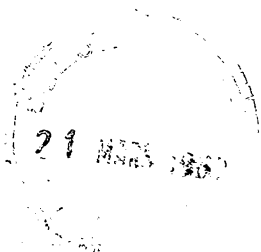


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FIELD TESTS OF RUBBER DISC REGULATORS ON COMPRESSION SPRAYERS

by

R. A. Fitzjohn, WHO Sanitarian
and P. A. Stevens, WHO Sanitary Engineer

1. INTRODUCTION

In order to control the rate of liquid discharge from the hand-operated compression sprayers, mechanical pressure regulators and rubber disc flow regulators are available on the market. The characteristics of rubber disc regulators and the performance of one make¹ in preliminary field trials have been described.^{2,3} Further field trials were undertaken in 1961 in Northern Nigeria which have confirmed the potential usefulness of the devices in house-spraying operations and which have also provided some quantitative idea of their limitations. This paper describes the results obtained and suggests some possible improvements in the design.

2. DESCRIPTION OF TEST

Two squads, each of six sprayers, in the Western Sokoto (Northern Nigeria) Mass Malaria Control Campaign, equipped with Hudson 710S/WHO/01 compression sprayers (4 US gal./15 litres) were used for the tests. Both squads were spraying DDT suspensions in normal house-spraying operations. The field tests lasted from April to December 1961, during the last two months of which additional squads were assigned to the work. Both the type of nozzle and the strength of DDT concentration were

¹ Produced by the H. D. Hudson Manufacturing Company, Chicago, Illinois.
Part Numbers: Flow regulator 153-805, gasket (two required) 151-877

² Lonergan & Hall (1959) The regulation of flow through residual spray nozzles,
(2) Flow control orifices in soft rubber discs, Bull. Wld Hlth Org. 20, 961

³ Hall & Taylor (1962) Regulated flow of insecticides, Bull. Wld Hlth Org. 27, 279

changed several times during this period for operational reasons not connected with the tests but records were kept which enabled calculation both of total liquid and total DDT powder (75% w.d.p.) discharged by each device being tested. Throughout the tests the sprayer tanks were filled with 10 litres of liquid at each charging and this amount was discharged each time with two pressurizings of the tank in such a way that the tank pressure was maintained between 4.5 and 2.0 kg/cm²; 1 39 972 pump charges (399 720 litres) were discharged through the devices under test during this period.

Six sprayers were equipped with rubber disc regulators and the remaining six with standard mechanical regulators.² In order to compare the effect of the two systems of regulation it was intended that the latter would be adjusted to discharge at the same average rate as the rubber disc regulators, but since it was found that the mechanical regulators would not maintain constant setting at such low pressures they were, in practice, set to discharge at a slightly higher rate (see below). Before being put into use in the field all discs were tested for constancy of discharge at different pressures. Nozzle tips of all the types previously used in the Sprayer Evaluation Project were tried out. All nozzle tips used in the test were tested for discharge and liquid distribution at different pressures both with and without regulators. Regulators and tips were numbered with punch markings.

The criteria for failure and removal of tested units were drawn up in anticipation that the rubber disc regulators would normally become unusable sooner than the nozzle tips and without knowing in advance in what ways they were likely to fail. The testing protocol required that weekly tests should be made of discharge rates at different specified tank pressures with clear water and that swath widths should be measured. If for a given disc under test the average discharge rate was found to

¹ Throughout the paper pressure measurements are shown in kg/cm²; 1 kg/cm² = 14.2 p.s.i.

² The mechanical regulators (Hudson part number 148-958) were removed from the sprayers used for testing the rubber discs, the hoses being attached directly to the tanks by fittings numbers 115-960 and 115-968. The low pressure (pop-off) valves on the remaining six sprayers were inactivated by removal of the springs (part number 150-406).

have increased or decreased by 10% or more from the value at the beginning of the test, if the range (difference between maximum and minimum discharge values obtained at different tank pressures) had reached or exceeded twice the range obtained at the beginning of the test, if the swath width had changed from the initial value by 20% or more if the liquid distribution had become noticeably poor, then the regulator was to be replaced by a new one. According to the plan, nozzle tips were to be changed only when the replacement of a disc failed to bring the measured quantities within the allowable limits. In practice it was observed that tips usually had to be removed because they had developed poor liquid distribution before other failures in the system were detected. On the other hand a number of discs were removed from service because of the swath width criterion before it was realized that this effect was dependent on nozzle erosion. Some of the discarded discs were later on put back into service after different periods of rest and thus provided some information on the "recuperating" effect of resting the devices.

Although the effects of long periods of rest have not been systematically studied, the effects on both new and old discs of short rest periods comparable with those occurring during regular daily operations were examined. Finally, in order to compare field and laboratory observations of liquid distribution and justify the removal of nozzle tips for poor liquid distribution, a great many liquid distribution tests were run and plotted.

On each weekly visit to the squad which was equipped with mechanical regulators note was taken of the average discharge rate of each sprayer as well as any malfunctioning and parts replaced during the week were recorded. Regulators were re-set each week to about 825 ml/min.

