

the introduction of the motor. As will be seen in this plate, each head is driven by a 20-horse power motor, from which the cutting bars are driven through powerful friction clutches, which permits the operators to have convenient control of the bars at all times. This improved method of drive has superseded the long shaft, which ran the entire length of the bed in the older machines, communicating the power to the cutting bars through a system of clutches.

These facts will show that the slotting machine of to-day has three times the capacity of the machine manufactured a few years ago. In consequence a very great saving has been effected in the cost of slotting frames, for, as has been shown, in the earliest machine it required 60 hours to slot one pair of frames, the machine as next improved slotted four frames in 32 hours, while the latest improved machine averages six frames in 40 hours.

In passing rather hurriedly through an outline of machine tool improvements, a few words should be said on the subject of the drilling machine. In common with nearly all classes of machinery the drilling machine has of late years received its share of attention. The following plates will serve to illustrate the development of this type of machine tool, and render unnecessary an explanation of the improvements in detail.

Fig. No. 20 shows the first ratchet and drill brace used in the shops some forty years ago. Fig. No. 21 is a very old illustration of an American-built drill. Fig. No. 22 illustrates a vertical drill, built in the Bertram Works about 1869. Fig. No. 23 illustrates the latest Bertram vertical drill. Fig. No. 24 shows a full universal radial drill. The first machine built from this pattern was exhibited at the Centennial Exposition at Philadelphia in 1876. Fig. No. 25 represents the latest production in full universal radial drills.

Time will not permit the discussion of present-day drilling records, or to compare them with those of early days. Many articles on high speed drilling have appeared from time to time in engineering publications, and the wide variations in results obtained might be an interesting point for discussion at a subsequent meeting. Some of those present might then be able to give valuable information regarding personal experiences.

This paper should not be concluded without giving some attention to one of the most important machines, namely, the iron planer, and in doing so it should not be necessary to go into its past history further than to state that since 1694 little was accomplished in its development until early in 1800.

As stated in the introductory remarks, there was a machine of this type in the Gartshore Foundry in 1863. This machine had a cutting speed of about 10' per minute. The gearing was made