PROLOGUE

PARIS, FRANCE

—1901—

THE SCIENTIST HAD FORGOTTEN ALL ABOUT THE RADIUM. IT WAS tucked discreetly within the folds of his waistcoat pocket, enclosed in a slim glass tube in such a small quantity that he could not feel its weight. He had a lecture to deliver in London, England, and the vial of radium stayed within that shadowy pocket for the entirety of his journey across the sea.

He was one of the few people in the world to possess it. Discovered by Marie and Pierre Curie late in December 1898, radium was so difficult to extract from its source that there were only a few grams available anywhere in the world. He was fortunate indeed to have been given a tiny quantity by the Curies to use in his lectures, for they barely had enough themselves to continue experiments.

Yet this constraint did not affect the Curies' progress. Every day they discovered something new about their element: "it made an impression on photographic plates through black paper," the Curies' daughter later wrote, "[I]t corroded and, little by little, reduced to powder the paper or the cotton wool in which it was wrapped…What could it *not* do?" Marie called it "my beautiful radium"—and it truly was. Deep in the dark pocket of the scientist, the radium broke the gloom with an unending, eerie glow.

"These gleamings," Marie wrote of its luminous effect, "seemed suspended in the darkness [and] stirred us with ever-new emotion and enchantment."

Enchantment… It implies a kind of sorcery, almost supernatural power. No wonder the U.S. surgeon general said of radium that "it reminds one of a mythological super-being." An English physician would call its enormous radioactivity "the unknown god."

Gods can be kind. Loving. Benevolent. Yet as the playwright George Bernard Shaw once wrote, "The gods of old are constantly demanding human sacrifices." Enchantment—in the tales of the past, and present—can also mean a curse.

And so, although the scientist had forgotten about the radium, the radium had not forgotten him. As he traveled to that foreign shore, through every second of his journey, the radium shot out its powerful rays toward his pale, soft skin. Days later, he would peer in confusion at the red mark blooming mysteriously on his stomach. It looked like a burn, but he had no memory of coming near any flame that could produce such an effect. Hour by hour, it grew more painful. It didn't get bigger, but it seemed, somehow, to get *deeper*, as though his body was still exposed to the source of the wound and the flame was burning him still. It blistered into an agonizing flesh burn that grew in intensity until the pain made him suck in his breath sharply and rack his brains for what on earth could have inflicted such damage without his being aware.

And it was then that he remembered the radium.

PART ONE

KNOWLEDGE

1

NEWARK, NEW JERSEY
UNITED STATES OF AMERICA

—1917—

KATHERINE SCHAUB HAD A JAUNTY SPRING IN HER STEP AS SHE walked the brief four blocks to work. It was February 1, 1917, but the cold didn't bother her one bit; she had always loved the winter snows of her hometown. The frosty weather wasn't the reason for her high spirits on that particular icy morning, though: today, she was starting a brand-new job at the watch-dial factory of the Radium Luminous Materials Corporation, based on Third Street in Newark, New Jersey.

It was one of her close pals who had told her about the vacancy; Katherine was a lively, sociable girl with many friends. As she herself later recalled, "A friend of mine told me about the 'watch studio' where watch-dial numerals and hands were painted with a luminous substance that made them visible in the dark. The work, she explained, was interesting and of far higher type than the usual factory job." It sounded so glamorous, even in that brief description—after all, it wasn't even a factory, but a "studio." For Katherine, a girl who had "a very imaginative temperament," it sounded like a place where anything could happen. It certainly beat the job she'd had before, wrapping parcels in Bamberger's department store; Katherine had ambitions far beyond that shop floor.

She was an attractive girl of just fourteen; her fifteenth birthday was in five weeks' time. Standing just under five foot four, she was "a very pretty little blonde" with twinkling blue eyes, fashionably bobbed hair, and delicate features. Although she had received only a grammar-school education before she left school—which was "about all the education that girls of her working-class background received in those days"—she was nevertheless fiercely intelligent. "All her life," *Popular Science* later wrote, "[Katherine] Schaub…had cherished [the] desire…to pursue a literary career." She was certainly go-getting: she later wrote that, after her friend had given her word of the opportunities at the watch studio, "I went to the man in charge—a Mr. Savoy—and asked for a job."

And that was how she found herself outside the factory on Third Street, knocking on the door and gaining admittance to the place where so many young women wanted to work. She felt almost a little star-struck as she was ushered through the studio to meet the forewoman, Anna Rooney, and saw the dial-painters turning diligently to their tasks. The girls sat in rows, dressed in their ordinary clothes and painting dials at top speed, their hands almost a blur to Katherine's uninitiated eyes. Each had a flat wooden tray of dials beside her—the paper dials were preprinted on a black background, leaving the numerals white, ready for painting—but it wasn't the dials that caught Katherine's eye; it was the material they were using. It was the radium.

Radium. It was a wonder element; everyone knew that. Katherine had read all about it in magazines and newspapers, which were forever extolling its virtues and advertising new radium products for sale—but they were all far too expensive for a girl of Katherine's humble origins. She had never seen it up close before. It was the most valuable substance on earth, selling for $120,000 for a single gram ($2.2 million in today's values). To her delight, it was even more beautiful than she had imagined.

Each dial-painter had her own supply. She mixed her own paint,

dabbing a little radium powder into a small white crucible and adding a dash of water and a gum arabic adhesive: a combination that created a greenish-white luminous paint, which went under the name "Undark." The fine yellow powder contained only a minuscule amount of radium; it was mixed with zinc sulfide, with which the radium reacted to give a brilliant glow. The effect was breathtaking.

Katherine could see that the powder got everywhere; there was dust all over the studio. Even as she watched, little puffs of it seemed to hover in the air before settling on the shoulders or hair of a dial-painter at work. To her astonishment, it made the girls themselves gleam.