3. TESTING APPARATUS

All discharge rates were measured for 30 seconds in 500-ml glass graduates. Clear water was used and readings were taken after discharge lines and nozzle tips had been rinsed and cleaned. Nozzle tip orifices were cleaned with a tooth-brush. During most of the testing period pressure for these tests was produced by a motorized air compressor¹ connected by means of a Schraeder valve fitted to the tank cover of

¹ Villiers petrol-engined Devilbiss Aerograph Compressor

a normal Hudson sprayer. Pressures were controlled in the field by two hydraulic manometers¹ which were calibrated daily against a precision manometer.² Liquid distribution and swath width were observed in the field by spraying against a smooth porous wall and in the laboratory with the aid of a patternator.³ All measurements were made with nozzles held 18 inches from the sprayed surface. Calibrated test-tubes were used and the test-tube rack in the patternator was fitted with a ruled plastic scale so that the amounts of liquid collected in individual test-tubes could be read off in ml by one worker and plotted directly on cross-section paper by another. All the field and laboratory observations were made by one of the authors (R. A. F.).

4. RESULTS AND DISCUSSION

The data collected was examined in relation to the following points:

- (a) Effect of new disc on discharge rate
 - (b) Constancy of discharge rate under continued usage of disc
 - (c) Effect of disc on liquid distribution from the nozzle
 - (d) Effect of disc on nozzle erosion
 - (e) Comparison of field maintenance required for the two types of regulator
 - (f) Comparison of costs for the two types of regulator
 - (g) Suggestions for improved design of disc regulator
- (a) Effect of new disc on discharge rate

It was observed in preliminary tests of rubber disc regulators with nozzle tips of different orifice size that the discharge rate was independent of the orifice size and remained essentially constant with varying upstream (tank) pressures. It was also observed that for every disc and nozzle combination

¹ Haenni & Company, Jagensdorf, fig. 1 in catalogue of September 1953, 0-10 kg/cm², 15 cm diam. was used to control tank pressures and model shown in fig. 648 of the same catalogue, 0-6 kg/cm², 15 cm diam. was used to control lance pressures.

² Haenni & Company, fig. 58 in catalogue of September 1953, 0-5 kg/cm², 15 cm diam.

³ Similar to the one pictured in Specifications for Pesticides 1961, page 428, Fig. 16

a critical tank pressure could be found below which the discharge rate fell off. By inserting a manometer between the disc and the nozzle tip, it was possible to verify that the constant discharge rate corresponded to a specific "nozzle tip pressure". For each disc/tip combination this nozzle tip pressure was naturally highest for the tips with the smallest apertures (8002) and lowest for tips with the largest apertures (8006) and it tended to decrease as a tip became eroded in service. The minimum head loss between tank and nozzle at the critical point where the disc stopped regulating was slightly over 1.0 kg/cm^2 for an 8002 tip and about 0.7 kg/cm^2 for an 8004 tip. About 0.2 kg/cm^2 is the normal line loss, and it is assumed that most of the difference was due to loss through the disc itself, though the (inactivated) mechanical regulator may have contributed. After the discovery of this fact discharge rate values made below the critical tank pressure were disregarded in calculating average discharge rates and ranges.

Two batches of 25 rubber disc regulators¹ were received for field testing, the second batch having a lower discharge rate. It can be seen in Table 1 that constant discharge was obtained between tank pressures of $6-2 \text{ kg/cm}^2$ for new 8003, 8004, 8006, Galeazzi and Macop nozzle tips. A fall to about 310 ml/30 seconds was observed at 1 kg/cm^2 with both new 8004 and 8003 tips. New 8002 tips exhibited a fall already at 3 kg/cm^2 tank pressure. The discharge rate of the 23 new batch "A" discs which were field tested was $792.9 \pm 13.4 \text{ ml/minute}$ and the discharge rate of the 14 new batch "B" discs which were field tested was $728.4 \pm 21.4 \text{ ml/minute}$. The approximate average values of critical tank pressure and nozzle tip pressure are given in Table 2. The values shown are for batch "B" regulators; values for batch "A" are about 0.1 kg/cm^2 higher. These figures confirm Hall's statement that 8003 and 8004 tips can be used with this device but that 8002 tips are unsuitable.

¹ Regulator Hudson part number 153-805 and plastic nozzle gasket part number 151-877

TABLE 1. INITIAL DISCHARGE RATE OF NEW DISCS WITH VARIOUS NOZZLE TIPS

Tips	No. of observations	Average discharge (ml/30 sec.) at indicated tank pressures (kg/cm ²)					
		6	5	4	3	2	1
<u>Batch "A" rubber discs:</u>							
8003, -04, -06, Galeazzi, Macop	84	398.1	397.3	396.3	395.9	394.4	
8002	2	395.5	395.0	390.0	337.0	255.0	
8003	5						302.4
8004	38						311.4
<u>Batch "B" rubber discs:</u>							
8003, -04, -06, Galeazzi, Macop	35	364.1	362.8	362.7	361.8	361.2	
8002	2	363.0	362.5	379.5	359.5	288.0	
8003	4						309.2
8004	1						308

TABLE 2. APPROXIMATE PRESSURE CONSTANTS FOR DIFFERENT NOZZLES USED WITH HUDSON MANUFACTURING CO. RUBBER DISC FLOW REGULATORS DISCHARGING 725 ML/MINUTE

Nozzle tip	Critical tank pressure kg/cm ² (p.s.i.)	Nozzle tip pressure kg/cm ² (p.s.i.)	Design discharge ml/min and tank pressure (kg/cm ²)
Spraying Systems 8002	4.0 (57)	2.5 (35)	757 (2.8)
Spraying Systems 8003	2.2 (31)	1.2 (17)	1 135 (2.8)
Galeazzi No. 521 (new type)	2.0 (28)	1.0 (14)	950 (1.1)
Macop No. XLT	1.6 (23)	0.8 (11)	1 000 (1.0)
Spraying Systems 8004	1.5 (21)	0.7 (10)	1 514 (2.8)
Galeazzi No. 521 (old type)	1.5 (21)	0.6 (9)	950 (1.0)
Spraying Systems 8006	0.9 (13)	0.2 (3)	2 270 (2.8)

It is obvious that the liquid tank charge and instructions on pumping given to the spraymen should be such that the tank pressure will remain above the critical point during regular field operations. With 8004 tips having a critical tank pressure of about 1.5 kg/cm^2 , 10 litres could be discharged entirely by pressurizing the tank initially to about 6.5 kg/cm^2 , and smaller tank charges with less initial pressure.

