there are three genotypes (*KK, Kk, kk*) corresponding to three phenotypes.

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A New Time Scale for Kymograph Recording

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In laboratory experiments involving the kymograph recording of biological responses a time line is generally traced on the smoked paper, together with the experimental record. This time line allows the observer to correlate the observed phenomenon with absolute time.

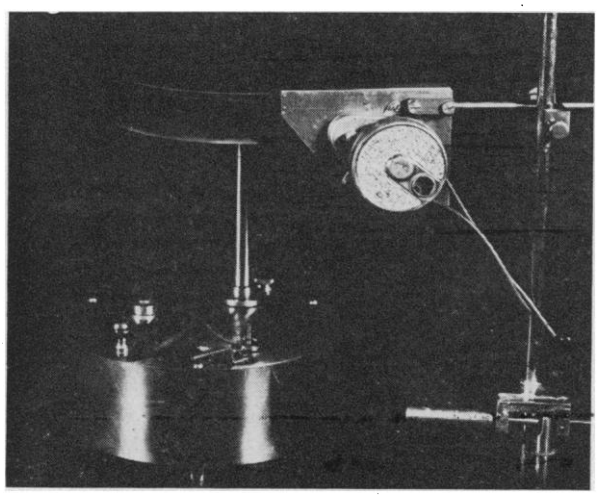

FIG. 1. The new interval timer for kymograph recording, in use.

With the usual equipment available in the laboratory, tracing this time line involves the use of signal magnets, dry cells, and a signal source. Failure on the part of any of these units leads to inconveniences. When the signal source is centrally located and is used by several investigators in different experiments, the adjustment of the signal may not be suitable for all. To overcome these troubles, a small instrument which is independent of such auxiliary apparatus has recently been developed. This instrument is a small self-contained unit (Fig. 1) which will trace a characteristic time scale when plugged into any 110-volt, 60-cycle circuit. Although the intervals on this scale are not adjustable, the form of the time scale traced makes it suitable for use over a wide range of kymograph speeds. (See Fig. 2.)

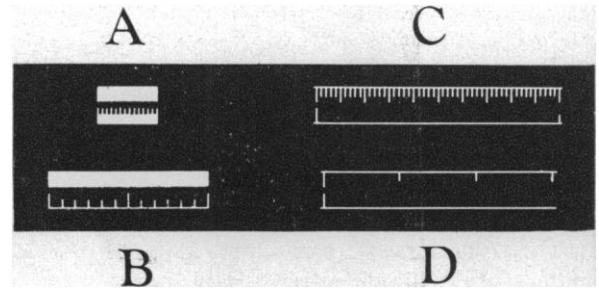

FIG. 2. Four examples of the new time scale for kymograph recording, illustrating its enormous range. The upper base line indicates intervals of 1 sec (long lines) and ⅕ sec (short lines). The lower base line similarly indicates 1-min and 10-sec intervals. Note that, at very slow drum speeds, the 1-sec and ⅕-sec divisions merge into a solid phalanx. (A) At drum speed of 0.5 mm/min. (B) At drum speed of 10 mm/min. (C) At drum speed of 200 mm/min. (D) At drum speed of 3000 mm/min.

The instrument used to trace the time scale operates as follows: Two very light styli (A and B in Fig. 3) spaced 4 mm apart trace the base lines. The upper stylus (A) is struck from above by an impactor (C) at a rate of five impacts per sec. Every fifth impact is heavier than the others. This results in the tracing of a longer line than the others. Thus 1-sec division lines are traced, each divided by four shorter lines representing 1/5-sec intervals. These lines extend downward from the upper base line. The lower stylus (B) is struck from below by another impactor (D) at a rate of one impact in 10 sec, each sixth impact being heavier than the others. Thus 1-min division lines are traced, each minute being divided into six divisions of 10 sec each. These lines extend upward from the lower base line. The adjustment is such that the 1-min and 10-sec divisions align exactly with the corresponding 1-sec division lines. The impactors are operated by cams (E and F) driven by a small self-starting synchronous motor. The accuracy of

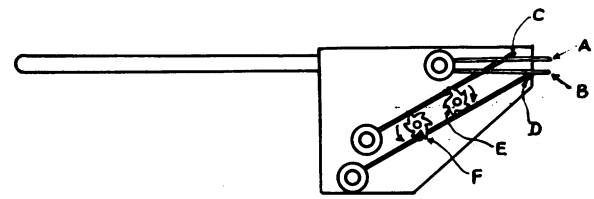

FIG. 3. The new interval timer for kymograph recording, as seen from the rear with cover removed.

[1] I am grateful to Dr. Warren H. Yudkin (now at Cambridge University, England) for pointing out the inconveniences of older methods and for requesting a solution of the problem, and to Dr. Edgar J. Boell of Yale University for making available to me facilities for testing the timer and for his helpful advice.

the intervals is ensured by the 60-cycle alternating current.