Katherine, like many before her, was entranced by it. It wasn't just the glow—it was radium's all-powerful reputation. Almost from the start, the new element had been championed as "the greatest find of history." When scientists had discovered, at the turn of the century, that radium could destroy human tissue, it was quickly put to use to battle cancerous tumors, with remarkable results. Consequently—as a life-saving and thus, it was assumed, health-giving element—other uses had sprung up around it. All of Katherine's life, radium had been a magnificent cure-all, treating not just cancer, but hay fever, gout, constipation…anything you could think of. Pharmacists sold radioactive dressings and pills; there were also radium clinics and spas for those who could afford them. People hailed its coming as predicted in the Bible: "The sun of righteousness [shall] arise with healing in his wings, and ye shall go forth and gambol as calves of the stall."

For another claim of radium was that it could restore vitality to the elderly, making "old men young." One aficionado wrote: "Sometimes I am halfway persuaded that I can feel the sparkles inside my anatomy." Radium shone "like a good deed in a naughty world."

Its appeal was quickly exploited by entrepreneurs. Katherine had seen advertisements for one of the most successful products, a radium-lined jar to which water could be added to make it radioactive: wealthy customers

drank it as a tonic; the recommended dose was five to seven glasses a day. But as some of the models retailed for $200 ($3,700), it was a product far out of Katherine's reach. Radium water was drunk by the rich and famous, not working-class girls from Newark.

What she did feel part of, though, was radium's all-pervasive entry into American life. It was a craze, no other word for it. The element was dubbed "liquid sunshine," and it lit up not just the hospitals and drawing rooms of America, but its theaters, music halls, grocery stores, and bookshelves. It was breathlessly featured in cartoons and novels, and Katherine—who loved to sing and play piano—was probably familiar with the song "Radium Dance," which had become a huge hit after being featured in the Broadway musical *Piff! Paff! Pouf!* On sale were radium jockstraps and lingerie, radium butter, radium milk, radium toothpaste (guaranteeing a brighter smile with every brushing) and even a range of Radior cosmetics, which offered radium-laced face creams, soap, rouge, and compact powders. Other products were more prosaic: "The Radium Eclipse Sprayer," trumpeted one ad, "quickly kills all flies, mosquitoes, roaches. [It] has no equal as a cleaner of furniture, porcelain, tile. It is harmless to humans and easy to use."

Not all of these products actually contained radium—it was far too costly and rare for that—but manufacturers from all kinds of industries declared it part of their range, for everyone wanted a slice of the radium pie.

And now, to Katherine's excitement, thanks to her job, she would have a prime seat at the table. Her eyes drank in the dazzling scene before her. But then, to her disappointment, Miss Rooney ushered her into a room that was separate from the main studio, away from the radium and the shining girls. Katherine would not be dial-painting that day—nor the day after, as much as she longed to join the glamorous artists in the other room.

Instead, she would be serving an apprenticeship as an inspector, checking the work of those luminous girls who were busy painting dials.

It was an important job, Miss Rooney explained. Although the

company specialized in watch faces, it also had a lucrative government contract to supply luminous airplane instruments. Given there was a war raging in Europe, business was booming; the company also used its paint to make gunsights, ships' compasses, and more shine brightly in the dark. And when lives were hanging in the balance, the dials had to be perfect. "[I was] to see that the number outlines were even and [thorough] and to correct minor defects," Katherine recalled.

Miss Rooney introduced her to her trainer, Mae Cubberley, and then left the girls to it, resuming her slow march up and down the rows of painting girls, casting a watchful eye over their shoulders.

Mae smiled at Katherine as she said hello. A twenty-six-year-old dial-painter, Mae had been with the company since the previous fall. Although she was new to the industry when she joined, she already had a reputation as a brilliant painter, regularly turning in eight to ten trays of dials daily (there were either twenty-four or forty-eight dials in each tray, depending on the dial size). She had quickly been promoted to training other girls in the hope that they would match her productivity. Now, in the little side room, she picked up a paintbrush to instruct Katherine in the technique that all the dial-painters and inspectors were taught.

They were using slim camel-hair brushes with narrow wooden handles. One dial-painter recalled: "I had never seen a brush as fine as that. I would say it possibly had about thirty hairs in it; it was exceptionally fine." Yet as fine as the brushes were, the bristles had a tendency to spread, hampering the girls' work. The smallest pocket watch they painted measured only three-and-a-half centimeters across its face, meaning the tiniest element for painting was a single millimeter in width. The girls could not go over the edges of these delicate parameters or there would be hell to pay. They had to make the brushes even finer—and there was only one way they knew of to do that.

"We put the brushes in our mouths," Katherine said, quite simply. It

was a technique called lip-pointing, inherited from the first girls who had worked in the industry, who came from china-painting factories.

Unbeknownst to the girls, it wasn't the way things were done in Europe, where dial-painting had been in operation for over a decade. Different countries had different techniques, but in none was lip-pointing used. Very likely this was because brushes weren't used either: in Switzerland, there were solid glass rods; in France, small sticks with cotton wadding on the ends; other European studios employed a sharpened wooden stylus or metal needle.

However, American girls did not take up the lip-pointing technique with blind faith. Mae said that when she first started, not long after the studio had opened in 1916, she and her colleagues had questioned it, being "a little bit leery" about swallowing the radium. "The first thing we asked," she remembered, "[was] 'Does this stuff hurt you?' And they said, 'No.' Mr. Savoy said that it wasn't dangerous, that we didn't need to be afraid." After all, radium was the wonder drug; the girls, if anything, should benefit from their exposure. They soon grew so used to the brushes in their mouths that they stopped even thinking about it.