(b) Constancy of discharge rate under continued usage of disc

In regular spraying operations in the Western Sokoto Mass Malaria Control Campaign a sprayman discharges on an average 700-900 litres of insecticide in a 5-1/2 day week. Under these conditions most of the disc regulators maintained for several weeks acceptable discharge rates (as measured during the working hours after appropriate "priming" described in the following paragraph). A few were usable for several months. Considering that strain and fatigue of the discs are related to the amount of liquid discharged, the total litres discharged have been worked out for each disc up to the day on which its discharge rate was observed to have passed both $\pm 7\%$ and $\pm 10\%$ of its own initial discharge, and $\pm 7\%$ of the supposed design discharge (757 ml/minute). These figures have been grouped into 1000-litre intervals, taking into account the discs which were lost or removed from service before "failure". The per cent. remaining serviceable has been calculated for each interval (Table 3). While all discs maintained within 7% of their initial discharge rate until they had discharged 1000 litres, only about half maintained this level until 4000 litres had been discharged (five weeks). There seems to be no significant difference for discs which have been rescued for a few weeks and returned to service, between the average durability in the first and second phase of service. The last four columns of Table 3 show that only half the discs remained within 7% of the supposed design discharge rate of 757 ml/minute after discharging 2000 litres. Several discs of batch "B" were outside the range $757 \text{ ml/minute} \pm 7\%$ when received. The figures showed no significant difference in durability between batches "A" and "B". It is obvious from the results that, if used continuously as in these tests, the discs would have to be tested for discharge rate fairly frequently (perhaps once a fortnight) in order to ensure prompt removal of defective discs.

TABLE 3. PER CENT. OF DISCS REMAINING SERVICEABLE AFTER DISCHARGING
 X LITRES OF INSECTICIDE

Litres discharged	Comparison of batches "A" and "B"						Comparison of 1st and 2nd usage of discs							
	7% from init. disch.			10% from init. disch.			7% from init. disch.				7% from 757 ml/min			
	All discs	Batch A	Batch B	All discs	Batch A	Batch B	Batch "A"		Batch "B"		Batch "A"		Batch "B"	
	(37)	(23)	(14)	(37)	(23)	(14)	1st (23)	2nd (8)	1st (14)	2nd (6)	1st (23)	2nd (8)	1st (14)	2nd (6)
0	100	100	100	100	100	100	100	100	100	100	100	100	86	100
1 000	100	100	100	100	100	100	100	100	100	100	100	100	79	50
2 000	83	97	76	95	93	100	76	73	92	100	<u>67</u>	<u>60</u>	<u>63</u>	50
3 000	72	97	<u>66</u>	95	77	100	62	<u>58</u>	<u>79</u>	100	47	45	32	50
4 000	<u>53</u>	90	47	84	<u>59</u>	100	<u>51</u>	29	34	100	31	30	10	<u>50</u>
5 000	46	87	42	78	49	100	46	29	34	80	26	30		30
6 000	38	83	30	71	49	100	32	0	34	80	15	0		30
7 000	38	83	30	71	49	100	24		34		9			
8 000	38	75	30	<u>63</u>	49	<u>100</u>	24				9			
9 000	16	57	13	46		0	14				0			
10 000	16	<u>57</u>	13	46			14							
11 000	0	38	0	37			0							
12 000		9		9										
13 000		9		9										
14 000		9		9										
15 000		9		9										
16 000		9		9										
17 000		0		0										

N.B. (1) Figures in brackets show number of discs tested
 (2) The first percentage figures above 50 are underlined.

The test protocol required that discharge rate measurements be made after establishment of steady flow. There were indications during the preliminary testing that the time necessary to establish steady flow varied and since rest periods of a few seconds or minutes are common in regular spraying operations, several new and old discs were tested as follows:

- (i) water was discharged continuously through the disc until successive 30-second fractions were constant; this took two to five minutes;
- (ii) after a measured rest time of 15 seconds water was discharged continuously for 10-1/2 minutes and 30-second fractions were measured and recorded;
- (iii) after a 30-second rest (ii) was repeated;
- (iv) after rest times of 60, 120 and 240 seconds the procedure was repeated.

The observations made during this test are summarized in Table 4. Each time the disc is rested, even for as little as 15 seconds, the discharge rate increases temporarily 20-40 ml/minutes, or even more. Following rests of two or three minutes continuous spraying is needed to bring the discharge rate down to a constant value. There is no consistent difference in performance between new and used discs. It is clear from these results that fairly large variations in the observed discharge rate of a rubber disc may be obtained at any time by varying the amount of priming prior to taking the reading. When purchase specifications and field testing procedures are drawn up, they should indicate clearly how the discharge tests are to be made.

