997), p. 29.
  48. Construction Research Bureau of New York. Cited in Daniel, *Mass Producing the American Dream*, p. 29.
- This parallels the Jacobses' and Sergeant's descriptions. See notes 19 and 20.
49. Holohan, *Classic Hydronics*, p. 138.
  50. The author was informed of the existence of this letter by the author's student Yonghyeok Choi, who discovered its citation in Steve Sikora, 'Willey House Stories Part 17 – Roll Down to Levittown', *The Whirling Arrow* (blog), Frank Lloyd Wright Foundation (27 December 2019) <<https://franklloydwright.org/willey-house-stories-part-17-roll-down-to-levittown>> [accessed 9 September 2020]. However, Sikora misdated it as 'February 19, 1939'. The author's confirmation comes from the digital copy of the letter archived in The Frank Lloyd Wright Foundation Archives (The Museum of Modern Art | Avery Architectural & Fine Arts Library, Columbia University, New York) in February 2022.
  51. See note 22.
  52. One may come up with the brick-floored Willey House (1933–4). Equipped with radiators, however, it was not designed to be floor-heated, although one section drawing shows a long underground conduit for hot-water pipes that connects the boiler of the cellar and the bathroom of the first floor (The Frank Lloyd Wright Foundation Archives, Drawing no. 3401.25). The Willey House was also published in *Architectural Forum* (January 1938), as well as *Architectural Record* (November 1935), but its heating was not discussed in the publications.
  53. See its section drawings, including the one catalogued 'Millwork details' (Drawing no. 3801.028) in The Frank Lloyd Wright Foundation Archives.
  54. Copies of the two drawings, the 1947 Cape Cod and 1950 Ranch, are exhibited in the Levittown Historical Society and Museum, Long Island, and their smaller-size or piece-by-piece copies have been preserved in the nearby Levittown Public Library. The author's research in each institution took place in October 2019 and February 2022, respectively.
  55. Kelly, 'Levittowns', pp. 421–3. Although partly controversial, this study restated the second and third Levittowns' completion years in Kelly: from 1955 to 1957 for Bucks County and from 1965 to 1968 for Willingboro. The former is based on Dianne Harris, "'The House I Live In": Architecture, Modernism, and Identity in Levittown', in