But for Katherine it felt peculiar, that first day, as she lip-pointed over and over, correcting defective dials. Yet it was worth persevering: she was constantly reminded why she wanted to work there. Her job involved two types of inspection, daylight and darkroom, and it was in the darkroom that the magic really happened. She would call the girls in to discuss their work and observed, "Here in the room—daylight barred—one could see evidences of the luminous paint everywhere on the worker. There was a dab here and there on her clothes, on the face and lips, on her hands. As some of them stood there, they fairly shone in the dark." They looked glorious, like otherworldly angels.

As time went on, she got to know her colleagues better. One was Josephine Smith, a sixteen-year-old girl with a round face, brown bobbed

hair, and a snub nose. She had worked at Bamberger's too, as a saleslady, but left to earn the much higher wage of a dial-painter. Although the girls weren't salaried—they were paid piecework, for the number of dials they painted, at an average rate of 1.5 cents a watch—the most talented workers could walk away with an astonishing pay package. Some earned more than three times the average factory-floor worker; some even earned more than their fathers. They were ranked in the top 5 percent of female wage-earners and on average took home $20 ($370) a week, though the fastest painters could easily earn more, sometimes as much as double, giving the top earners an annual salary of $2,080 (almost $40,000). The girls lucky enough to gain a position felt blessed.

Josephine, Katherine learned as they talked, was of German heritage, just like Katherine herself. In fact, most dial-painters were the daughters or granddaughters of immigrants. Newark was full of migrants, hailing from Germany, Italy, Ireland, and elsewhere; it was one of the reasons the company had opened the studio in the city in the first place, for the large immigrant communities provided a workforce for all sorts of factories. New Jersey was nicknamed the Garden State for its high agricultural production, but in truth it was just as productive industrially. At the turn of the century, the business leadership of Newark had labeled it the City of Opportunity and—as the girls themselves were finding out—it lived up to its name.

It all made for a thriving metropolis. The nightlife after the factories closed was vibrant; Newark was a beer town, with more saloons per capita than any other American city, and the workers made their downtime count. The dial-painters embraced the social bonhomie: they sat together to eat lunch in the workroom at the Newark plant, sharing sandwiches and gossip over the dusty tables.

As the weeks passed, Katherine observed the challenges as well as the attractions of dial-painting: Miss Rooney's constant observation as she walked up and down the studio, and the ever-present dread of being called

into the darkroom to be reprimanded for poor work. Above all else, the girls feared being accused of wasting the expensive paint, which could ultimately be a dismissible offense. But although Katherine could see that there were downsides, she still longed to join the women in the main room. She wanted to be one of the shining girls.

A quick learner, Katherine soon excelled at her inspecting, not only perfecting the art of correcting defective dials with her lip-pointed brush, but also becoming adept at brushing off the dust with her bare hand or removing excess paint with her fingernail; the technique taught her. She worked as hard as she could, longing for promotion.

Finally, toward the end of March, her perseverance paid off. "I was asked to paint dials," she wrote excitedly; "I said I would like to try it."

Katherine had achieved her ambition through merit—but there were also wider forces at work in that spring of 1917. Dial-painters were about to be in demand as never before: the company now needed all the women it could get.

2

FOR THE PAST TWO AND A HALF YEARS, THE WAR IN EUROPE HAD left America mostly untouched, except for the economic boom it brought. The majority of Americans were happy to stay out of the horrific trench warfare happening across the Atlantic, stories of which had reached them undiluted by distance. But in 1917, the neutral position became untenable. On April 6, just a week or so after Katherine's promotion, Congress voted America into the conflict. It would be known as "the war to end all wars."

In the dial-painting studio on Third Street, the impact of the decision was immediate. Demand rocketed. The studio in Newark was far too small to produce the numbers required, so Katherine's bosses opened a purpose-built plant just down the road from Newark in Orange, New Jersey, closing the Third Street factory. This time there wouldn't only be dial-painters on site; the company had grown so much it was to do its own radium extraction, requiring labs and processing plants. The Radium Luminous Materials Corporation was expanding massively, and the new site comprised several buildings, all located in the middle of a residential neighborhood.

Katherine was among the first workers through the door of the

two-story brick building that would house the application department. She and the other dial-painters were delighted by what they found. Not only was Orange an attractive, prosperous town, but the second-floor studio was charming, with huge windows on all sides and skylights in the roof. The spring sunshine streamed in, giving excellent light for dial-painting.

An appeal for new workers to help the war effort was made, and just four days after war had been declared, Grace Fryer answered the call. She had more reason than most to want to help; two of her brothers would be joining the several million American soldiers heading to France to fight. Lots of dial-painters were motivated by the idea of helping the troops: "The girls," wrote Katherine, "were but a few of the many who through their jobs were 'doing their bit.'"

Grace was a particularly civic-minded young woman. "When Grace was just a schoolgirl," a childhood friend of hers wrote, "she planned to be a real citizen when she grew up." Her family was of a political bent; her father Daniel was a delegate to the carpenters' union, and you couldn't grow up in his house without picking up his principles. He was out of work rather a lot, as unionism was not popular at that time, but while the family may not have had much money, they did have a lot of love. Grace was one of ten children—she was number four—and she was especially close to her mother, also called Grace; perhaps because she was the eldest girl. There were six boys and four girls in total, and Grace was close to her siblings, especially her sister Adelaide, who was nearest to her in age, and her little brother Art.

Grace was already working when the call-up came, in a position that earned about the same as dial-painting, but she left to join the radium company in Orange, where she lived. She was an exceptionally bright and exceptionally pretty girl, with curly chestnut hair, hazel eyes, and clear-cut features. Many called her striking, but her looks weren't of much interest to Grace. Instead, she was career-minded, someone who at the age of eighteen

was already fashioning a prosperous life for herself. She was, in short, "a girl enthused with living." She soon excelled at dial-painting, becoming one of the company's fastest workers, with an average production rate of 250 dials a day.