(c) Effect of disc on liquid distribution from the nozzle

Liquid distribution patterns were made for several nozzle tips before they were put in service, both with disc regulators and without regulators, but at the same nozzle tip pressure.¹ Liquid distribution curves for Spraying Systems nozzles

¹ It was confirmed that the discharge rate was not affected by moving the disc regulator from directly behind the tip to a position 7 cm away. It could therefore be assumed in routine testing that when the discharge without regulator was the same as with regulator, the nozzle tip pressures were the same.

TABLE 4. EFFECT OF SHORT REST PERIODS ON DISCHARGE RATE THROUGH NEW AND USED DISC REGULATORS

Disc No.	History:		Initial priming time (min)	Changes in discharge rate during indicated operation (ml/min)										Final change from init. discharge rate after priming	
	weeks used	rested		Priming	15 sec rest	10-1/2 min spray	60 sec rest	10-1/2 min spray	120 sec rest	10-1/2 min spray	240 sec rest	10-1/2 min spray			
0	new	-	2.0	.60	+10	-.28	+16	-.34	+60	-.46	+34	-.42	+54	-.60	-.36
11	new	-	3.5	-.60	+24	-.36	+24	.24	+26	-.28	+32	-.30	+36	-.38	-.16
3	new	-	5.5	-.40	+14	-.18	+16	-.22	+18	-.20	+22	-.20	+18	-.18	-.10
P	new	-	5.5	-.80	+14	.16	+22	-.30	+28	-.28	+30	-.30	+36	-.36	-.10
2/2	12	8	2.5	-.22	+14	-.30	+10	-.12	+8	-.10	+28	-.28	+20	-.20	-.16
3d	7	20	4.0	-.34	+14	-.20	+18	-.20	+20	-.16	+22	-.26	+26	-.26	-.16
6	4	23	3.0	-.30	+6	-.18	+20	-.26	+32	-.30	+32	-.32	+32	-.30	-.6
4/5	5	19	3.5	-.50	+22	-.32	+32	-.34	+32	-.34	+44	-.42	+32	-.32	-.10
Average			3.7	-.47	+14	-.24	+20	-.26	+28	-.26	+30	-.32	+32	-.32	-.15

were also plotted at the nozzles' design pressure of 2.8 kg/cm^2 (40 p.s.i.). Curves were obtained for the same nozzles after they were removed from service. These curves showed that when placed close to the nozzle tip, a rubber disc regulator has two desirable effects. It flattens out both central and lateral peaks and it widens the swath. The latter effect is important since the narrowing of swath produced by nozzle tips designed to operate at higher pressures has been an inconvenience in low pressure operations. Table 5 shows that for new tips the swath width of the disc/tip combination approaches that of the tip alone at 2.8 kg/cm^2 .

These effects were very pronounced both with new and old nozzle tips and by masking poor liquid distribution allowed some tips to be used which would otherwise have been discarded. There was, however, no evidence that the use of the disc prevented development of poor liquid distribution; in fact the rate of nozzle replacement for this reason was at least as high as in operations without the disc regulator (Table 6).

These effects are illustrated by Figures 1 to 4. Figure 1 represents liquid distribution curves for a Spraying Systems HSS 8004 nozzle tip when new and Figure 2 at the time it was rejected after a period of field use. Three curves are shown for each case, curve (a) being at the design pressure, curve (b) with rubber disc regulator, and curve (c) without rubber disc regulator at the same discharge rate as with the regulator. Figures 3 and 4 represent liquid distribution curves for a Galeazzi nozzle tip when new and when rejected after use in the field.

(d) Effect of disc on nozzle erosion

In order to study the erosion of nozzle tips the weekly records of discharge rate through tips alone were used to estimate the time at which the discharge rate increased 10% from its initial value. The amount of powder in kilograms which had passed through each tip was calculated and the results averaged for all tips of the same kind with rubber disc and with mechanical regulators. The results,

TABLE 5. SWATH WIDTHS OF NOZZLE TIPS WHEN NEW AND WHEN DISCARDED (IN CM)

Nozzle tip	No. of observations	New tips			Discarded tips		
		With disc	At same nozzle tip pressure without disc	At 2.7 kg/cm ² (40 p.s.i.)	With disc	At same nozzle tip pressure without disc	At 2.7 kg/cm ² (40 p.s.i.)
HSS 8004	10	73±3	61±3	85±5	62±4	51±3	81±3
SS 8004	6	77±4	64±2	83*	65±3	60±4	...
HSS 8003	1	71	66	...	63	60	...
SS 8003	9	71±3	66±3	74±2	58±3	51±3	66*
HSS 8002	3	...	...	83±5	...	...	76±1
SS 8002	2	...	...	85±0	...	...	77±0
Galeazzi	10	90±4	82±5	-	78±3	67±5	-
Macop	9	81±3	71±5	-	70±3	58±3	-

* Single observation

N.B. (1) The swath widths were measured from liquid distribution curves made on the patternator. They are slightly wider than would be visible in ordinary spraying.

(2) Standard deviation is shown for each group of observations.