- Second Suburb*, pp. 200–42; and the latter is based on the fact that Levitt & Sons continued constructing houses in some sections of Willingboro between 1965 and early 1970s, although not using the brand name 'Levittown', but the company was sold in 1968. See 'LevittownBeyond', an unofficial online community of Levittowns <<http://levittownbeyond.com/LevittownNJ.html>> [accessed 17 May 2022].
56. The Levittown in Bucks County introduced as diverse as seven models – 'Budgeteer', 'Levittowner', 'Country Clubber', 'Jubilee', 'Rancher', 'Pennsylvanian', and 'Colonial' – to embrace the preferences of modern (e.g., Budgeteer) and deluxe (e.g., Country Clubber), too. In Willingboro, however, the types became simplified and restored to the conservative tendency of Long Island, while targeting somewhat more affluent clients. Harris, "The House I Live In": Architecture, Modernism, and Identity in Levittown', pp. 200–42; and Kelly, 'Levittowns', pp. 421–3.
  57. For this comment on floor heating, as well as images of the flyers, see Richard Wagner and Amy Duckett Wagner, *Images of America: Levittown* (Charleston, SC: Arcadia, 2010), pp. 33, 44–5, 49–50.
  58. The three models were variations of 'Cape Cod', 'Rancher', and 'Colonial', respectively. The drawings of the 1958 models and some other models are downloadable from the above-mentioned website 'LevittownBeyond' (note 55). They were originally published in various issues of the *House & Home* magazine.
  59. On the Eichler homes, see Susan Hall Harrison, 'Post World War II Tract Houses: The Subdivision Developments of Joseph L. Eichler 1949–1956' (unpublished Master's thesis, University of Virginia, 1980); Jerry Ditto and others, *Eichler Homes: Design for Living* (San Francisco, CA: Chronicle Books, 1995); and Paul Adamson, *Eichler: Modernism Rebuilds the American Dream* (Layton, UT: Gibbs Smith, 2002).
  60. In the meantime, Eichler Homes was effectively dissolved by the end of 1968, the same year of the Levitts' downfall. For the last years of Eichler's career, see Adamson, *Eichler*, pp. 216–21.
  61. Adamson, *Eichler*, p. 23. This term involves the works of William Wurster (1895–73) and his contemporaries in California, amid which context the Eichler homes were built. 'Everyday modernism [...] tempered national and international architectural trends with a concern for things local.' See Marc Treib, 'Introduction' and 'The Feeling of Function', in *An Everyday Modernism: The Houses of William Wurster*, ed. by Marc Treib (Berkeley, CA: University of California Press, 1995), pp. 8–11, 12–83 (pp. 8, 74).
  62. Harris, "The House I Live In": Architecture, Modernism, and Identity in Levittown', p. 389 (note 51).
  63. The company employed Ernie (Ernest) Braun as an official photographer. For his photographs as well as Eichler's marketing, see Adamson, *Eichler*, pp. 122–77.
  64. *Ibid.*, p. 93.
  65. Sergeant, *Frank Lloyd Wright's Usonian Houses*, p. 61.
  66. Bill Rodd, 'Joseph Eichler Explains: The Eichler Success Formula', *American Builder* (August 1963), p. 66. Cited in Harrison, 'Post World War II Tract Houses', p. 27. There is a similar quotation: 'I admired Wright's rich design, with its wooden walls and beamed ceiling, and I asked myself if such houses could be built for people'. Sally B. Woodbridge, 'Introduction', in *Eichler Homes*, pp. 21–33 (p. 31).
  67. Ned Eichler, 'A Cherished Legacy', in *Eichler Homes*, pp. 34–117 (p. 54).
  68. The gatherings were hosted by Louis and Betty Frank, who bought it from Sydney and Louise Bazett in 1945 when Eichler, as a tenant, still lived there. Adamson, *Eichler*, pp. 50–1.
  69. *Ibid.*, p. 80 (note 28).
  70. 'The principal design considerations – the desirability of indoor and outdoor privacy and the orientation towards garden areas – as well as elements such as built-in furniture, tile flooring, radiant heat, galley kitchen and interpenetrating roofs were extracted from the Bazett house.' Harrison, 'Post World War II Tract Houses', p. 31. This design was not executed owing to postwar restrictions, but the second design (1949–50) was realised in Atherton in 1951, still with Wrightian motifs although diluted a lot. Adamson, *Eichler*, p. 53.
  71. The first one was Sunnymount Gardens that started being advertised in *Daily Palo Alto Times* from May 1949. Harrison, 'Post World War II Tract Houses', pp. 28–31, 83–4. According to Harrison, Eichler homes at the Stanford Gardens subdivision in Melno Park, advertised from January 1950, offered 'radiant heat' among other amenities, but no evidence was provided.
  72. The first phase of Sunnyvale Manor, advertised in April 1949, was carried out under the name of 'Sunnyvale Building Company', erecting and selling prefabricated houses on Eichler's developed land. *Ibid.*
  73. 'Gamble in Modern', *Architectural Forum*, 92:4 (April 1950), 145–6.
  74. 'The Long Island Builder's House', *Architectural Forum*, 93:1 (July 1950), 102–09.
  75. Harrison, 'Post World War II Tract Houses', p. 33. In fact, the magazine dealt with only three without mentioning specific subdivisions. Considering that the Geer Park was the last one on marketing, as late as 15 December, it is this subdivision that was excluded from here. 'Subdivision of the Year', *Architectural Forum*, 93:6 (December 1950), 80–7.
  76. Adamson, *Eichler*, p. 65.
  77. Harrison, 'Post World War II Tract Houses', Fig. 27; and Adamson, *Eichler*, p. 65.
  78. The initial collaboration between Eichler and Anshen & Allen broke up after the success in Sunnyvale and Palo Alto owing to their disagreement over architects' fee, but they came to work again for Eichler even after other architects were employed. Adamson, *Eichler*, p. 66.
  79. However, the steel-frame type was not fully utilised owing to 'the complexity of steel fabrication and delivery'. *Ibid.*, pp. 94–9.
  80. *Ibid.*, pp. 72–9.
  81. Adamson supposes that this drawing was made c. 1968. So, it perhaps belonged to J. L. Eichler Associates, but its feature would be hardly different from that of Eichler Homes. Oakland worked for Eichler until the latter died. *Ibid.*, pp. 115, 212–15.
  82. 'The Long Island Builder's House'.
  83. See note 32.
  84. Many East Coast builders copied Levitt houses and 'more than 4,000 non-Levitt, Levitt Types' were expected to be built in eastern cities by the 1950 summer. See 'The Most Popular Builder's House', *Architectural Forum*, 92:4 (April 1950), 134–83.
  85. By the time when the first Levitt houses were built in Long Island, various research results on radiant heating had been accumulated in America. See, for example: Adlam, *Radiant Heating* (1947) and Schoemacher, *Radiant Heating*