A young woman called Irene Corby also signed on that spring. The daughter of a local hatter, she was a very cheerful girl aged about seventeen. "She had a very humorous disposition," revealed her sister Mary, "exceptionally so." Irene instantly got on well with her coworkers—with Grace in particular—and they regarded her as one of the more skilled employees.

It fell to Mae Cubberley and Josephine Smith to train the new girls. The women sat side by side at long tables running the full width of the studio; there was a walkway in between them, so Miss Rooney could continue her over-the-shoulder inspections. The instructresses taught them how to dab a tiny amount of the material (the girls always called the radium "the material") into their crucibles, "like a fine smoke in the air," and then mix the paint carefully. Even the softest stirring, however, left most women with splashes on their bare hands.

Then, once the paint was mixed, they instructed them to lip-point. "She told me to watch her and imitate her," Katherine remembered of her training. As surely as night follows day, Grace and Katherine and Irene followed the instructions. They put the brush to their lips…dipped it in the radium… and painted the dials. It was a "lip, dip, paint routine": all the girls copied each other, mirror images that lipped and dipped and painted all day long.

They soon found the radium hardened on their brushes. A second crucible was supplied, ostensibly for cleaning the bristles, but the water was changed only once a day and soon became cloudy: It didn't so much clean as spread the bristles, which some workers found a hindrance; they simply used their mouths to dampen the brush instead. Others, however, always used the water: "I know I done it," one said, "because I couldn't stand that gritty taste in my mouth."

The taste of the paint was a source of debate. "It didn't taste funny," Grace observed; "it didn't have any taste." Yet some ate the paint specifically because they liked it.

Another new worker tasting the magic element that summer was sixteen-year-old Edna Bolz. "Here is a person," *Popular Science* later wrote of her, "blessed from birth with a sunny disposition." She was taller than many of her coworkers, though still only five foot five, and had an innate elegance about her. She was nicknamed the "Dresden Doll" because of her beautiful golden hair and fair coloring; she also had perfect teeth and, perhaps as a result, a beaming smile. Over time she became close to the forelady, Miss Rooney, who described her as "a very nice type of girl; very clean-living type of very good family." Edna's passion was music, and she was also devoutly religious. She joined in July, at a time when production was rocketing due to wartime demand.

That summer, the plant was a ferment of activity: "The place was a madhouse!" one worker exclaimed. The girls were already doing overtime to keep up with demand, working seven days a week; now, the studio started operating night and day. The dial-painters glowed even brighter from the radium against the dark windows: a workshop of shining spirits laboring through the night.

Though the pace was demanding, the setup was in many ways fun for the women, who reveled in the drama of the long shifts painting dials for their country. The majority were teenagers—"merry giggling girls"—and they found time for the odd bit of fun. One favorite game was to scratch their name and address into a watch: a message for the soldier who would wear it; sometimes, he would respond with a note. New girls were joining all the time, which made the job even more sociable. In Newark, perhaps seventy women had worked in the studio; during the war, that number more than tripled. The girls now sat crammed in on both sides of the desks, only a few feet apart.

Hazel Vincent was among them. Like Katherine Schaub, she came from Newark; she had an oval face with a button nose and fair hair that she set in the latest styles. Another new worker was twenty-one-year-old Albina Maggia, the daughter of an Italian immigrant, who came from a family of seven girls; she was the third. She was a somewhat round and diminutive woman of only four foot eight, with classic Italian dark hair and eyes. She was pleased to get back into the world of work—as the eldest unmarried daughter, she'd quit her hat-trimming job to nurse her mother, who'd died the year before—but she discovered she was not the fastest dial-painter. She found the brushes "very clumsy" and painted only a tray and a half a day. Nonetheless, she tried as hard as she could, later remarking, "I always did my best for that company."

Joining Albina at the long wooden desks was her little sister Amelia, whom everyone called Mollie. She seemed to have found her calling at the studio, being unusually productive. A foot taller than Albina, she was a sociable nineteen-year-old with a broad face and bouffant brown hair, often seen laughing with her colleagues. She got on particularly well with another newcomer, Eleanor Eckert (nicknamed Ella): the two were as thick as thieves. Ella was popular and good-looking, with blond, slightly frizzy hair and a wide smile; a sense of fun was never far from her, whether she was at work or play. The girls would socialize and eat lunch together, barely stopping work as they shared food across the crowded desks.

The company also organized social events; picnics were a favorite. The dial-painters, dressed in white summer dresses and wide-brimmed hats, would eat ice-cream cones while sitting on the narrow makeshift bridge that lay across the brook by the studio, swinging their legs or holding on to one another as they tried not to fall in the water. The picnics were for all employees—so at these events the girls got to mix with their coworkers, whom they rarely saw: the men who worked in the laboratories and refining rooms. It wasn't long before the odd "office romance" began; Mae

Cubberley started walking out with Ray Canfield, a lab worker: one of many blossoming relationships among the girls, though most were not with colleagues. Hazel Vincent, for one, was in love with her childhood sweetheart, a mechanic called Theodore Kuser, who had baby-blue eyes and fair hair.

The company's founder, Sabin von Sochocky, an Austrian-born, thirty-four-year-old doctor, could often be seen holding court at these picnics, seated among his workers on a rug, his jacket off and a beaker of cold drink in one hand. The girls seldom saw him in their studio—he was usually too busy working in his lab to grace them with his presence—so it was a rare opportunity for their paths to cross. It was he who had invented the luminous paint they used, back in 1913, and it had certainly been a success for him. In his first year, he had sold 2,000 luminous watches; now, the company's output ranked in the millions. In many ways he was an unlikely entrepreneur, for his training had been in medicine; initially, he'd intended the paint to be a "potboiler" to fund medical research, but the growing demand had necessitated a more businesslike approach. He had met a "kindred soul" in Dr. George Willis, and the two physicians had founded the company.