TABLE 6. EFFECT OF DISC AND MECHANICAL REGULATORS ON NOZZLE LIQUID DISTRIBUTION PER CENT. OF NOZZLES REMAINING SERVICEABLE AFTER DISCHARGING X LITRES

Total litres discharged	8004				8003				Galeazzi		Macop	
	HSS		SS		HSS		SS		D	M	D	M
	D (14)	M (9)	D (14)	M (19)	D (1)	M (1)	D (25)	M (22)	D (17)	M (10)	D (13)	M (0)
0	100	100	100	100	100	100	100	100	100	100	100	
1 000	93	100	93	83	<u>100</u>	100	96	95	100	89	100	
2 000	91	88	85	70	0	100	<u>52</u>	<u>76</u>	76	77	83	
3 000	<u>65</u>	76	<u>57</u>	55		100	16	46	56	<u>60</u>	<u>71</u>	
4 000	43	<u>51</u>	38	<u>55</u>		100	0	32	56	40	29	
5 000	0	22	28	25		100		22	56	20	29	
6 000		0	19	12		<u>100</u>		22	56	0	29	
7 000			0	0		0		7				
8 000												

N.B. (1) D = used with rubber disc regulator
 M = used with mechanical regulator

(2) The first percentage figures above 50 are underlined.

recorded in Table 7, apparently show that the SS 8004 tips resisted erosion better than HSS 8004 tips, that the Galeazzi tips eroded faster, and that no conclusion should be drawn as to whether the discs affected or not the rate of tip erosion.

(e) Comparison of field maintenance required for the two types of regulator

Table 8 shows the number of times clogging occurred and Table 9 the regulator spare parts and nozzle tips consumed during the testing by squads using rubber disc and mechanical regulators. No significant differences could be observed between the two squads in terms of work output and general maintenance problems but clogging behind disc regulators occurred more often than at the nozzle tips of sprayers using mechanical regulators. As noted earlier, the disc regulators, like the mechanical regulators, would require periodic discharge rate testing. In properly organized spraying teams this could be made part of the normal maintenance procedure.

During the field tests, despite the diligent efforts of supervisors, a number of disc regulators were lost¹ by spraymen, mostly while clearing the clogging. It is suggested that the device ought to be screwed or otherwise tightly fitted into the nozzle body to prevent as far as possible its accidental loss in field operations. The gasket provided with batch "A" regulators which was about 1 mm thick, produced a satisfactory seal and resisted considerable use in the field. The gasket provided with batch "B" regulators which was much thinner, did not always produce a satisfactory seal and was easily destroyed. Gaskets of the first type appear preferable.

¹ 8 out of 37 discs tested were lost.

FIG. 1. LIQUID DISTRIBUTION CURVES FOR NEW
HSS 8004 NOZZLE TIP (TIP NO. 3S/3S, 31.10.61)

- (a) At design pressure (40 psi = 2.8 kg/cm²)
- (b) With rubber disc regulator
- (c) Without rubber disc regulator but at same discharge rate as with regulator

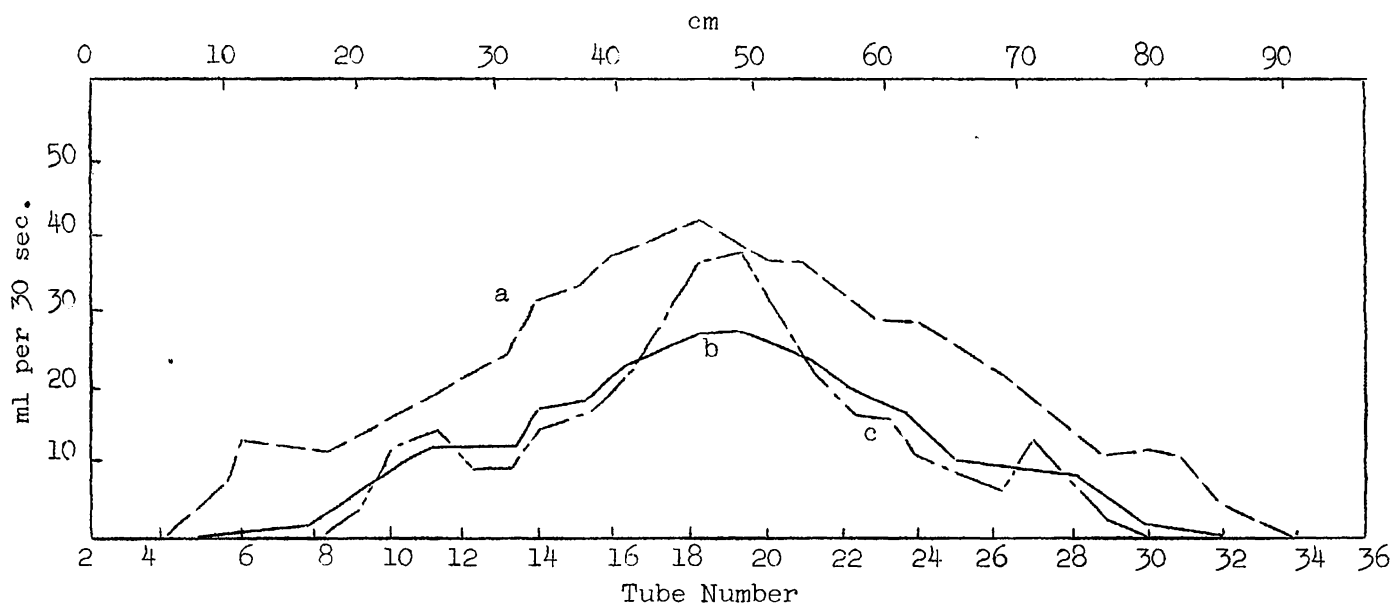
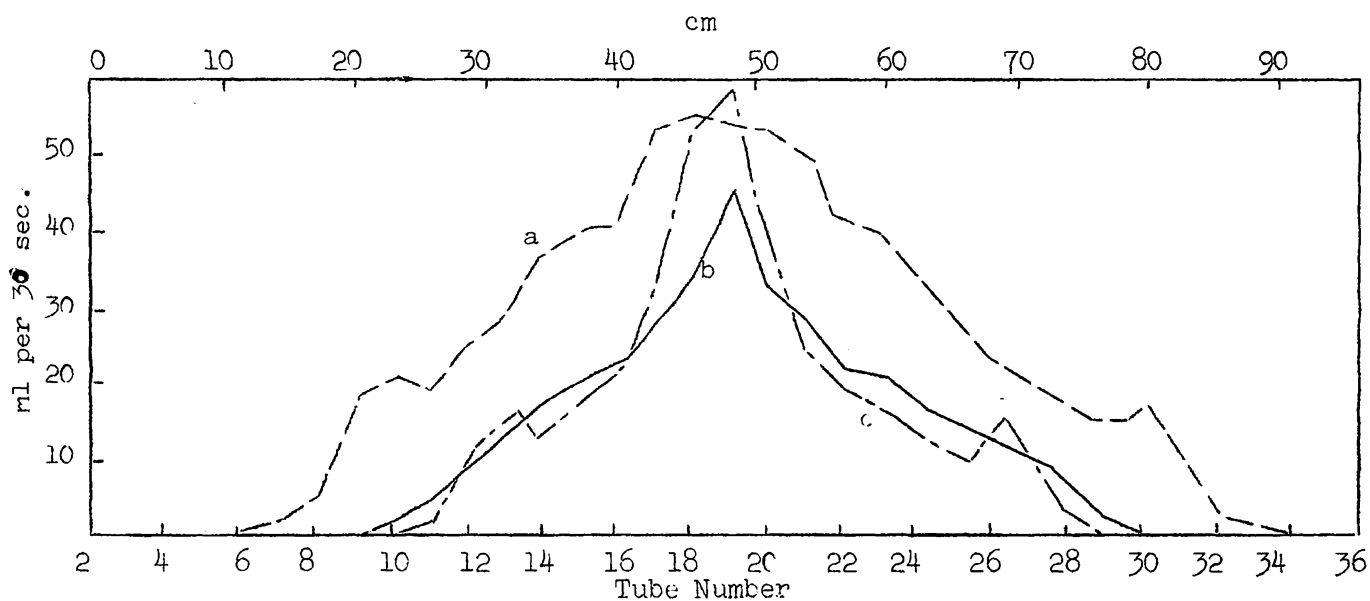