Both impactors follow a path of motion which is oblique to the deflection of the styli levers. The object achieved by this disposition of the impactors is the dissipation of sufficient energy by frictional contact to prevent rebound, which would cause the tracing of fuzzy division lines between intervals. The impactors are light in weight and do not strike the styli until they have reached their maximum velocity. Their high velocity is then transmitted to the styli, ensuring sharp graduations.

Records made with this instrument are shown in Fig. 2. It is apparent that, at either moderately slow or moderately fast speeds of the kymograph drum, the time scale traced on the paper can be read clearly. Due to the nature of this time scale no adjustment of the intervals traced by this instrument is necessary when changing drum speeds within very wide limits.

A new nonadjustable interval timer is described which traces a characteristic time scale on kymograph records (Fig. 2). The distinctive nature of the time scale traced allows its use on most records of moderate speed. It records intervals from 1/5 sec to 1 min. The timer described is a self-contained unit which requires no dry cells or signal magnet but merely an electricity supply of 110-volt, 60-cycle alternating current.

Induction of Cytogenetic Changes and Atypical Growth by Hexachlorocyclohexane

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We have treated with insecticides containing hexachlorocyclohexane the seedlings of the following plants: *Zea mays, Triticum vulgare, T. monococcum, T. compactum, Secale cereale, Setaria italica, Panicum miliaceum, Helianthus annuus, Crepis capillaris, Vicia faba, V. sativa, Brassica nigra,* etc. The insecticides chiefly used were: Agrocide 7, Agrocide 3, hexachlorane, 666. The main active substance of the first two is the gamma isomer of 1,2,3,4,5,6-hexachlorocyclohexane. The others contain gamma isomer and some of the other isomers. Crystals of almost pure gamma isomer display the same activity as these.

The cytological studies of the affected root, stem, and coleoptile tissues show that the agents act first upon the cytoplasm and interfere with the cytoplasmic processes involved in the formation of achromatic figures. The chromosomes do not arrange in an equatorial (metaphase) plate after prophase, but remain scattered approximately as they are during the prophase. They appear less bent than usual. The thickening of the chromosomes and their reproduction and splitting proceed, regardless of the fact that the processes involved in the formation of achromatic figures are highly disturbed or even entirely inhibited. Poles are not formed. After reproduction, the chromatolytic (nucleoproteolytic) processes proceed, and a nucleus is formed containing twice as many chromosomes as at the start of the abnormal mitotic processes. The main trend of the processes of chromosome doubling recalls those induced by colchicine, acenaphthene, and other polyploidizing agents.

Since the insecticide continues to act further, the next abnormal (Ab-) mitosis ends with a second chromosome doubling, and so on. Thus tetraploid and octoploid cells and cells of a much higher polyploid degree are formed. Along with these, certain diploid cells that have not yet undergone Ab-mitosis can still be found.

Chromosome multiplication leads to increase in the size and occasionally in the number of the nuclei and further to increase in the size of the cells. Thus the cells grow instead of multiplying and differentiating, bringing about the swelling of the roots, stems, and coleoptiles.

The chromosome reproduction and separation in *Zea mays* should be considered as a somewhat special case. We have observed in a series of cells that the chromatids of the somatic chromosomes bend at the centromeres reciprocally toward each other, each being shaped like a V, and together forming a X, the chromatids being attached at the centromere. These figures can be interpreted by postulating certain repulsion forces existing between the chromatids, the reproduction (or division) of the centromere being somewhat delayed. This phenomenon occurs when the chromatic figure is highly or completely disturbed. In other words, it does not seem to be regulated to a very great extent by the forces exerted by the achromatic figure.

The solubility of hexachlorocyclohexane in water is very low; therefore, it is applied in the form of small solid particles. The particles act when they are in contact with the plant tissue. It has a specific odor, but the experiments failed when we tried to induce specific atypical growth from a distance. In this respect its effect differed from that of acenaphthene. For the sublimating particles of the acenaphthene act even when the crystals are not in contact with the plant tissue.

The effect of hexachlorocyclohexane is so striking that it can be used as a polyploidizing agent, especially when one considers that it is much cheaper than other such agents.

In certain cases one or more chromosome groups may move slightly in various directions into the cytoplasm. Such a slight separation may occasionally end in the formation of two or more aneuploid nuclei; thus polynucleate cells or cells with monstrously deformed nuclei arise. In certain cases a cell wall is formed between such nuclei. This leads to the formation of cells with aneuploid chromosome numbers. Dead cells were occasionally found in the roots, stems, and coleoptiles; they may have been aneuploid.

All these phenomena are due to the activity of the agent upon the cytoplasm.

The active agent may also induce certain changes in the nuclear elements, i.e., in the chromosomes. Chroma-