Von Sochocky was, according to his colleagues, a "remarkable man." Everyone called him simply "the doctor." He was indefatigable: "someone that liked to start late, but is then willing to go on and on until all hours." *American* magazine called him "one of the greatest authorities in the world on the subject of radium"—and he had studied under the best: the Curies themselves.

From them, and from the specialist medical literature he had studied, von Sochocky understood that radium carried great dangers. Around the time he studied with the Curies, Pierre was heard to remark that "he would not care to trust himself in a room with a kilo of pure radium, as it would burn all the skin off his body, destroy his eyesight, and probably kill him."

The Curies, by that time, were intimately familiar with radium's hazards, having suffered many burns themselves. Radium could cure tumors, it was true, by destroying unhealthy tissue—but it was indiscriminating in its powers, and could devastate healthy tissue too. Von Sochocky himself had suffered its silent and sinister wrath: radium had got into his left index finger and, when he realized, he hacked the tip of it off. It now looked as though "an animal had gnawed it."

Of course, to the layman, all this was unknown. The mainstream position as understood by most people was that the effects of radium were all positive; and that was what was written about in newspapers and magazines, championed across product packaging and performed on Broadway.

Nonetheless, the lab workers in von Sochocky's plant in Orange were provided with protective equipment. Lead-lined aprons were issued, along with ivory forceps for handling tubes of radium. In January 1921, von Sochocky would write that one could handle radium "only by taking the greatest precautions."

Yet despite this knowledge, and the injury to his own finger, von Sochocky was apparently so transfixed by radium that all reports say he took little care. He was known to play with it, holding the tubes with his bare hands while watching the luminosity in the dark or immersing his arm up to the elbow in radium solutions. Company cofounder George Willis was also lax, picking up tubes of radium with his forefinger and thumb, not bothering with forceps. Perhaps understandably, their colleagues learned from them and copied what they did. No one heeded the warnings of Thomas Edison, working just a few miles away in sight of the Orange plant, who once remarked, "There may be a condition into which radium has not yet entered that would produce dire results; everybody handling it should have a care."

Yet in the sunny second-floor studio, the girls working there had not a care in the world. Here there were no lead aprons, no ivory-tipped forceps,

no medical experts. The amount of radium in the paint was considered so small that such measures were not deemed necessary.

The girls themselves, of course, had no clue that they might even be needed. This was radium, the wonder drug, they were using. They were lucky, they thought, as they laughed among themselves and bent their heads to their intricate work. Grace and Irene. Mollie and Ella. Albina and Edna. Hazel and Katherine and Mae.

They picked up their brushes and they twirled them over and over, just as they had been taught.

Lip… Dip… Paint.

3

WARS ARE HUNGRY MACHINES—AND THE MORE YOU FEED THEM, the more they consume. As the fall of 1917 wore on, demand at the factory showed no signs of slowing; at the height of operations, as many as 375 girls were recruited to paint dials. And when the firm announced it needed more women, the existing workers eagerly promoted the job to their friends, sisters, and cousins. It wasn't long before whole sets of siblings were seated alongside each other, merrily painting away. Albina and Mollie Maggia were soon joined by another sister, sixteen-year-old Quinta.

She was an extremely attractive woman with large gray eyes and long dark hair; she considered her pretty teeth her best feature. Down-to-earth and kind, her favorite pastimes included card games, checkers, and dominoes. She also confessed cheekily, "I don't go to church half as often as I should." She hit it off brilliantly with Grace Fryer, and the two became "inseparable."

Grace was another who brought her little sister to work: Adelaide Fryer adored the social side of it, being a very gregarious girl who loved to be around people, but she wasn't quite as sensible as her big sister; in the end, she was fired for talking too much. The girls may have been sociable, but

they still had a job to do, and if they didn't knuckle down and do it, they were out. It could be tough. As Katherine Schaub had observed in Newark, the girls were under a lot of pressure. If a worker failed to keep up, she was criticized; if she fell short repeatedly, she eventually lost her job. The only time the girls really saw Mr. Savoy, whose office was downstairs, was when he came to scold them.

The biggest issue was the wasting of the paint. Each day, Miss Rooney issued a set amount of powder to the girls for completing a particular number of dials—and they had to make it last. They could not ask for more, but neither could they eke it out; if the numerals were not sufficiently covered by the material, it would show up during inspection. The girls took to helping each other out, sharing material if one found she had a little extra left over. And there were also their water dishes, filled with the radium sediment. Those, too, could be a source of extra material.

But the cloudy water hadn't gone unnoticed by the company bosses. Before too long, the crucibles for cleaning the brushes were removed with the explanation that too much valuable material was wasted in the water. Now the girls had no choice but to lip-point, as there was no other way to clean off the radium that hardened on the brush. As Edna Bolz observed, "Without so doing it would have been impossible to have done much work."

The girls themselves were also targeted in the drive to limit waste. When a shift was over and they were about to leave for home, they were summoned to the darkroom to be brushed off: the "sparkling particles" were then swept from the floor into a dustpan for use the next day.

But no amount of brushing could get rid of all the dust. The girls were covered in it: their "hands, arms, necks, the dresses, the underclothes, even the corsets of the dial-painters were luminous." Edna Bolz remembered that even after the brushing down, "When I would go home at night, my clothing would shine in the dark." She added, "You could see where

I was—my hair, my face." The girls shone "like the watches did in the darkroom," as though they themselves were timepieces, counting down the seconds as they passed. They glowed like ghosts as they walked home through the streets of Orange.