- (1948). Both were published in New York.
86. Richard Sennett, *The Craftman* (New Haven, CT: Yale University Press, 2008), pp. 119–29.
  87. Heschong, *Thermal Delight*, p. 36.
  88. *Ibid.*, p. 29.
  89. Stamatis Zografos, *Architecture and Fire* (London: UCL Press, 2019), pp. 103–04.
  90. In general, the whole floor has to come up for repair, and there is no major difference in this method between America and Korea.
  91. For the cases of Levitt houses, see Kelly, *Expanding the American Dream*, p. 132; Holohan, *Classic Hydronics*, pp. 142–4; and comments on Sikora, 'Willey House Stories Part 17 – Roll Down to Levittown'. However, a survey of Eichler homes says that 'there have been very few maintenance problems with the [radiant-heating] systems'. Adamson, *Eichler*, p. 65. Eichler residents have shared knowhow to maintain and repair the heating system. See the FAQ page of 'Eichler Network', an online community of Eichler homeowners <<https://www.eichlernetwork.com/faq#radiant>> and the 'Eichler Flooring Ideas' page in 'Eichler for Sale' <<https://www.eichlerforsale.com/eichler-flooring>> [accessed 14 June 2022].
  92. As Gans wrote, 'during the 1950s, when attacks on the physical and demographic homogeneity of the postwar suburban subdivisions began, Levittown was frequently mentioned as the prototype', and one of the harshest critics was Lewis Mumford. Therefore, when Levitt & Sons introduced the idea of building different house types within the same neighbourhood in Willingboro, one executive of the company said: 'Now Lewis Mumford can't criticize us any more.' Gans, *The Levittowners*, pp. 8–9. Concerning the racial segregation and desegregation matter, including the FHA's segregation policy, see Gans, *The Levittowners*, pp. 368–470; and Thomas J. Sugrue, 'Jim Crow's Last Stand: The Struggle to Integrate Levittown', in *Second Suburb*, pp. 175–99. Amid the 'institutionalised racialism' and discriminatory social atmosphere at that time, Eichler communities, too, could not but reveal a similar racial problem, but it was relatively milder owing to Eichler and his partners' liberal and non-discriminatory stance. Adamson, *Eichler*, pp. 197–204. For other reasons for the decline of Eichler homes, see Ned Eichler, 'A Cherished Legacy', pp. 91–3.
  93. Many researchers that the present paper refers to had used this phrase or similar expressions to explain postwar mass-produced houses, particularly the Levittowns and Eichler homes. See 'The New Suburban Expansion and the American Dream', Chapter 13 of G. Wright (1981), 'Expanding the American Dream: Building and Rebuilding Levittown' of Kelly (1993), 'Eichler: Modernism Rebuilds the American Dream' of Adamson (2002), etc.
  94. Among diverse efforts to modernise the traditional *ondol* system during the Japanese colonisation period, the publication of Kilyong Park (1898–1943), the representative figure of the first-generation Korean architects, was the most conspicuous. Kilyong Park, *On the Improvement of Traditional Korean Houses*, 2 (Seoul: Yimoondang, 1937).
  95. Byoung-Heon Lee and Hyon-Sob Kim, 'A Study on the Modernization of the Heating Method of Apartment Houses in the 1950s and 1960s Korea' (text in Korean with English abstract), *Journal of Architectural History*, 30:6 (2021), 33–44.
  96. Carl G. Lans, 'Housing as an Industry', *Architecture* (Architectural Institute of Korea), 2 (1956), 41–8.
  97. Dongmin Park, 'Free World, Cheap Buildings: U.S. Hegemony and the Origin of Modern Architecture in South Korea, 1953–1960' (unpublished doctoral thesis, University of California, Berkeley, 2016), p. 83. Cited in Lee and Kim, 'A Study on the Modernization of the Heating Method of Apartment Houses in the 1950s and 1960s Korea', pp. 33–44. Apart from the forty-eight units of 'Apartment House', fifty-two units of 'Row House' with a modernised briquette-*ondol* system were also built for this Haengchon project.
  98. Lee and Kim, 'A Study on the Modernization of the Heating Method of Apartment Houses in the 1950s and 1960s Korea', pp. 33–44. Differently from the Mapo Apartment I, the subsequent Mapo Apartments II (192 units; 1963–4) installed a briquette-*ondol* system, which was more updated than that of the Haengchon row houses.
  99. Moe, *Thermally Active Surfaces in Architecture*, pp. 63–5. When the Jacobs House was restored in 1980s, the original wrought-iron pipes were replaced by polybutylene pipes, plastic products similar to the PEX. John Eiffler, 'Restoring the Jacobs House', *Fine Homebuilding*, 81 (April/May 1993), 78–82.

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The author declares none.

#### Author's biography

Hyon-Sob Kim is Professor of Architectural History at Korea University. Based on doctoral and postdoctoral research on European modernism at the University of Sheffield, his research interests extended to historiography of modern architecture in Korea and Korean architecture's representation in the modern West, accompanied by numerous publications. Awarded a 2022 special grant of the Harvard-Yenching Institute, he has recently taken his second sabbatical stay at the Harvard University for researching on 'Korean Architecture Described in Western Publications, 1876–1910', as well as finalising this article.

#### Author's affiliation

Hyon-Sob Kim, Korea University, Korea.

#### Author's address

Hyon-Sob Kim  
[archistory@korea.ac.kr](mailto:archistory@korea.ac.kr)