

## A REVIEW OF PIECEWORK

**The HCI community has used the term “piecework” to describe myriad instantiations of on-demand labor, but this reference has generally been offered in passing.** As this paper principally traces a relationship between the historical piecework and the contemporary crowd work (or on-demand labor more generally), this casual familiarity with piecework may prove insufficient. We’ll more carefully discuss piecework in this section in order to inform the the rest of the argument. Specifically, we will 1) define “piecework” as researchers in the topic understood it; and 2) trace the rise and fall of piecework at a very high level, identifying key figures and ideas during this time; This section is not intended to be comprehensive: instead, it sets up the scaffolding necessary for our later investigations of crowd work’s three questions: complexity limits, task decomposition, and worker relationships.

### What is piecework?

**Aligning on-demand work with piecework requires an understanding of what piecework is.** While “piecework” has had multiple definitions over time, we can trace a constellation of characteristics that recur throughout the literature. We will follow this history of research, collecting descriptions, examples, and provided definitions of piecework, trying to trace the outline of a working understanding of *what piecework is*.

Raynbird offers a concise definition of piecework — which he variously also calls “measure work”, “grate work”, and “task work” — by contrasting the “task-labourer” with the “day-labourer”: “the chief difference lies between the day-labourer, who receives a certain some of money. . . for his day’s work, and the task-labourer, whose earnings depend on the *quantity* of work done [emphasis added]” [23]. Chadwick gives a more illustrative definition of piecework, offering examples: “payment is made for each hectare which is pronounced to be well ploughed [...] for each living foal got from a mare; [...] for each living calf got” [7]. This framing perhaps makes the most intuitive sense; “payment for results,” as Chadwick calls it, is not only common in practice, but well-studied in labor economics as well [11, 29, 30, 15].

**It’s worth acknowledging that “this distinction [between piece-rates and time-rates] was not completely clear-cut” [14].** Indeed, work adopted piece-rate compensation in some aspects and time-rate compensation in others. The “Rowan premium system”, which essentially paid workers a base rate for time plus (the potential for) an additional pay dependent on output, was just one of several alternatives to stricter time- and piece-rate remuneration paradigms, which muddies the waters for us later as we attempt to categorize cases of piecework [27]. As Rowan’s premium system guaranteed an hourly rate regardless of the worker’s productive output *as well as* an additional compensation tied to performance, workers under this regime were in some senses “task-labourers”, and in other senses (more conventional) “day-labourers”.

**It may be worth thinking about piecework through the lens of its emergent properties to help understand it.** Returning to Raynbird, several arguments for the merits of piece-

work crop up; he points out that “piece work holds out to the labourer an increase of wages as a reward for his skill and exertion [...] he knows that all depends on his own diligence and perseverance [...] and] so long as he performs his work to the satisfaction of his master, he is not under that control to which the day-labourer is always subject.” Raynbird highlight the freedom from control that “task-labourers” enjoy [23, 27].

**We see this sense of independence regardless of the time, locale, and industry.** Satre offers a look into the lives and culture of “match girls” — young women paid by piecework to assemble matchsticks generally in the late 19th century. Of particular interest was their independent nature, via their reputation “... for generosity, independence, and protectiveness, but also for brashness, irregularity, low morality, and little education” [28]. J. Hagan documents piecework from 1850–1930 in Australia, finding similar assertions of the freedom compositors of newspapers experienced as pieceworkers: “If a piece-work compositor who held a ‘frame’ decided that he did not want to work on a particular day or night, the management recognised his right to put a ‘substitute’ or ‘grass’ compositor in his place” [17]. From these accounts we identify a sense of independence and autonomy that resonates across decades, industries, and locales where piecework is found.