They were unmissable. Unassailable. The residents of the town noticed not just the wraithlike shine but also the expensive, glamorous clothes, for the girls dressed in silks and furs, "more like matinee idlers than factory workers," a perk of their high wages.

Despite the attractions of the job, however, it wasn't for everyone. Some found the paint made them sick; one woman got sores on her mouth after just a month of working there. Though the girls all lip-pointed, they did so at different intervals, which perhaps accounted for the varying reactions. Grace Fryer found that "I could do about two numbers before the brush dried," whereas Edna Bolz lip-pointed on every number, sometimes even two or three times per number. Quinta Maggia did the same, even though she hated the taste: "I remember chewing [the paint]—gritty—it got between my teeth. I remember it distinctly."

Katherine Schaub was one of the more infrequent pointers; only four or five times per watch would she slip the brush between her lips. Nonetheless, when she suddenly broke out in pimples—which could have been due to her hormones, for she was still only fifteen—she was perhaps mindful of some of her colleagues' adverse reactions, as she decided to consult a doctor.

To her concern, he asked her if she worked with phosphorus. This was a well-known industrial poison in Newark, and it was a logical suspicion—but it made Katherine feel anything but logical and calm. For it wasn't only her acne that caused the doctor concern: there were changes, he noted, in Katherine's blood. Was she *sure* she didn't work with phosphorus?

The girls weren't entirely clear what was in the paint. Flummoxed by her doctor's questions, Katherine turned to her colleagues. When she told

them what her physician had said, they became frightened. En masse, they confronted Mr. Savoy, who tried to allay their fears, but this time his words about the paint being harmless fell on deaf ears.

And so, as any middle manager would do, he went to *his* managers. Soon after, George Willis came over from New York to lecture the girls on radium and convince them it was not dangerous; von Sochocky also participated. There was nothing hazardous in the paint, the doctors promised: the radium was used in such a minuscule amount that it could not cause them harm.

And so the girls turned back to their work, their shoulders a little lighter, Katherine probably feeling a bit sheepish that her teenage spots had caused such bother. Her skin cleared up, and so too did the minds of the dial-painters. When one of the greatest radium authorities in the world tells you that you have no need to worry, quite simply, you don't. Instead, they laughed about the effect the dust had on them. "Nasal discharges on my handkerchief," Grace Fryer remembered, "used to be luminous in the dark." One dial-painter, known as a "lively Italian girl," painted the material all over her teeth one night before a date, wanting a smile that would knock him dead.

Those budding romances of the girls were now coming into full flower. Hazel and Theo were as close as ever, and Quinta started courting a young man called James McDonald—but it was Mae Cubberley who became a winter bride on December 23, 1917. As was traditional, she wanted to leave work right away, but Mr. Savoy asked her to stay a little longer, so she was still in the studio when Sarah Maillefer signed on that same month.

Sarah was a little different from the other girls. For a start, she was older at twenty-eight: a shy, matronly woman who often seemed a little separate from the teenagers, though they were inclusive of her. Sarah was broad-shouldered with short dark hair—and those shoulders needed to be broad, for she was also a single mother. She had a six-year-old daughter, Marguerite, named after Sarah's little sister.

Sarah had married, back in 1909. Her husband, Henry Maillefer, was a tall, French-Irish sexton with black hair and black eyes. But Henry had disappeared; where he was now, nobody knew. And so Sarah and Marguerite still lived with her mom and pop, Sarah and Stephen Carlough, as well as her sister Marguerite, who was sixteen. Stephen was a painter and decorator, and the family were "hard-working, reasonable" people. Sarah, too, was hard-working, and would become one of the most loyal employees the radium company had.

For Mae Cubberley Canfield, however, her loyalty had come to an end. Soon after she married, she became pregnant and therefore handed in her notice in the early months of 1918. That chapter of her life was over.

Her place was quickly filled. That year, an estimated 95 percent of all the radium produced in America was given over to the manufacture of radium paint for use on military dials; the plant was running at full capacity. By the end of the year, one in six American soldiers would own a luminous watch—and it was the Orange girls who painted many of them. Jane Stocker (nicknamed Jennie) was a new recruit, and in July a slim, elfin-featured girl called Helen Quinlan joined. She was an energetic woman whom the company rather sniffily described as "the type that did altogether too much running around for her own good." She had a boyfriend she often brought to the girls' picnics, a smart, blond young man who wore a shirt and tie to the gatherings. He and Helen posed for a picture at one of them: Helen had her skirts flapping around her knees, always on the move, while he stared at her rather than the camera, looking utterly besotted with this playful creature he had somehow been lucky enough to meet.

The women were still encouraging their families to join them in their work. In September 1918, Katherine wrote proudly, "I obtained a position for Irene at the factory." Irene Rudolph was her orphaned cousin, the same age as Katherine; she lived with the Schaubs. Perhaps understandably given her early life, Irene was a cautious, thoughtful young lady. Rather

than spending her wages on silks and furs as some of the other girls did, she squirreled it away in a savings account. She had a narrow face and nose with dark eyes and hair; the only picture of her that survives shows her somewhat downcast.

A month after Irene started, another new employee began work. But this was no dial-painter striding into a new job: this was Arthur Roeder, a highly successful businessman who was the company's new treasurer. He'd already demonstrated a skill for seizing career opportunities: though he had left his university without a degree, he'd ascended rapidly through the ranks of his chosen career. A round-faced, smart-looking man with a Roman nose and thin lips, he favored bow ties and pomade, which he slicked through his dark hair to press it close to his skull. He was based at the head office in New York and now took on responsibility for the dial-painters. Though he said he was in the studio on numerous occasions, his presence there was an exception, as most of the executives rarely went inside. In fact, of the firm's top men, Grace Fryer remembered von Sochocky passing through her place of work just once. She didn't pay it much attention at the time, but it would come to take on a great significance.