FIG. 2. LIQUID DISTRIBUTION CURVES FOR
HSS 8004 NOZZLE TIP WHEN DISCARDED (TIP NO. 3S/3S, 2.12.61)

- (a) At design pressure (40 psi = 2.8 kg/cm²)
- (b) With rubber disc regulator
- (c) Without rubber disc regulator but at same discharge rate as with regulator



Note. This tip discharged 2310 litres of suspension containing 82 kg of DDT 75% wwp. It was rejected for over 10% increase in discharge rate and poor liquid distribution.

FIG. 3. LIQUID DISTRIBUTION CURVES FOR NEW
GALEAZZI FAN TYPE NOZZLE TIP (TIP NO. 4S/4D 31.10.61)

- (a) At design pressure (40 psi = 2.8 kg/cm²)
- (b) With rubber disc regulator
- (c) Without rubber disc regulator but at same discharge rate as with regulator

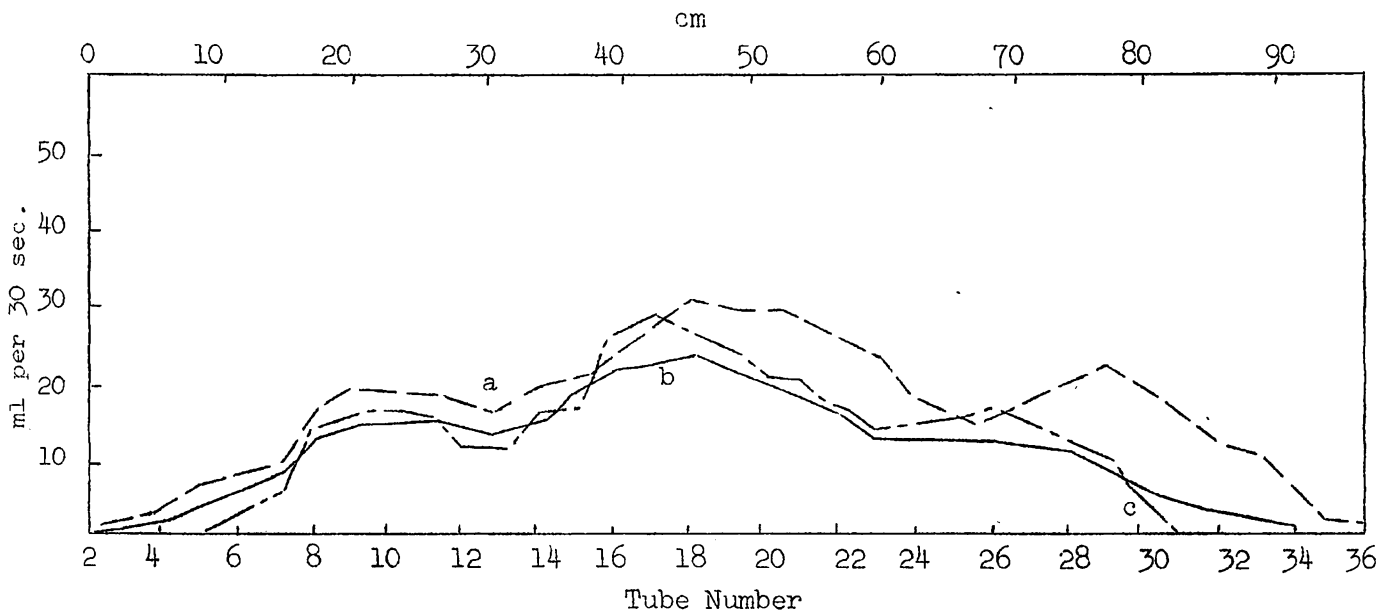
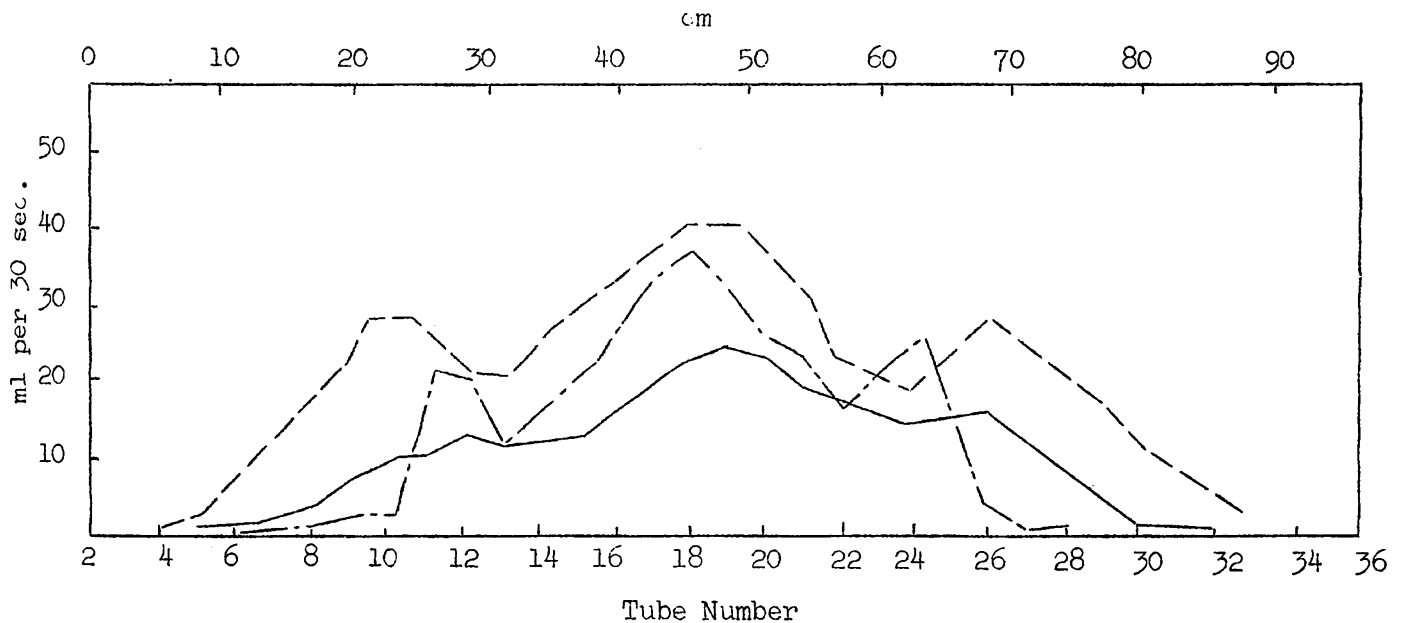


FIG. 4. LIQUID DISTRIBUTION CURVES FOR
GALEAZZI FAN TYPE NOZZLE TIP WHEN DISCARDED (TIP NO. 4S/4D 2.12.61)

- (a) At design pressure (40 psi = 2.8 kg/cm²)
- (b) With rubber disc regulator
- (c) Without rubber disc regulator but at same discharge rate as with regulator



Note. This tip discharged 2930 litres of suspension containing 104 kg of DDT 75% wdp. It was rejected for over 10% increase in discharge rate and poor liquid distribution.

TABLE 7. COMPARISON OF EROSION IN NOZZLE TIPS USED WITH RUBBER DISC AND MECHANICAL REGULATORS. PER CENT. OF TIPS WHOSE DISCHARGE RATE INCREASED LESS THAN 10 PER CENT. WHEN X KG DDT POWDER HAD BEEN DISCHARGED

kg DDT 75% w.d.p. discharged	8004				8003			Galeazzi				Macop D (9) 0.8