**Piecework opened the door for people who previously couldn’t participate in the labor market — for example due to lack of training — to do so, and to acquire job skills incrementally.** For example, women could receive training in narrow subsets of the general body of skills, enabling them to act in capacities similar to what conventional (male) apprentices would undertake [14]. In addition, workers with specific slices of skills could be matched to suitable tasks. Workers without conventional training — like women, who had no such opportunities to engage in engineering and metalworking apprenticeships as men did — could be trained very narrowly on a very tightly constrained task, demonstrate proficiency, and become experts in their own ways.

In summary, piecework:

1. paid workers for quantity of work done, rather than time done, but occasionally mixed the two payment models;
2. afforded workers freedom in when and how much to work; and
3. structured tasks such that people who didn’t have the training to engage in the traditional labor force could still participate.

Viewing crowd work as a modern instantiation of piecework is relatively straightforward by this definition. First, platforms such as Mechanical Turk, Uber and TaskRabbit pay by the task, though some such as Upwork do offer hourly rates as well. Second, workers are attracted to these platforms by the freedom they offer to pick the time and place of work [20, 4]. Third, system developers as on Mechanical Turk typically assume no professional skills in transcription or other areas, and attempt to build that expertise into the workflow [21, 2]. Given this alignment, many of the same properties of piecework historically will apply to on-demand work as well. In the next section, we perform this application to three of

the major questions in crowd work and gig work, identifying similarities and differences between historical piecework and modern on-demand work.

### A Piecework Primer

**In this section we will offer a brief overview of the history of piecework; this should not be mistaken for a comprehensive background.** Instead, this section will attempt to provide a sense of orientation when thinking about piecework. In other words, it will frame piecework in the contexts of the early days of the Industrial Revolution, through the political and economic turmoil of the early and mid-20th century, and into the 21st century. While the previous section provided a *definition* of piecework, this section attempts to shine a light on the *zeitgeist* of piecework.

**Piecework's history traces back further perhaps than most would expect.** Grier describes the process astronomers adopted of hiring young boys to calculate equations in order to better-predict the trajectories of various celestial bodies in the 19th century [13]. George Airy was perhaps the first to rigorously apply piecework-style decomposition of tasks to work; by breaking complex calculations into constituent parts, and training young men to solve simple algebraic problems, Airy could distribute work to many more people than could otherwise complete the full calculations.

**Piecework may have started in the intellectual domain of astronomical calculations and projections, but it found its foothold in manual labor.** Piecework took off on in farm work [23], in textiles [1, 25], on railroads [5], and elsewhere in manufacturing [28]. Fordism and scientific management thrust piecework into higher gear, especially as mass manufacturing and a depleted wartime workforce forced industry to find new ways to eke out more production capacity. Hart and Roberts point out that the Second World War, which called millions of Americans to military service, necessitated the rapid training and employment of a labor pool that hadn't historically been utilized in industrial labor: women [14]. [a2: I'd like to bring the Rosie the Riveter anecdote in here but it's not feeling natural. . .]

The early proliferation of manual piecework led to discussion surrounding how best to manage pieceworkers [22, 8]. Despite this, workers' means were mostly ignored, leading to frustration over poor working and living conditions (famously documented by Riis) [25]. This led to industry organizations representing railway workers, mechanical engineers, and others beginning to speak out on pieceworkers' behalf [19, 24].

**Piecework's popularity in the United States and Europe plummeted almost as quickly as it had climbed.** Hart and Roberts's work substantively explores the precipitous decline of piecework in the last third of the 20th century. In their work, Hart and Roberts offer a number of explanations for the sudden vanishing of piecework. The salient suggestions include: 1) the emergence of more effective, more nuanced incentive models — rewarding teams for complex achievements, for instance; 2) the shifting of these industries (manufacturing, clothing, etc. . .) to other countries; and 3) the quality of “multidimensional” work becoming too difficult to evaluate [14].

### Case studies in piecework

**We'll try to discuss the context and general details of three instructive cases of piecework, which will substantively inform the three questions we investigate later (what are the complexity limits of crowd work, how far can work be decomposed into smaller microtasks, and ??).** The three major threads we'll explore will be 1) Airy's employment of *human computers*, 2) the “matchstick” girls, and 3) railroad workers across the United States.