She was at her desk as usual that day, lipping and dipping her brush, as were all the other girls. Von Sochocky, as per *his* usual, had his head full of ideas and complex science as he walked briskly about his work. On this occasion, as he passed swiftly through the studio, he stopped and looked straight at her—and at what she was doing, as though seeing her actions for the first time.

Grace glanced up at him. He was a memorable-looking man, with a dominant nose and close-cut dark hair above his slightly protruding ears. Conscious of the pace of work around her, she bent again to her task and slipped the brush between her lips.

"Do not do that," he said to her suddenly.

Grace paused and looked up, perplexed. This was how you did the job; how all the girls did it.

"Do not do that," he said to her again. "You will get sick." And then he was on his way.

Grace was utterly confused. Never one to back down from something she thought needed further investigation, she went straight over to Miss Rooney. But Miss Rooney merely repeated what the girls had already been told. "She told me there was nothing to it," Grace later recalled. "She told me it was not harmful."

So Grace went back to her work: *Lip… Dip… Paint*. There was a war on, after all.

But not for much longer. On November 11, 1918, the guns fell silent. Peace reigned. More than 116,000 American soldiers had lost their lives in the war; the total death toll for all sides was around 17 million. And in that moment of the Armistice, the radium girls, the company executives, and the world gave thanks that the brutal, bloody conflict was over.

Enough people had died. Now, they thought, it was time for living.

4

EXACTLY ONE MONTH AFTER THE ARMISTICE, QUINTA MAGGIA PUT those seize-the-day principles into action, marrying James McDonald. He was a cheery man of Irish heritage who worked as a chain-store manager. The newlyweds set up home in a two-story cottage; to begin with, Quinta was still dial-painting, but that didn't last long. She left the firm in February 1919 and soon became pregnant; her daughter, Helen, would be born two days after Thanksgiving.

Nor was she the only dial-painter to depart. The war was over; the girls were growing up. Irene Corby also resigned, having landed a job as an office girl in New York City. Later, she would marry the rather dashing Vincent La Porte, a man with piercing blue eyes who worked in advertising.

Those who left were quickly replaced. Sarah Maillefer managed to get a position for her little sister, Marguerite Carlough, in August 1919. She was a dynamic young woman who wore rouge and lipstick and liked dramatic clothes: smart tailored coats with oversized lapels and wide-brimmed hats with feathered edges. Marguerite became best friends with the little sister of Josephine Smith, Genevieve, who had also started working there; another close friend was Albina Maggia, who was still slaving away over her trays of

dials, having seen her younger sister marry ahead of her. Albina didn't resent Quinta's happiness, but she couldn't help but wonder when her time might come; that summer, she too decided to leave, returning to hat-trimming.

It was a time of change all round. That same summer, Congress passed the Nineteenth Amendment, giving women the right to vote. Grace Fryer, for one, couldn't wait to make it count. At the plant, too, change was afoot: soon a new chemist—and future vice president—Howard Barker, together with von Sochocky, started playing around with the recipe of the luminous paint, substituting mesothorium for radium. A memo revealed: "Barker would just mix whatever he had around the place and sell it, 50–50 or 10 per cent [mesothorium] and 90 percent [radium], or whatever." Mesothorium was an isotope of radium (dubbed radium-228 to denote its difference from the "normal" radium-226): also radioactive but with a half-life of 6.7 years, in contrast to radium-226's 1,600 years. It was more abrasive than radium and—crucially for the firm—much cheaper.

In the studio, meanwhile, the girls, for some unknown reason, were asked to try a new technique. Edna Bolz remembered, "They passed little cloths around: we were supposed to wipe the brush on this little cloth instead of putting it in our mouth." But within a month, Edna said, "They were taken away from us. We were not allowed to use the cloths; it wasted too much of the radium." She concluded, "The lips were resorted to as the better way."

It was important to the company that the production process be as efficient as possible, because the demand for luminous products showed no signs of slowing, even now the war was over. In 1919, much to new treasurer Arthur Roeder's delight, there was a production high: 2.2 million luminous watches. No wonder Katherine Schaub was feeling tired; that fall, she noticed "cracking and stiffness of her legs." She was feeling in poor spirits generally, as her mother had passed away that year; Katherine became closer to her father, William, as they grieved.

Yet life, as Katherine's orphaned cousin Irene Rudolph knew too well, goes on, even when those we love die. She and Katherine could do nothing but knuckle down to their jobs, alongside their fellow workers still toiling in the dust-filled studio: Marguerite Carlough and her sister Sarah Maillefer, Edna Bolz and Grace Fryer, Hazel Vincent and Helen Quinlan, Jennie Stocker and—still making everyone laugh—Ella Eckert and Mollie Maggia, who were in fact two of the fastest workers, despite their high jinks at the company socials. They played hard, but they were tough workers too. You had to be to keep your job.

Still the endless orders came. The company began to consider its postwar strategy. It resolved to expand its presence in the field of radium medicine; Arthur Roeder also oversaw the trademarking of "Undark." Peacetime frivolity meant there were numerous products customers wanted to make glow in the dark: the company now sold its paint directly to consumers and manufacturers, who performed their own application. All this gave the radium firm another idea—they planned to set up in-house studios for watch manufacturers. This would dramatically reduce the dial-painting workforce in Orange, but the company would still profit by supplying the paint.

In fact, the firm had a compelling reason to want to leave Orange, or at least condense operations. The site's position in the middle of a residential neighborhood was proving problematic now that the fervor of wartime patriotism had gone. The local residents started to complain that factory fumes discolored their laundry and affected their health. Company officials took the unusual step of appeasing the residents themselves: one executive gave a neighbor $5 ($68.50) compensation for her damaged washing.