	HSS		SS		HSS	SS		Old type		New type		
	D (6) 0.7	M (4) 0.8	D (7) 0.7	M (5) 0.8	M (1) 1.3	D (19) 1.2	M (15) 1.3	D (11) 0.6	M (3) 0.8	D (4) 1.0	M (6) 1.1	
0	100	100	100	100	100	100	100	100	100	100	100	100
20	100	100	100	100	100	100	100	100	100	75	67	100
40	100	100	100	100	100	84	93	<u>55</u>	<u>100</u>	50	50	89
60	100	100	84	100	100	<u>53</u>	80	18	<u>33</u>	<u>50</u>	<u>50</u>	<u>67</u>
80	100	100	84	100	100	42	80	9	33	0	<u>33</u>	44
100	67	100	84	100	<u>100</u>	16	<u>73</u>	9	0		0	11
120	67	100	71	100	0	0	40	9				0
140	<u>50</u>	100	71	80			40	9				
160	17	<u>50</u>	57	80			27	0				
180	17	25	57	60			7					
200	17	25	57	60			7					
220	0	25	57	60			7					
240		0	57	<u>60</u>			7					
260			<u>57</u>	40			0					
280			43	40								
300			29	20								
320			14	20								
340			0	20								
360				20								
380				0								
400												

N.B. (1) At the head of each column is shown type of regulator (D = disc, M = mechanical), number of tips tested in parenthesis, and the approximate nozzle tip pressure (kg/cm²) during field operation with regulators. Discharge rates of the tips without regulators were measured at or near 1.0 kg/cm² pressure during most of the testing. Some tips were tested at the design pressure of 2.8 kg/cm². The difference in per cent. increase of discharge rate measured at the two pressures has, however, been shown to be small. The erosion indicated by readings at the lower pressure being slightly greater than at the higher.

