If the main object of the experiment is the estimation of the unknowns with the least variance, the most efficient design (for a specified value of N) would be the one for which the *minimum minimorum* of $\frac{\sigma^2}{N}$ is attained for all the p unknowns. The quantity $\frac{p}{N \sum_{i=1}^{p} c_{ii}}$ may, therefore, be defined as the *efficiency* of a given design for providing the estimates of the p unknowns. I have used this quantity for judging the precision of the designs I have obtained.

3. By utilizing the properties of a 2-sided m-fold completely orthogonalized Hyper-Græco-Latin hyper-cube of the *first* order introduced earlier,[4] I have constructed a completely orthogonalized design for $N=2^m$, $p \leqslant 2^m$ (zero bias) or $p \leqslant 2^m - 1$ (non-zero bias), m being any positive integer, by which each unknown is estimated with the minimum variance $\frac{\sigma^2}{N}$, and thus its efficiency is 100 per cent.

For $N = 2^m+1$, $p \leqslant 2^m$ (zero bias) or $p \leqslant 2^m-1$ (non-zero bias), m being any positive integer, I have obtained two types of designs. The efficiency of the first design for which

$$X'X = \begin{bmatrix} N & 1 & 1 \ldots 1 \\ 1 & N & 1 \ldots 1 \\ 1 & 1 & N \ldots 1 \\ \ldots & \ldots & \ldots \\ 1 & 1 & 1 \ldots N \end{bmatrix},$$

the order of the matrix being $p \times p$ if there is zero bias, or $(p+1) \times (p+1)$ if there is bias, comes out to be

$$1 - \frac{p-1}{N(N+p-2)} \text{ for zero bias,}$$

$$\text{or} \quad 1 - \frac{p}{N(N+p-1)} \text{ for non-zero bias.}$$

It is surmised that this is probably the most efficient design available for these values of N and p. For the second design, the efficiency is $\frac{(N-1)p}{Np-1}$ for zero bias, or $\frac{N-1}{N}$ for non-zero basis.

For $N = 2^m + r$, $p \leqslant 2^m$ (zero bias) or $p \leqslant 2^m - 1$ (non-zero bias), r being any positive integer $< 2^m$ and m any positive integer, I have worked out two designs, which are exact analogues of the two designs just discussed. For the first design of this type, the efficiency is

$$1 - \frac{(p-1)r^2}{N[N+(p-2)r]} \text{ for zero bias, and}$$

$$1 - \frac{pr^2}{N[N+(p-1)r]} \text{ for non-zero bias.}$$

For the second design of this type, the efficiency comes to be $\frac{(N-r)p}{Np-r}$ if there is zero bias, and $\frac{N-r}{N}$ if bias is present.

Finally, when N is at our choice, we can always obtain a completely orthogonalized design by taking N equal to a sufficiently large power of 2.

A short paper giving details of these results has been sent to Prof. Harold Hotelling and is likely to be published in the *Annals of Mathematical Statistics*.

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May 31, 1945.

1. Harold Hotelling, "Some Improvements in Weighing and other Experimental Techniques," *Annals of Mathematical Statistics*, 1944, **15**, 297-306. 2. Bose, R. C., "The fundamental theorem of linear estimation," *Proceedings of the Thirty-first Indian Science Congress*, 1944, Part 3. 3. Radhakrishna Rao, C., "On Linear Estimation and Testing of Hypothesis," *Current Science*, 1944, **13**, 154-155. 4. Kishen, K., "On Latin and Hyper-Græco-Latin Cubes and Hypercubes," *Current Science*, 1942, **11**, 98-99.

D.C.-A.C. VIBRO CONVERTER (50 C.P.S.)

A VIBRO converter unit has been designed and developed at the Department of Electrical Technology of the Indian Institute of Science, Bangalore, during 1944-45 on new lines and using indigenous materials. It converts 110/220 volts D.C. (mains supply) to 110/220 volts A.C. of square topped wave form (fundamental frequency of 50 cycles/sec.). Many difficult problems like the selection of proper contact material, the determination of the suitable make to break time ratio, the suppression of high voltage surge in the transformer secondary, etc., have been solved to make the design successful. The efficiency of the machine increases with the increase of load from 50 to 75 per cent., and the vibro converter is capable of supplying current up to 2 amps. with a voltage regulation of 3 to 4 per cent. Full details of the machine will be published elsewhere.

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MAGNETIC ANISOTROPY OF IODINE CRYSTAL

INFORMATION regarding the magnetic anisotropy of crystals of non metallic elements is scanty. In the case of metals, studies of the magnetic properties of crystals have been possible since large cylindrical crystals can be grown by the method of slow cooling. But with non metallic elements such methods are not applicable. Other lines of approach have to be considered.

One such method is the critical torsion method developed by Krishnan.[1] Small crystals can be employed and using fine quartz fibres, the magnetic anisotropy of any crystal can be accurately determined. Krishnan's method has been found to be successful in the case of elements as evidenced by the work of John[2] and Rao.[3]

In the case of iodine, Krishnan's method is ideal. Resublimed iodine crystals, having masses of about 100 mg., were employed. Test experiments proved that the specimen of iodine was free from any ferromagnetic impurity. Investigations on critical torsion were