Well, that was a mistake. It opened the floodgates. Next thing, *all* the residents wanted money. People in this poor community were "anxious to take advantage of the company." The firm learned its lesson: it immediately drew the company purse strings tight, and not a single further dollar was paid out.

The executives turned their attention back to the watch-company studios. The demand for them was obvious; in 1920, luminous-watch production would surpass four million units. Arrangements were soon put in place and everyone was happy—everyone, it seemed, but the original dial-painters.

For while the *company* was doing well through the new agreement, it left the women out in the cold. There was simply not enough work coming in to keep them all employed. Demand dwindled until the Orange studio was running only on a part-time basis.

For the dial-painters, who were paid by the number of dials they did, it was an unsustainable situation. Their numbers decreased until there were fewer than a hundred women remaining. Helen Quinlan was one of those who got out, as did Katherine Schaub, in search of better-paid employment. Helen became a typist, while Katherine found a job in the office of a roller-bearing factory—and found that she loved it. "The girls at the office," she wrote, "were a sociable crowd; they had a club which they invited me to join. Most of the girls embroidered or crocheted, making things for their hope-chests."

Hope-chests were also called dowry chests, and contained items collected by young single women in anticipation of marriage. In the spring of 1920, Katherine was eighteen, but she didn't seem in any hurry to settle down; she liked the nightlife too much for that. "I wasn't making anything for my hope-chest," she wrote, "so while the girls worked, I played the piano and sang songs that were popular in those days."

Grace Fryer was also canny enough to see the writing on the wall. Dial-painting, for her, could only ever have been a stopgap job: it was something important to help the war effort, but it wasn't a long-term proposition for someone of her skills. She set her sights high and was thrilled to secure a position at the Fidelity, a high-end bank in Newark. She loved traveling to her office, her dark hair neatly set and an elegant string of pearls around her neck, ready to get to grips with work that challenged her.

As with Katherine's new colleagues, the girls at the bank were sociable; Grace was "the kind of girl who loved dancing and laughing," and she and her new work friends often hosted dry parties, for Prohibition had begun in January 1920. Grace also liked to swim in her spare time, propelling her lithe body through the local swimming pool as she kept fit. She thought the future looked bright—and she wasn't the only one. In Orange, Albina Maggia had met her man at last.

It felt so wonderful to be courting after waiting all this time. Just when she'd started to feel really old—she was twenty-five, years older than most girls wed at that time; and with a suddenly creaky left knee to boot—he had finally come along: James Larice, a bricklayer and Italian immigrant who'd moved to the United States aged seventeen. He was a war hero, awarded a Purple Heart and one oak leaf cluster. Albina started to allow herself to dream of marriage and children, of finally moving out of the family home.

Her sister Mollie, meanwhile, wasn't waiting for any knight in shining armor to come for her. Independent-minded, confident, and unmarried, she left her family to board in an all-female house on Highland Avenue, a tree-lined street in Orange with beautiful detached homes. Mollie was still working at the radium company; one of the few girls left, but she was brilliant at her job and didn't want to leave. Every morning she went to work full of energy and enthusiasm, which was more than she could say for some of her colleagues. Marguerite Carlough, who could normally be relied on for a laugh, kept saying she felt tired all the time; Hazel Vincent, meanwhile, felt so run-down that she decided to leave. She and Theo weren't yet married, so she got herself a job with the General Electric Company.

But her new surroundings didn't improve her condition. Hazel had no idea what was wrong with her: the weight was dropping off her, she felt weak, and her jaw ached something rotten. She was so concerned that in the end she asked the company doctor at her new firm to examine her, but he was unable to diagnose her illness.

The one thing she could be assured of, at least, was that it wasn't her work with radium that was the cause. In October 1920, her former employer was featured in the local news. The residue from radium extraction looked like seaside sand, and the company had offloaded this industrial waste by selling it to schools and playgrounds to use in their children's sandboxes; kids' shoes were reported to have turned white because of it, while one little boy complained to his mother of a burning sensation in his hands. Yet, in comments that made reassuring reading, von Sochocky pronounced the sand "most hygienic" for children to play in, "more beneficial than the mud of world-renowned curative baths."

Katherine Schaub certainly had no qualms about returning to work for the radium firm when she was head-hunted at the end of November 1920 to train the new workers in the watch-company studios. These were mostly based in Connecticut, including at the Waterbury Clock Company. Katherine taught scores of girls the method she herself had learned: "I instructed them," she said, "to put the brush in their mouth."

The new girls were excited to be working with radium, for the unstoppable craze continued, brought to fever pitch by a visit of Marie Curie to the United States in 1921. In January of that same year, as part of the constant press coverage of the element, von Sochocky penned an article for *American* magazine. "Locked up in radium is the greatest force the world knows," he opined gravely: Through a microscope, you can see whirling, powerful, invisible forces, the uses of which"—he admitted—"we do not yet understand." He added, as a cliffhanger on which to leave his readers: "What radium means to us today is a great romance in itself. But what it may mean to us tomorrow, no man can foretell."

In fact, no man can foretell much, von Sochocky included. And there was one event in particular that the doctor didn't see coming: in the summer of 1921, he was frozen out of his own company. His cofounder, George Willis, had sold a large share of his stock to the company treasurer,

Arthur Roeder; not long after that, both Willis and von Sochocky were unceremoniously ousted in a corporate takeover. The newly named United States Radium Corporation (USRC) seemed destined for great things in the postwar world, but von Sochocky wouldn't be at the helm to guide it through whatever lay ahead.

Instead, it was Arthur Roeder who slipped graciously into the vacant president's chair.