(2) The first percentage figures above 50 are underlined.

TABLE 8. NOZZLE CLOGGING

Type of regulator	Total litres discharged	Number of times clogging reported			
		by grass	by suspension	by sand	Total
Disc	222 540	143	1 894	688	2 725
Mechanical	177 180	83	1 182	421	1 686
TOTAL	399 720	226	3 076	1 109	4 411

TABLE 9. REGULATOR PARTS AND NOZZLE TIPS CONSUMED

Hudson part number (old number in parenthesis)	Description	Number and approximate cost of parts consumed on sprayers using			
		disc regulators		mechanical regulators	
153-805	Flow regulator	22*	\$ 22		
151-877	Nozzle gasket	56	\$ 1		
(various)	Nozzle tip	65	\$ 49	53	\$ 40
125-986 (2598-6)	Regulator diaphragm			13	\$ 1
150-407 (7039-5)	Regulator spring			12	\$ 1
	Cost		\$ 72		\$ 42
	Cost per 1000 litres discharged		\$ 0.32		\$ 0.24

* Including 8 lost

(f) Comparison of costs for the two types of regulator

Table 9 shows that during the period of testing the cost of parts replacement was not very different for the two types of regulator. These results do not indicate how long individual rubber disc regulators could be used if they were rotated at weekly or monthly intervals. In any case, the disc regulators are initially cheaper and easier to handle from the supply point of view in large field operations.

(g) Suggestions for improved design of disc regulator

It has often been noticed in field operations that nozzle tips designed to be used at higher pressures produce spray jets and spray patterns which seem, for one reason or another, to be unsatisfactory. For example, an 8004 tip discharging 750 ml/minute has a narrower swath, produces a coarser spray, and wets a sprayed surface much more slowly than an 8002 tip discharging at the same rate. Consequently a sprayman used to using an 8002 tip will tend to overdose the sprayed surface by moving the spray lance too slowly. Observations during the tests in Nigeria have suggested that better results might be obtained if a regulator producing a higher discharge rate were used. While practice varies in different countries, spraying speeds as high as 25 m²/minute are quite satisfactory and application rates of 50 ml/m² are not uncommon. Thus discharge rates of 1000-1200 ml/minute can be considered reasonable for design purposes. Two flat fan nozzle tips available on the market¹ are designed to deliver about 1000 ml/minute at a nozzle tip pressure of about 1 kg/cm². It seems likely that a nozzle tip designed to operate under these conditions used with a rubber disc regulator discharging 1000 ml/minute would perform more satisfactorily both in respect to appearance of the jet and pattern and with respect to actual liquid distribution produced than the devices tried out during these tests.

¹ Galeazzi Part No. 521
Macop Part No. XLT

5. CONCLUSIONS

(a) When used with adequate tank pressure rubber disc regulators produce an essentially constant discharge through a variety of nozzle tips. The rate of discharge is not affected by erosion of the nozzle tip.

(b) Each time a disc is rested the discharge rate temporarily increases and when spraying is resumed two or three minutes continuous operation is needed to bring the discharge rate down to a constant level. Since most house spraying against Anopheles is carried out in small rooms and with numerous obstacles, continuous discharges of over two minutes are rare; the average discharge in practice is therefore somewhat above this constant level. The "constant level" itself usually decreases over a period of weeks so that in order to maintain the discharge rate at an acceptable level the disc must be changed. Rest periods of 8 to 23 weeks bring the discharge rates back to acceptable levels and the average length of useful life of used discs after being rested is not significantly different from that of new ones. The average lifetime of rubber disc regulators under the conditions of the test was not sufficiently constant to suggest a routine replacement schedule. The need for fairly frequent testing of discharge rates is indicated.

(c) When placed close to the nozzle tip a rubber disc regulator flattens central and lateral peaks in the liquid distribution curve and widens the swath. Rubber disc regulators do not prevent the development of poor liquid distribution, nor is the rate of nozzle replacement due to poor liquid distribution less with rubber discs than with mechanical regulators.

(d) There is no evidence that use of rubber disc regulators affects the rate of nozzle tip erosion.

(e) The greatest advantage of the rubber disc regulator from the point of view of the field operator is its simplicity. Including gaskets there are 3 parts while the mechanical regulator of the same make has 17 parts. Operationally rubber discs show two disadvantages as compared with mechanical regulators. They tend to become clogged more frequently with debris and they are rather easily lost in the process of cleaning discs or nozzle tips.

(f) The size of this test was too small to provide evidence of possible savings in programme cost with the rubber disc regulator. It was indicated that with a system of rotation the use of discs might result in savings over the use of mechanical regulators.

(g) It is likely that the optimum pattern and liquid distribution would be produced by a nozzle tip designed to deliver about 1000 ml/minute at a nozzle tip pressure of about 1 kg/cm² used with a rubber disc regulator designed to discharge 1000 ml/minute.

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