#### Airy's Computers

**Grier gives early accounts of a piecework strategy in Airy's creation of the British Nautical Almanac [13].** Airy's goal was complex — mathematical calculations to produce tables that would allow sailors to locate themselves by starlight from sea. Many of his contributors did not have high-level mathematical training, so Airy broke down the task into simpler calculations and distributed them by mail, accomplishing the complex goal through piecework tasks that paid little.

However, when piecework entered the American economy, it was not used for complex work. One reason for low complexity was workers' skills: it was infeasible to provide new pieceworkers with the comprehensive education that apprenticeships imparted [14]. So, initially piecework arose for farm work, and as Raynbird and others discuss, the practice remained relatively obscure until it blossomed in the textile industry [23]. Complexity levels remained low at the turn of the 20th century as piecework saturated New York City [25]. However, writers of the time focused their attention on wage [6] and management regimes [22] rather than training.

**Piecework became an important factor in the war effort for the Second World War, cementing its role not only in American factories, but in industrial work around the world.** The 1930s represented a boom for piecework on an unprecedented scale, especially among engineering and metalworking industries. As discussed earlier, Hart and Roberts characterize the 1930s — and more broadly the first half of the 20th century — as the “heyday” of the use of piecework. He attributes this to the shortage of male workers, who would have gone through a conventional apprenticeship process affording them more comprehensive knowledge of the total scope of work. One might reflect on the observation that “Rosie the Riveter”, an icon of 20th century America who represented empowerment and opportunity for women [16], was a pieceworker [9].

**The research community relating to piecework and labor has been wrestling with the decomposition of work for centuries.** The beginnings of systematic task decomposition stretch back as far as the 19th century, when Airy employed young boys at the Greenwich Observatory who “possessed the basic skills of mathematics, including ‘Arithmetic, the use of Logarithms, and Elementary Algebra’ ” to compute astronomical phenomena [13]. The work that Airy solicited resonates with modern crowd work for several reasons. First, work output was quickly verifiable; Airy could assign variably skilled workers to compute values, and have other workers check their work. Second, tasks were discrete — that is, independent from

one another. Finally, workers could be trained on a very narrow subset of mathematical skills to be sufficiently qualified to do this work.

This approach found its audience in the early 20th century with the rise of Fordism and scientific management (or Taylorism). Scientific management suggested that it was possible to measure work at unprecedented resolution and precision. As Brown points out, piecework most greatly benefits the instrumented measurement of workers, but certainly in Ford and Taylor's time, highly instrumented, automatic measurement of workers was all but impossible [5]. As a result, the distillation of work into smaller units ultimately bottomed out with tasks as small as could be usefully measured [12].

**Piecework researchers enumerate a number of problems with the decomposition of work, and the conflicting pressures managers and workers put forth.** Bewley in particular points out that the approach of paying workers by the piece is "... not practical for workers doing many tasks, because of the cost of establishing the rates and because piecework does not compensate workers for time spent switching tasks". Ultimately, Bewley argues that "[piecework is] infeasible, because ... total output is the joint product of varying groups of people" [3].

Workers' relationships with employers quickly soured. The match-girls strike of 1888 was one of the earliest and most famous successful worker strikes and perhaps the beginning of "militant trade unionism" [28]. As Weyer, Webb, and Webb described, "the match-girls' victory turned a new leaf in Trade Union annals" [31]: in the 30 years after the match-girls strike, the Trade Union Movement enrollment grew from 20% of eligible workers to over 60%. This strike was followed by others, including women in the garment industry in Philadelphia who established collective bargaining rights [10] and national coal miners who effected an individual minimum wage in 1912 [26]. The adoption of piecework's time-studies and other Taylorist and scientific management approaches reliably precipitated strikes and more generally gave workers a clear enemy against which to rally [18].

#### Human Computers The Matchstick Girls

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#### Railroad Workers

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